Cadastre 2.0 – A technology vision for the cadastre of the future

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SUMMARY

It is generally accepted that a well functioning cadastre is essential for securing rights in land and property, wealth creation, and contributing to better land and environmental management. And yet there are only around forty countries in the world where their cadastral systems can be described as ‘well functioning’. There are a number of reasons for this including, institutional inertia, inadequate and inappropriate legislation, poor leadership and badly designed land information systems.

A fresh approach is required and one in which technology can be an important enabler. In this paper, the authors will present the main technical components of a cadastral system for the future – Cadastre 2.0. Such a system will be:

- ‘multi-purpose’, meeting a wide range of needs beyond simply recording land ownership or defining parcels for taxation;
- support incremental quality improvement of data to allow for more cost effective and faster implementation;
- enable the full spectrum of rights and parcel definitions to be modelled and managed within the system, consistent with the LADM and STDM standards;
- encourage citizen engagement and greater transparency and accountability to generate more trust and support for the cadastral system;
- truly 3-D, better reflecting the real world of overlapping rights, the registration of utilities or multi-level properties;
- allow for multiple implementation patterns, including mobile and cloud based, and easy to implement and use Apps which will maximise the use and value of the land information; and,
- the platform for a nation’s SDI, providing the basis for more effective integration of a wide variety of land and geographic information to better address many of the challenges facing the world today and in the future such as poverty, rapid urbanisation, environmental disasters etc.

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1. INTRODUCTION

It is generally accepted that a well functioning cadastre is essential for securing rights in land and property, wealth creation, and contributing to better land and environmental management. And yet there are only around forty countries in the world where their cadastral systems can be described as ‘well functioning’. There are a number of reasons for this including, institutional inertia, inadequate and inappropriate legislation, poor leadership and badly designed land information systems.

Technology is changing rapidly, and the rate of change will continue to increase. The rate of change far exceeds our institutions’ traditional adoption rate of new technology. These new technologies provide new, exciting methodologies for data collection, analysis, sharing and use. These new capabilities advance our abilities to maintain and publish current data while maintaining a rigorous historic record of how the same data has changed.

This paper explores how these exciting advances in Geographical Information System (GIS) technology can be applied to the next generation of cadastral systems – Cadastre 2.0 – that will be better able to meet the challenges of today and tomorrow.

2. MULTIPURPOSE

We face many societal challenges, from environmental degradation, rapid (and in many cases uncontrolled) urbanization, natural disasters to economic recession and unacceptably high levels of poverty. This places additional requirements on cadastral agencies to respond with information products and services that can serve these wider needs. Leveraging new technology in the ‘multi-purpose’ environment to meet a wide and growing range of needs moves beyond simply recording land ownership or defining parcels for taxation. Uses include analyzing land use; managing new and sustainable development; developing and deploying revenue systems that are transparent, fair and equitable; and integrating all available land and geographic information for building reliable decision support systems. Geographic Information Systems (GIS) is at the core of multi-purpose cadastral systems.

3. DATA IMPROVEMENT

Cadastral agencies are faced with a continual challenge to maintain and improve the quality of their data. Data quality embraces many different aspects of ‘fitness for purpose’ including positional accuracy of cadastral parcels, currency (speed with which changes in the real world are reflected in the database), and semantic accuracy (correct attribution of objects, for example land cover or land use classification). This is an area where technology has provided many new tools in ongoing data improvement.

There are many new and rapidly evolving geographic data collection tools. The quality of satellite imagery is rapidly increasing. Lidar delivers rapid collection of digital terrain models. Nearly everyone has a cellular telephone, of which many are enabled with smart operating systems such as Android. These tools add to the maintenance of land and geographic data.

These systems provide tools to leverage new data types and collection techniques in an integrated, multi-user system. In Esri's ArcGIS it is possible to integrate and manage survey accurate cadastral data – as a parcel fabric – with other layers of land and geographic information. The quality of the cadastral data can be incrementally improved as new data is added using higher precision surveying techniques, and the other layers adjusted to fit the cadastral base. Leveraging the new technology capabilities for collecting and maintain data, and building workflows that incrementally improve data with normal work, provides a framework for an evolving system that manages and distributes current and accurate information for many uses, or 'multi-purpose' needs. Incremental data improvement enables more cost effective and faster implementation.

4. CONTINUUM OF RIGHTS

The concept of incremental improvement can also be applied to registering land and property. Recent work by UN-HABITAT on the Continuum of Rights demonstrates the value of a pragmatic approach to secure tenure as it exists first, and then work to enhance and improve individual land rights, moving land holders along the continuum of rights or survey accuracy. UN-HABITAT, recognizing the diverse number of academic approaches and practical implementations, has supported the development of a new data (reference model) standard for land administration - the Land Administration Domain Model (LADM) - and a specialization of this model, the Social Tenure Domain Model (STDM). These standards recognize different forms of tenure lesser than freehold, for example allowing for overlapping rights and customary use of land. Cadastre 2.0 recognizes data standards and helps build consistent delivery mechanisms and lower cost land administration system implementations leveraging the broad services environment and utilizing commercial off-the-shelf software (COTS) solutions.

International standards help the implementation COTS solutions by allowing research from the academic community to be shared and implemented by many service and software providers from the private sector. These standards allow for many applications to be built on a single data model eliminating costly duplicated efforts and difficult to support software customization. COTS is particularly important in developing economies that lack technical capacity and technical support structures without which implementations are destined to fail. Cadastre 2.0 employs such standards and builds flexible systems that can easily evolve and take full advantage of new technology applications as they are integrated into COTS solutions.

