BENEFITS AND ISSUES OF DEVELOPING A
MULTI-PURPOSE CADASTRE

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ABSTRACT

The effective and efficient operation of a nation's cadastral system is an integral part of sustainable development. In recent years, cadastral systems have been influenced by the introduction of the web and Cadastre 2014 that have heavily impacted on the geo-information scene through the development of the Multi-Purpose Cadastre concept. The concept is expected to benefit all levels of governments and society. Increased sharing of datasets, public transactions of data and reduction of administrative costs are a few of the benefits foreseen. In a bid to understand the complexity and structure of the Multi-Purpose Cadastre concept, a review of worldwide online cadastral systems was conducted with its comparison listed in this paper. Unfortunately, there is little documentation readily available which discusses the issues involved.

With the current trends of distributed computing and the heavy demand for easy access to land information, the development of the Victorian Land Information System (VLIS) concept prototype was conceived. The development was an effort to justify the possibility of delivering cadastral information through a portal site on the World Wide Web. Various issues such as data format, system integrity and performance considerations are discussed in an effort to paint a picture of a futuristic cadastral system.

The contents of this paper are not only aimed to shed some light on the development of online cadastral systems but to contribute further technical understanding from an open research environment. This paper is expected to

INTRODUCTION

The effective and efficient operation of a nation's cadastral system is an integral part of sustainable development. From Ting, it was argued that land is seen as a source of wealth with the cadastral system as the fiscal tool in recording the ownership of land (Ting 1999). The earliest of such records dated back to 3000 BC where the Romans recorded information about their controlled land for a basis 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. Since then, cadastral systems have been used as important tools for urban planning and service delivery. This gave rise to the formal definition of the cadastral system.

The International Federation of Surveyors (FIG) recently proclaimed that the modern cadastral system by definition is a parcel based land information system containing records of interests in land and is closely aligned with the operations of land markets (Kaufman 1998). The modern cadastral system has also became 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 systems have concentrated on certainty and security in land tenure (Williamson 1997).

The modern cadastral system is made up of the cadastral map and the associated registers. Both of these entities represent the graphical and the textual component of the cadastral system. With the modern cadastral system continually evolving to meet the demand of the land market, other land information databases containing information such as planning control and the land-value assessment are being progressively added onto the modern cadastral system. Together with the geodetic, topographic and road networks, the modern cadastral system is providing crucial and overall situation relating to land.

This modern cadastral system is a step towards the Multi-Purpose Cadastre concept. Kaufman defined a Multi-Purpose Cadastre as a "methodically arranged public inventory of data concerning all legal land objects in a certain country or district, based on a survey of their boundaries" (Kaufman 1998). The Multi-Purpose Cadastre is an extension of the modern cadastre to include other land information registers. These registers might include databases with planning and valuation information. In Figure 1, a Multi-Purpose Cadastre (MPC) is expected to serve more than its original purpose of primarily serving the land market.

