Massive Collection of Cadastral Data in Greece Using Web-enabled GIS Technologies

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Key words: Cadastre, Web services, applications, GIS, data collection

SUMMARY

Ktimatologio S.A. is in charge of creating and operating the Cadastre in Greece. Ever since 2003, cadastre operates in many remote offices based on software developed and maintained by the IT department of Ktimatologio S.A. In 2008 Ktimatologio S.A. managed to collect about 6.5 million rights of 2.5 million citizens with the use of web enabled technologies and thin clients all over Greece, combining spatial and non-spatial components. In order to support the declaration, a high-availability, powerful and secure centralized infrastructure was implemented. The collection was possible in two ways: a) inside 75 rights' collection offices with more than 2000 dedicated professional users b) through internet, which was chosen by almost 100.000 citizens.

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1. INTRODUCTION

Ktimatologio S.A. is responsible for the creation and management of cadastral information in Greece. It is a private company that is funded by the Greek State.

Cadastre is in its first steps in Greece and having begun with its first municipality in 2003, it already covers 15% of estimated total information of registrable rights in Greece in 335 municipalities. Furthermore, during 2008, another 15% of total estimated information was gathered. This applies to 107 more urban municipalities of Greece. The majority of the country municipalities, though, (i.e. circa 5.330 out of 5.770), still follows a 19th century deed-based registration system with poor or nil accompanying spatial information.

Cadastre in Greece is digital. Thus, digital technologies are used to store and diffuse information. In only a few years, great steps have been made towards the digital era including services for citizens, professionals and the private or public sector.

Creation of more digital web-based services is also in progress to accelerate establishment of cadastre in more areas and to ease land transactions and environmental planning activities in Greece.

2. MAJOR DIGITAL CADASTRE PROJECTS

There are two major projects running in parallel for the Greek Cadastre. One is the maintenance of the existing information system which serves the land transactions in 335 municipalities and the second is the collection of cadastral information in new areas, including the 107 new municipalities of 2008.

2.1 Operating Cadastre

2.1.1 Overview

'Operating Cadastre', as the information system is called to distinguish from the procedure of collecting data of new areas, provides all the necessary functionality, in order to allow transactions and modifications upon cadastral information, through web-enabled applications available in the Cadastral Offices. The system is a centralised n-tier system. In contrast to descriptive legal data, which is updated locally, spatial information is being updated centrally. This choice is made since the majority of the offices have only a few spatial changes per month and it would be a waste of money to hire employees in each Cadastral Office for this purpose.

2.1.2 System functionality and architecture

Each Cadastral Office has access to the spatial information through a web application. This application includes tools for navigating, selecting and updating, in some cases, the spatial information. The Cadastral Office, for example, can create through this web application the new geometry of the parcel as it is described in a new deed and can also send it for approval to the central agency of Ktimatologio SA. The agency can then use this

geometry to update the spatial information centrally or can approve the proposed spatial change and update it automatically to the system.

All the necessary reports and certificates that are being produced by the system are dynamically created on-line in the Cadastral Offices and the central agency upon request, thus providing up-to-date information regarding either spatial of descriptive information. Web services responsible for the creation of cadastral diagram extracts are part of the applications supporting working cadastre.

The descriptive data management applications are based on Microsoft's .Net technology and the spatial data management applications are based on ESRI ArcIMS, ASP, Javascript and Arc Objects.

All the web applications are provided to the Cadastral offices through low-cost secure VPN connections over the Internet.

All data (both GIS and descriptive) is stored in a central database which at the moment is ORACLE 9.2 but will soon be updated at ORACLE 10g.

A schematic diagram of the architecture of the above system can be seen in Figure 1:

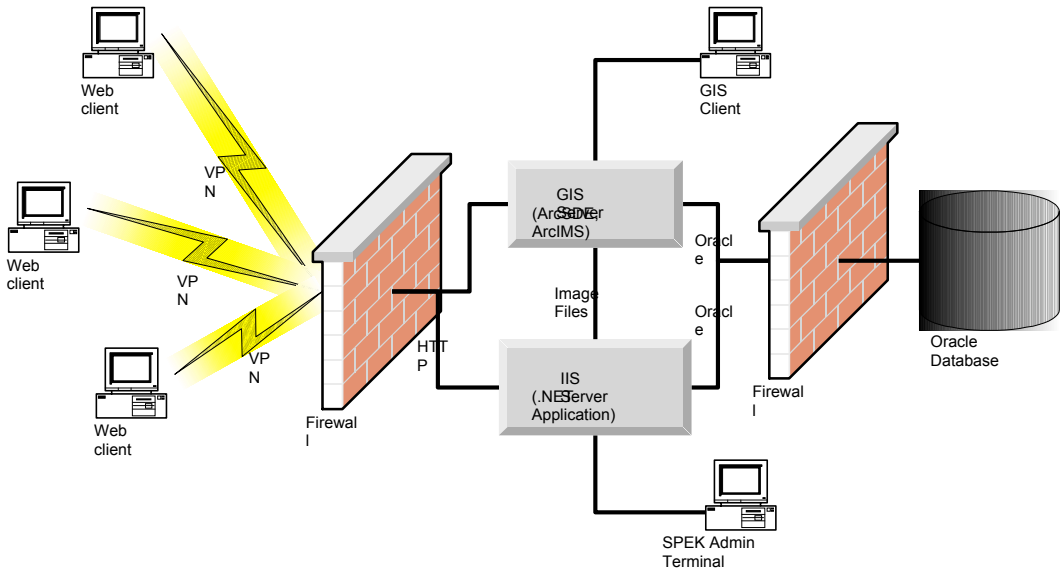

Figure 1: Operating cadastre architecture

The central service responsible for the update of the spatial information uses a customized version of ESRI ArcGIS, based on ESRI Arc Objects application, which provides all the necessary functionality, security and logging that this kind of data requires. One of the main features of the these applications is the use of wizard-based screens that protect the system from human mistakes, provide a common, homogeneous way of dealing with spatial changes and take the load out of the user for processes that can be automated. Of course logging of each user's actions is essential in order to protect the information and prevent unauthorized usage. In order to access both the spatial and descriptive applications, the users' rights are controlled through credentials that are linked to specific roles, thus allowing the user to perform only the actions that are applicable to his role.

All software developed or customized was developed in-house by the IT Division of Ktimatologio S.A. and counts more than 300.000 lines of source code.

2.1.3 Metrics of the system

The system has more than 700 users. It has already served more than 1 million new land transactions and more than 40.000 spatial changes. It hosts data for more than 2 million right owners, 1.8 million parcels, 1.5 million apartments, 900.000 addresses, 4.8 million documents and 6.7 million rights.

2.2 Collection of cadastral Information in new areas

2.2.1 Overview

The expansion of cadastre in new areas was co-funded by Greek state and the EU with 80 million Euros in 2008. The strategic plan had various activities. Two of them were a) the collection and digitisation of legal documents and property information in 107 new areas b) the creation of a modern IT infrastructure to help collection of cadastral information and to assist further development of cadastre in Greece through digital services.

Using the above mentioned infrastructure, which was acquired by the project, Ktimatologio S.A. collected successfully, during second semester of 2008, about 6.7 million rights, covering 107 mainly urban municipalities (cities of Athens and Thessaloniki were the biggest ones among them). The creation of cadastral information was designed as a two-phase approach: during the first phase, the descriptive information was massively collected, along with the deeds that prove each person's property and also a point on a map, which indicated the location of the property on an orthophoto-map. The second phase will begin during 2010 to create unique ids for the properties and also to create the boundaries of the parcels and to bind the descriptive information to those boundaries.

2.2.2 System functionality and architecture

The declarations could be made either by visiting an appropriate Cadastral Declaration Office (CDO) or through the internet from a web application that was created for this purpose. To assist declarations of new rights all systems still remain operational.

Apart from those alternatives, a third stand-alone application was built to assist domestic banks create a database of bulk mortgage data, since the majority of mortgages was logically assumed to be declared by banks.

All the CDOs that were located all over Greece were connected to Ktimatologio S.A. through secured VPN connections provided from the Internet Provider (IP SEC). The software that runs on each CDO was designed and developed by Ktimatologio S.A. personnel providing all the needed functionality for accepting both spatial and descriptive information. The network of CDOs consisted of 80 point across Greece.

On the other hand, the connections between the CDOs and the Ktimatologio S.A. were mostly 2 Mbps ADSL connections, which ensured low costs, but also did not allow for the necessary QoS to ensure very fast data transfers especially of spatial data. The citizens had to pinpoint their property on a basemap, which Ktimatologio had created before the beginning of the project.