5. CITIZEN ENGAGEMENT

Along with evolving land administration system technology, also evolving is technology in the hands of the citizen. Smart phones, GPS, internet connectivity and mapping capabilities are available all around the globe. Developing economies have had an extremely rapid uptake of cellular phones because of the return they immediately provide. With simple tools coupled with cellular phones, new mapping services such as OpenStreetMap (OSM) have become a valuable mapping tool to many countries. These have led to new ways to collect data, maintain its currency, and correct errors. Can citizen engagement make a greater contribution to land administration systems?

This availability of simple technology could provide information back into the land administration systems, but it also provides new methods of transparency and accountability. Transparency and accountability are critical for citizens to trust cadastral systems. Transparent information on ownership, value and tax is critical for the demonstration of fair and equitable taxation. Transparent information on transfer is important for accountable government stewardship of land and its information. Cadastre 2.0 takes full advantage of information provided from the citizen and provides information ownership, transfer, use, value and tax in easy to use formats that can be used on many devices.

6. BETTER MODELLING OF THE REAL WORLD

The rate of data accumulation continues to grow. There is no end in sight on the collection and accumulation of land and geographic data. Lidar, aerial photogrammetry, satellite imagery, survey, laser scanning, mobile mapping, and citizen collected information are among the types of geographic data that are used in land information systems. With this vast amount of information, new capabilities in Cadastre 2.0 of managing real three dimensional (3D) rights and usage, utility location and easements are employed. Compatible data models in land administration systems that leverage geographic location support the integration, sharing and use of this accumulating data.

Today more than half the world's population lives in urban areas and the pace of urbanization is increasing rapidly. By 2050, it is anticipated that seventy five percent of the world's population will live in urban centers. This calls for technology to model urban use and new forms of ownership.

3D cadastre is necessary to display and manage complex spatial relationships. To support a full 3D cadastral implementation, object boundary definitions, object topologies and their legal representations will have to be further defined. A hybrid approach combining 2D and 3D using GIS represents a feasible, economical and extensible approach (Bjornsson, C & Land, N).

Leveraging 3D capabilities from our past experience with underground transportation systems, mineral rights management (both leasehold and freehold), and strata title, we have the technology capabilities to better model, present, manage and visualize 3D ownership systems. Cadastre 2.0 takes full advantage of our past learning and incorporates into land administration systems a priori with a full understanding of the needs of the urbanizing world.

The challenge for Cadastre 2.0 is not technical therefore, but requires a better understanding of the 'real' need and associated legislative changes.

7. ONE SIZE NO LONGER FITS ALL

Technology has moved beyond client/server technology. Utilizing modern computing platforms and technology in the hands of the common citizen (cellular phones), Cadastre 2.0 allows for a wide variety and flexible implementation patterns. Although counterintuitive, cloud computing will deliver vast capabilities to developing economies. Technology capacity required for land administration system implementation is greatly reduced; programmers are not needed to support custom implementations, information technology (IT) staff is greatly reduced, and computing devices become simpler and less expensive.

The cloud assists with managing vast amounts of land and geographic data and with the elastic computing power, enables complex spatial analysis for core land administration functions such as land use analysis and development planning. Utilizing cloud computing capabilities requires an Internet enabled device, but essentially no computing power on that device.

The cloud delivers more than computing power and data storage. It enables users with simple devices (cellular phones and tablet computers) to access and use this data in a variety of new uses. It enables new citizen empowered capabilities such as addressing with cellular phones, mapping paths and mapping service access points that can be in turn shared with any other casual citizen user. With open standards, simple devices, and the cloud, Cadastre 2.0 enables the development and use of simple applications (Apps) to maximize the use and value of land information.

8. SPATIAL DATA INFRASTRUCTURE

Cadastral information is the core of spatial data infrastructure (SDI). Cadastre 2.0 provides the basis for effective integration of a nation's land and geographic information. The challenges of developing economies are many – poverty, food security, urbanization, natural disasters, natural resource management, land grabbing, access to potable water to name a few.

SDI provides the framework within which land and geographic information can be better managed and shared. The distinction between 'survey', 'land' and 'geographic' information becomes blurred and an almost academic debate. The cadastral parcel as a key underpinning layer of the SDI allows all decisions to be related to an individual (the owner) and the value, use and restrictions on any piece of land and property. Cadastre 2.0 will be fully integrated in a nations' SDI.

9. CADASTRE 2.0

In conclusion, Cadastre 2.0 takes advantage of many new technologies utilizing our learning and experience from the past. It recognizes the unique land tenure situation in each individual country/territory/region and allows for implementation that is sensitive to, and embraces cultural difference. Cadastre 2.0 is not a 'hard coded' system, but a flexible, configured system that allows for use of new technology as it becomes available. Relying on international data standards, commercial off-the-shelf software, the cloud, as well as open data provided by governments, the private sector, and citizens, Cadastre 2.0 provides the framework and capabilities to meet the land administration challenges of today and tomorrow.

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BIOGRAPHICAL NOTES

Brent Jones is a licensed professional land surveyor and engineer. He has worked in surveying, civil engineering, and building GIS systems for a wide variety of organizations. He is past president of the Geospatial Information and Technology Association (GITA) and is on the board of directors of the Open Design Alliance (ODA). He currently leads the industry group in land administration at Esri.

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