BENEFITS OF THE MULTI-PURPOSE CADASTRE

With the FIG and many government agencies expressing their interest to release their registers, map series and databases to the greatest extent possible, the creation of an MPC will be a welcoming effort by many. With most land information being produced by government authorities, the development of the MPC will be largely dependant on the commitment and contribution from these authorities. The MPC is envisaged to benefit a range of potential users such as federal, state and local governments, private firms, individual, academia and regional bodies.
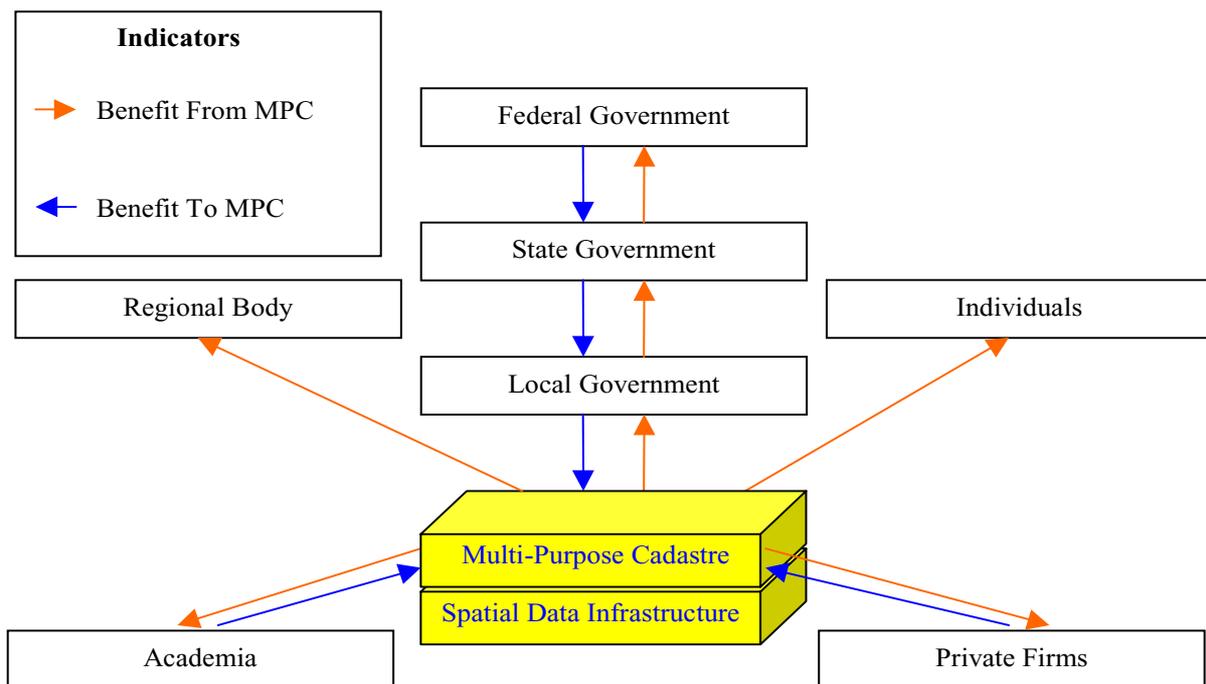
Figure 1: Benefits of the Multi-Purpose Cadastre

Federal governments are the roots of any national administration of land and other resources. Through an 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.

State governments are the mechanisms for the administration of state affairs, regulations and interests. 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.

The Panel on Multi-Purpose Cadastre Committee suggested that one of the biggest users of MPC would be local governments (Panel on a Multipurpose Cadastre 1983). This is because anMPC 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-information using a MPC. Higher accuracy data when needed, is available through existing connectivity with other geo-information repositories. The production of new themes or datasets 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 map systems and land information.

Private sectors will also benefit from the MPC through efforts such as the production of standard and regulations, sharing of themes and datasets and large-scale maps, amongst others. Most importantly, the private sector will benefit from the manner in which the MPC will speed up administrative actions and reduced 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 whole of community. Academic institutions will continue to contribute through extensive research and education into areas such as human interaction with the MPC, feasibility studies and the data transfer formats.

Individuals as the end-users would greatly benefit from efficient delivery of geo-information. The MPC will allow members of the public better access to geo-information than ever before. Faster access to records affecting individual rights, such as planning control, native title and land title issues could be achieved. The MPC is also expected to clarify minor boundary disputes through simultaneous access to planning, cadastral, title and customary land title databases. Ultimately, the public's attitude towards the administration of local governments programs may improve.

The MPC could also benefit regional institutions such as European Umbrella Organisation for Geographic Information (EUROGI) and Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). Regional institutions strive on the collaboration of their member nations on matters that extend beyond their respective national boundaries (European Umbrella Organisation for Geographic Information 2000), (Holland 1998). Regional disasters such as the forest fires and oil spills would greatly benefit from a MPC as countries require greater use of national data. Furthermore, the implementation of SDI will be particularly evident when member nations could share themes, datasets and information through a MPC.