At the same time, Ktimatologio could not deliver this basemap freely to the CDOs, which were handled by external contractors, because of legal limitations applied to the basemap. At the same time the CDOs should be able to use them. Bandwidth did not allow transfer of the basemap over the internet. To overcome all those limitations, Ktimatologio SA created its own image format and created clients, which could operate on that basemap, which was stored locally in encrypted format.

Apart from data-related limitations, those clients should also offer basic GIS capabilities, in order to provide the user all the necessary tools (geocoding, editing, attribute search, navigation, DXF overlay, connection with external databases for viewing and querying spatial information etc) that were needed, to allow locating and entering of the approximate position of the property in the system. The system was central and also on-line with all the CDOs.

To fulfil all the above functional requirements, Ktimatologio S.A. developed its own GIS client from scratch based on C++ and .NET. The software operated over the Internet consuming central web services that were developed as well and were based on ESRI's ArcGIS Server. The format through the custom GIS was communicating with the web-services was proprietary and not based on any known standards, because the first priority was to minimize the amount of traffic that was being exchanged between the clients and the servers. A great deal of attention was given to security, which led to a very sophisticated architecture that included application firewalls, reverse proxies, SSL and of course authentication and authorization mechanisms. More specifically, each client call, regarding spatial data, had to pass through a firewall followed by an application firewall, followed by a set of 6 reverse proxies followed by another firewall, followed by a set of 4 web servers acting as SOM (ArcGis server Server Object Manager) that spawned processes on 7 SOCs (ArcGis Server Object Container). Descriptive data followed the same route but used another set of 8 web servers bound together with Microsoft NLB.

The architecture diagram is seen in the following Figure 2:

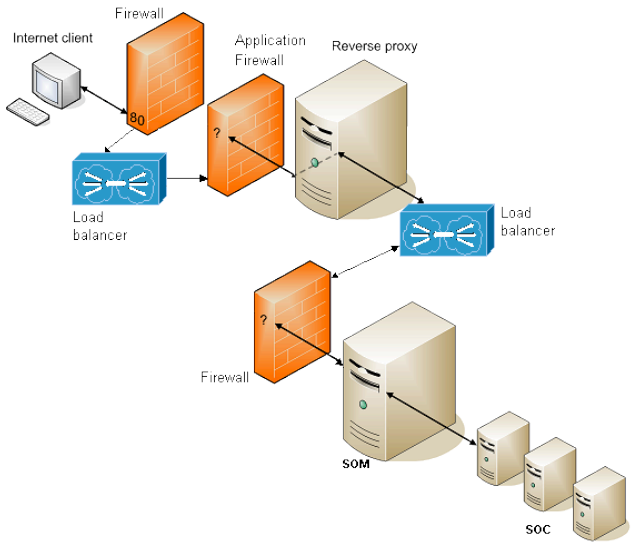

Figure 2: Architectural diagram of cadastral information system for new areas

To fulfil the requirement of declaring properties over the Internet, a portal was created by Ktimatologio SA (see 'References' section). The portal, allowed the users to acquire credentials, log-in, fulfil the declaration form, declare their properties, locate their properties on a map (see Figure 3) and either upload or send by post all the necessary documents in digital or analogue form respectively. To be able to pay for the fee required to fund the project, a credit card paying mechanism was also available. The spatial portal had a common repository with the CDOs infrastructure, since everything was finally stored in the same database. This helped the internet users seeing all the spatial information (points on map that were bound to the address) that was collected at the CDOs. Thus, the Internet user had, in order to locate his property, the option of either querying among the entries that the CDOs had entered, or trying to geocode the address of his property by using the geocoding services that the portal provided. On top of that, the user could also use predefined coordinates of points of interest (e.g. churches) in order to help him locate his property.