## IMPACTS OF THE WORLD WIDE WEB AND CADASTRE 2014

The introduction of the Internet has brought profound impacts to many industries and professions of today. In Australia, the proportions of Internet users has tripled over the past 3 years, when only 14% are using the Internet. Roughly 71% of Australian professionals, business owners and managers have access to the Internet (Roy Morgan Research 2000). The Internet has allowed computers across the world to be connected simply through household and dedicated communication lines. The Internet has allowed people across the world to communicate using Electronic Mail, transfer files using the File Transfer Protocol and chat using the Internet Relay Chat network. Nevertheless, it was the World Wide Web that brought fame to the Internet. The web is made up of web or HTTP (Hypertext Transfer Protocol) servers that reside on Internet machines and publish static documents, maps, applications and databases of information through a standard definition language called the Hypertext Markup Language (HTML). To view HTML, Internet users use a universal client: the browser. The browser allows the visualisation of the HTML pages sent by the HTTP servers. The two most popular browsers: Netscape Navigator and Microsoft Internet Explorer cater for most of the popular operating environment in the market. Evidently, the Internet is being used as a source of information and communication.

The web has also allowed information on spatial databases to be joined and manipulated through web-based GIS / mapping tools. Software developers such as ESRI, Intergraph and MapInfo have recently introduced software and plug-ins that deliver GIS and mapping functionality across the web. A plug-in allows the extension of browser features, by enabling it to perform functions such as pan and zoom. Plug-ins are specifically designed for a given browser and therefore evolves with it. Recently introduced software incorporate the Component Object Model (COM) that permits the operations of traditional GIS / mapping software to be distributed across networks and the Internet. Current COM architectures such as DCOM / ActiveX and CORBA (Common Object Request Broker Architecture) have adopted the front-end, middleware and back-end component concept. The concept allows Internet users and their browsers (the front-end) to view and execute applications and databases (the back-end) through web- servers (the middleware). Such architectures are aimed at solving the limitation of the organisational client/server architecture used whilst adopting the web as the medium of information delivery.

The visions of a future MPC have not only been driven by technology but have been supported by the FIG. The FIG has published *Cadastre 2014*, a document that contains the development of future cadastral systems (Kaufman, 1998). Cadastre 2014 argued that by the year 2014, cadastral systems will show the complete legal situation on land, including all of the rights, restrictions and responsibilities. The separations between maps and registers will be abolished while traditional cadastral mapping will be replaced by modeling. The paper and pencil cadastre will have gone and been replaced by systems that will be based on cost recovery. Future cadastral systems will also be highly privatized.

The signs toward the building of the future MPC are already visible. Already, initiatives such as the Open GIS Consortium and the Australian World Wide Web Mapping Consortium (AWWWMC) are adopting Internet technologies such as HTML, DCOM and CORBA to aggregate cadastral systems with other registers (Open GIS Consortium 2000). Worldwide government initiatives in building online cadastral systems are rapidly meeting the demand for geo-information. This was proven by a recent review of eleven online cadastral systems in 1999 by the author (Abdul Majid 1999). The review concluded that even though these systems were built for the web, there exists unique features that suggest the appropriateness in the use of technology in delivering geo-information. The features include:

- Integration of the cadastre. The reviewed online cadastral systems feature the seamless integration of the cadastral map and the title register. In reality, databases containing the cadastral map and title registry usually reside on separate databases in the same institution or in separate institutions all together.

- Breadth of information. Apart from the cadastral map and title register, other datasets that are regularly found in these systems include building footprints, zoning or land use, contour details and land-value assessment data.

- GIS functionality (by placing one layer of information on top of another). Each of the systems provides interfaces to allow Internet users to include the layers directly onto the cadastral map or as tabular information linked to a register. This is usually done through choosing the datasets through interfaces on the web.

- Database layout. The physical distribution of the databases in these systems plays an important role in the performance of an online cadastral system. The review found that the topology of the databases was grouped as either centralized or distributed. Centralised databases are ideal in systems with a fixed quantity of datasets and are easier to manage whilst use fewer resources. On the other hand, distributed databases are ideal for the expanding system. As the datasets grow in number, the storage space is simply increased to meet the demand without interfering with other agencies.
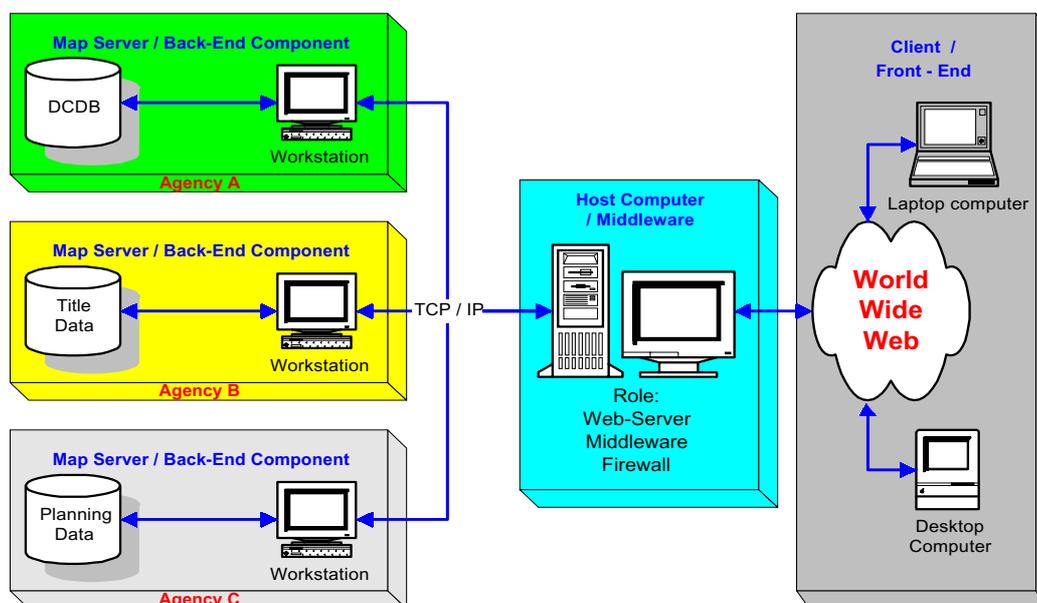
Figure 2: The components of the Victorian Land Information System concept prototype. URL: http://geogps.sli.unimelb.edu.au

In addition, the digital nature of modern cadastral systems has made the aggregation attractive and simplistic. The paradigm shift from a centralised architecture where the computer is merely a non-intelligent terminal accessing a mainframe to household computers as integral component of a distributed computing architecture served by web-servers is propelling the demand for digital geo-information. Jurisdiction wise, the separation between maps and related databases are being broken down through amalgamations of land related agencies such the recent joining of the Surveyor-General, Value-General and the Registrar-General in Victoria, (Natural Resources and Environment State Goverment of Victoria 1999). What more, concepts such as digital lodgments of cadastral data, E-Commerce and digital signatures are encouraging cost recovery and paving the way for a successful and privatised Multi-Purpose Cadastre.

DEVELOPMENT OF A MULTI-PURPOSE CADASTRE PROTOTYPE

The anticipated benefits of the MPC, the impacts of the web, the directions of Cadastre 2014 and the rapid developments of online cadastral systems have all suggested that the MPC will be an important tool for the use and delivery of geo-information for the future. However, there needs to be proper technical awareness of the creation of a MPC. As a result, the Victorian Land Information System (VLIS) was developed as a prototype in an effort to document technical issues and understanding of a future MPC. VLIS is made up of 3 components (see Figure 2). These components are:

- The back end. The back-end is served by six personal computers, running ODBC-compliant databases containing records of land-owners and parcels. ESRI Shapefiles were used to visualise the cadastral maps.