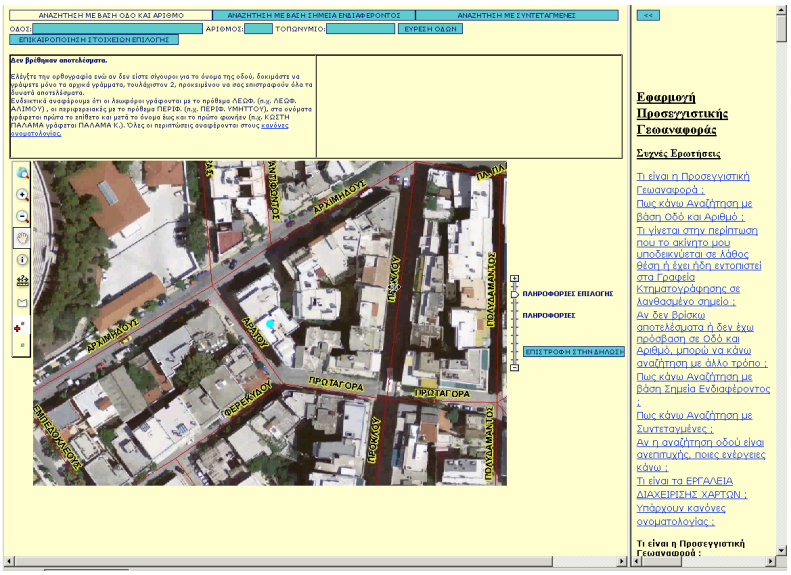

Figure 3: Web-based GIS portal for location of properties

To serve all the above applications –along with the future ones- Ktimatologio SA uses a centralized infrastructure, that is really powerful:

- A high-availability (99.99%) Data Center, connecting through a 100 Mbps line to the Disaster Recovery Center.
- Seventy servers in the primary Data Center and twenty servers in the secondary Data Center, which form clusters at various tiers. Especially the database cluster is an 8-node active-active cluster, one of the biggest installations in southern Europe.
- A high capacity (140TB) storage system in each of the two data centers, which hosts the 5 million scanned documents and all remaining raster data (orthophotos, aerial imagery etc). The storage system is able to expand to 2 petabytes, to host all the

cadastre-related documents and raster data of Greek state in the next 10 years. The corresponding backup systems rely on robotic technology and ensure automation.
- Sophisticated network and security equipment, able to handle thousands of simultaneous connections.
- High-capacity internet line for on-line and VPN services.

The above central infrastructure was designed to ensure availability, security, performance efficiency and scalability. Availability is ensured through redundancy of critical equipment (generators, coolers, UPS, servers, network equipment, storage media etc). Security is ensured using encryption, VPN technologies, net and application firewalls and procedures for controlled access of IT personnel to systems. Performance efficiency and scalability is ensured through powerful commodity hardware in form of clusters, which can easily increase to fulfill increased needs in the future.

It is worth saying, that the whole project was managed and developed by a team of twenty IT staff, including application development and management of system deployment. The amount of source code produced for both descriptive and spatial applications exceeded 1.3 million lines and most of the source code was written in only 6 months from a team of 10 developers.

2.2.3 Metrics of the systems

The CDOs system had more than 2.500 users during peak times in 100 points all-over Greece (80 CDOs and 20 back-offices of external contractors) while some CDOs had more than 100 data entry users. It served more than 3 million declarations of 6 million rights. It hosts data for more than 3 million right beneficiaries, 1 million addresses and 5 million scanned documents with quality that allows for reprinting. The exact number of parcels and properties will be part of the property identification procedure which will begin during this year. The system was able to handle easily more than 6 new rights every second during peak times and it exceeded collection of 140.000 rights in a single day during the same period.

The internet system had more than 100.000 users and helped them declaring more than 140.000 rights.

500.000 more rights were imported from external data media of banks with batch procedures.

3. FURTHER GIS SERVICES

Ktimatologio SA has also developed full custom-made GIS software that allows for internet access to its encrypted basemaps, while providing basic GIS viewing and editing capabilities, as a solution to users not having commercial GIS software, but would like to view the basemap of Ktimatologio S.A. For commercial GIS software special add-ons and extensions have been made (ESRI and AutoDesk), that allow each user to have access to the basemaps. The software is already in use in Greece by public sector companies since 2009.

4. FUTURE PLANS

The future plans of Ktimatologio S.A. include the creation of more web-based GIS and descriptive data services for the citizens and the professionals, which could expose all the data and functionality needed to create an e-Cadastral. Main applications include:

- Services for professionals involved in land market (2010-2011)
- Services for citizens to allow for application of correction of digitisation errors (2011) and public suspension of new areas' data

There is a strong confidence that the web-enabled GIS technology already used will play a key-role in those services as well.

REFERENCES

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BIOGRAPHICAL NOTES

Lefteris Lykouropoulos has a BSc in Physics and postgraduate studies in Computer Science. He is in charge of IT Division of Ktimatologio SA since 2003. His interests include large databases, cadastral applications and ERP-MIS design.

George Mourafetis is a Surveyor Engineer with an MSc in Geoinformatics. He is in charge of the GIS Department since 2003 and is a specialized GIS developer, with interests that cover large-scale web applications of GIS technology and cadastral applications.

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