- The middleware. The middleware was built on a Microsoft NT platform for better management of application memory and client requests from the Internet. MapObjects, Visual Basic, Active Server Pages (ASP), JavaScript and Java were used to build the middleware application. All client requests from the Internet is managed by the HTTP server. Within the server, dynamic link libraries (DLL) extensions coordinate features such as load balancing, request monitoring and client requests for maps and database updates.

- The front-end. The front-end consist of a 'thin-client' where the client uses a browser to view results and data that have been processed by the back-end.
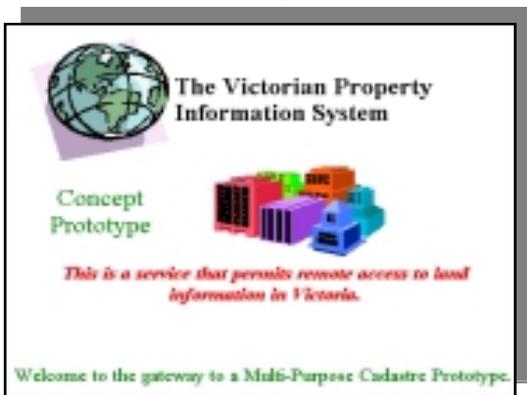

Figure 3: Login screen and gateway to the prototype prototype
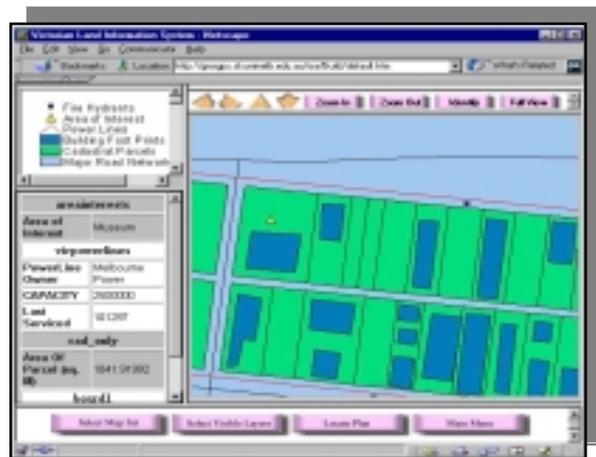

Figure 4: Querying the cadastre and its related activities

Figure 3 shows the welcome screen and the gateway to VLIS. Developed by the author, VLIS offers services that permit browsing of cadastral, title and census data through a central portal site. VLIS also provides searching of title, valuation and native title information (see Figure 4). Internet users are also able to update the title and the valuation registers whilst submitting plans to a central database (see Figure 5). A basic over the counter sale of maps and plans through an E-Commerce facility is also provided as a mechanism of cost recovery. All of these services are provided behind a firewall where authorised logins are required.

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:
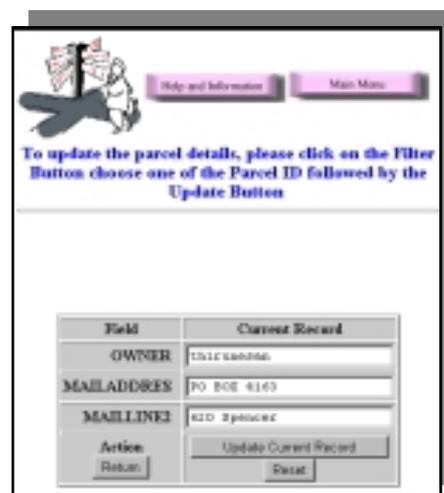

Figure 5: Title and Valuation Updating on the World Wide

- The back-end component is affected by issues such as data storage and format.

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

- The front-end component is affected by the data delivery and client issues.

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 2000). 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 utilises the Application Programming Interfaces (APIs) ensures 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-information. With the market for 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-information of different formats together. With each format having particular strengths and weaknesses, it is difficult to negotiate a common format for all geo-information producers and users to adopt. Fortunately, software developers are producing software that includes translators or converters that conveniently converts 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 that was originally conceived. Ideally, the process of converting one format to another preserves the shape, accuracy and content of the data. Thus, solving data format issues is imperitive in building a future MPC.

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

DATA DELIVERY AND CLIENT

Data delivery issue addresses the use of technologies in programming languages and front-end interfaces for data integration and delivery. Data integration concerns with the overall integration between the graphical and the textual components of the system. This is mainly attributed to the distinguishable nature of the two components. The graphical components are data containing maps and diagrams which can be placed on top of another to simulate the typical GIS operations. The textual components on the other hand are textual records of information that may contain names and street address that requires the use of SQL to extract the appropriate records. No doubt, integrating the right records with its graphical entity has been a challenge in data integration for VLIS. Solutions to this problem were either to link the parcel ID from both the textual records and the look-up table of the cadastral maps or include the use of real-world coordinates that are homogeneous across themes

and registers. Either of the solutions form a one-to-one unique relationship between the physical location of the parcel and its register of records.

VLIS is hoped to present clients with a one-stop dynamic geo-information repository. Unfortunately client expectations could then be very high thus leading to misunderstanding and over-emphasise of the data. There should be mechanisms in guiding clients in understanding the limitations of the data and the delivery of the data to them. Therefore the role of *web portal sites* such as the VLIS plays the important role as a starting web-site for users when they get connected to the web. A portal site is intended to preserve the style of its contents for greater understanding and awareness of the information presented. Ultimately, the future of geo-information delivery will have to be within *web portal sites* where geo-information are concise and unambiguous.

FUTURE OUTLOOK

The development of VLIS is one of many geo-information delivery systems that are built around the world to better serve geo-information in an improved, more meaningful and accessible nature. No doubt, most of the current cadastral systems and certainly future systems will be turning to the Internet and the web as an alternative medium of information repository and delivery. The signs are clear with efforts such as the Open GIS Consortium, the Australian Spatial Data Directory and spatial software that are encouraging geo-information sharing and open-architectures.

Geo-information, whether it is cadastral, title or environmental are being pushed to the limit by advanced processing power that current hardware and software are providing. Already, society is being bombarded with imagery from the Mars terrain, complex 3-D models of the earth and Multi-Purpose Cadastre for all land management needs. Other factors such as the use of sophisticated Symmetric Multiprocessor Computers, client and server side scripting and Component Object Models are significantly contributing to the way society will use and view geo-information.

Maps are no longer seen as static pieces of paper with outdated information. The web is catering for dynamic and interactive digital maps that are generated in real time by sophisticated systems that connect isolated databases and features together. Maps of combined themes and layers can now be generated within seconds and enhanced with imageries and related textual details. What more, the web has introduced the concept of *portal sites* where geo-information of the future will be presented in a concise and unambiguous manner.

The past century has brought tremendous changes in the way society view geo-information and this century will certainly be an exciting period for geo-information and to those who is willing to harness it.

CONCLUSION

This paper is part of an on-going research into the evolvement of the traditional cadastral system in recent years. The modern cadastral system has been greatly impacted by the World Wide Web and the global demands for integration and rationalization of title registers and cadastral systems with other related registers. The FIG noted in Cadastre 2014 that such modern cadastral system is becoming a Multi-Purpose Cadastre (MPC).

The move towards the MPC concept was apparent through the review of eleven online cadastral systems around the world by the author. The review noted that even though the systems reviewed were different in many ways, these systems have used the web and the latest information technology to deliver geo-information across the world. Nonetheless, little documentation exists in the understanding of building a MPC. There still remains a number of technical issues that needs to be understood and addressed.

To achieve this, the Victorian Land Information System (VLIS) prototype was developed by the author. VLIS is a portal site on the web that allows distributed geo-information databases to be integrated and served to the public. Through VLIS, the technical issues that affect the storage, management, processing and delivery of geo-information over the web were analysed and documented.

ACKNOWLEDGEMENT

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