GIS Cadastre Applications without GIS Software

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Key words: Maps served by Application Servers, Multi-level Transaction Management, Parent and Child Workspaces, Altruistic Locking, Implicit Savepoints

SUMMARY

The applications, which are developed in our days for the use through a GIS, are always correlated with a software company and its technology. This leads to a successful result which is that the technology is in one way "open" to the extension of data and in another way is "closed" to the allocation of the application itself in a broad network of information. This fact limits the possibilities of an interoperated application and GIS functionality in Cadastral Organizations, leading to an expensive cadastral system and limited allocation of information.

This project refers to the development of a new intelligence concerning the technology of GIS. This technology focuses not only on the "open" architecture of data but also on the "open" architecture of applications and functions so that they can be instituted as an independent platform of GIS software. This fact would signal the possibility to distribute data and applications through a broad allocation network (intranet) or a wider (internet) informational society without the existence of GIS software. This leads in utilizing effectively modern technologies to promote good land administration strategies in furtherance of appropriate governance practices to bring about integrated economic, environmental and sustainable development.

The project is based on modern Relational Spatial Database technologies combined with database tools, in order to take advantage of capabilities of modern spatial databases in application sharing and transaction processing. This will result to create spatial relational databases which will function without the existence of GIS software and will provide the ability to function with all the tools of storage, security, analysis, projection and allocation of the spatial and attribute information. This Database schema includes, not only the spatial and descriptive information, but also all the necessary for the function of GIS' databases (symbols, maps, legends) and all the necessary GIS' tools (analysis, security, access, history etc.). Extending a step further the current technology, the proposal demonstrates that existence of GIS software is not necessary for the function of GIS applications but also proves that this new GIS technology, introduces new abilities which are not supported by today GIS, introducing transaction management in multiple levels and "savepoints".

The new technology that is proposed is applied in databases and applications of the National Greek Cadastre so that they can function in a national level without the existence of GIS software. This solution even today has not yet been realized, especially for the spatial database, and it could assist in a more efficient design of the National Greek Cadastral Database.

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1. INTRODUCTION

The technology of the Land Information Systems has been established in the last decade as the total of hardware, software, data, applications and human resources which are applied in an object which can be recorded, saved, analyzed and distribute geographical information of great scale. This information has place and correlation in a certain geographical space. All this information in current platforms of geographic information systems is stored in a Relational Spatial Database.

Today, the information which is the most valuable good in society requires specialized developed tools for its information storage, administration, processing, distribution and security. In our days, the form and the content of the information is such that it possesses a huge amount of space for storage. Terabytes of data (thousands of Gigabytes) defines the amount of a current Database for a classic application in Industry, in Research, in Space Exploration. If someone could think which phenomenon requires such capacities for being recorded then he should think that at the takeoff, the flight and the landing of the space shuttle, terabytes of data are created. Only the data which have been recorded by the Endeavor space shuttle radar during its flight in February 2000 over the earth's atmosphere are 12 terabytes in storage. The data have been stored in a Qualstar TLS-412360 system (31 servers, 85 workstations, 150 clients, 360 films of storage with a total space of storage 36 terabytes compressed). The data have such a big space and demands of storage that the current principles of computer science examine the eventuality how the computer faculty could reach the data and not the reverse, as applies today. Like all informational applications, the applications of Geographical Information Systems (G.I.S.) need to be supported by such tools in order to manage effectively their information.

The modern G.I.S. technology follows the classic model: application – application server – data server. All the data are stored in a relational database, there is an application server that supports multi-user capabilities and of course a (custom) application that interacts between the user and the data. It is common that all classic G.I.S. applications are developed on a specific format of classic G.I.S. software environment. This applies that even if the data stored in a database are "open" for access to all these application, the application itself cannot be distributed through a wide network of users, without the existence of the specific G.I.S. software environment on the client side. This is a very expensive and redundant design of a G.I.S. solution, because the full G.I.S. functionality of a software vendor is way expensive and not required on every client.

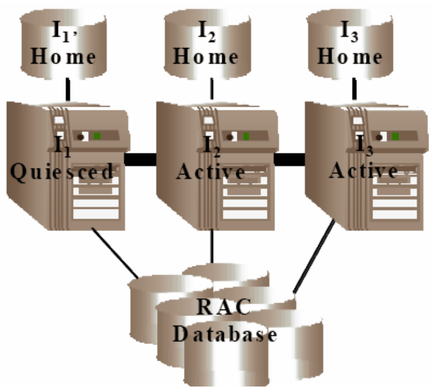
If someone focuses on the modern databases, he should realize that the database core itself can support spatial data and topology serving directly the data as maps through an application server and using metadata stored in the same database schema. It's been a few years that the constructors of database software have tried so that the G.I.S. capabilities and functions could be supported inside the Database Core. Also, the Database's function supports in the Core the classic G.I.S. functions, such as spatial overlay, buffers, Linear Reference Systems, transaction management etc.

It is predictable and logical that the spatial data which are stored in the Databases and support this technology function in great speed, with important benefits of security and integrity. Consequently, in a multi user work environment for very large Databases, those benefits could be fully exploited as all the procedures of G.I.S. would be executed through the Server (native) and not from client G.I.S. workstations. In this case, the amount of data for which a request is executed is not necessary to travel through a network to the client workstation. It can remain on the server side in which a command runs and only the result of the command returns back through the network. But most important benefit is the low budget of the development of such a G.I.S. system for two reasons: a) scalable database depending on the current needs on the server side using RAC technology and b) custom shared applications on the client side served through the application server.

2. DESIGN OF A SCALABLE AND AFFORDABLE DATABASE

The very large databases which store spatial and descriptive data are the most important of all the informational systems. Considering the cost which is related with the development and the function of a very large database of terabytes, the current technology of information examines the way of reducing this cost for the current environments. Other users, who do not have the financial ability for an informative system of this scale, examine how they can achieve the same result: to manage their information which continuously increases in space and demands, escalating the storage areas in multiple informational entities which are in their financial limits.

The technology of Real Application Clustering (RAC) which is applied from the top companies of database software is the solution for the scale of the database with low financial cost. This technology offers three important benefits for the information's storage:



- Scale: the first important benefit is the linear scale and the ability for a continuously diffusion of applications, providing a limitless computational appliance and development in an information system. The whole idea is simple: instead of the use of one big server, many inexpensive servers are used. With the RAC technology, a database could evaluate all the resources of computer power, memory and disk storage from unlimited servers and deal with them as a united informational system.
- Availability: A second benefit is the continuously availability of resources. The generosity of servers which is contained in a raid of an information system which utilizes the RAC technology, ensure that in case one server is set out off line, then the other servers could keep on

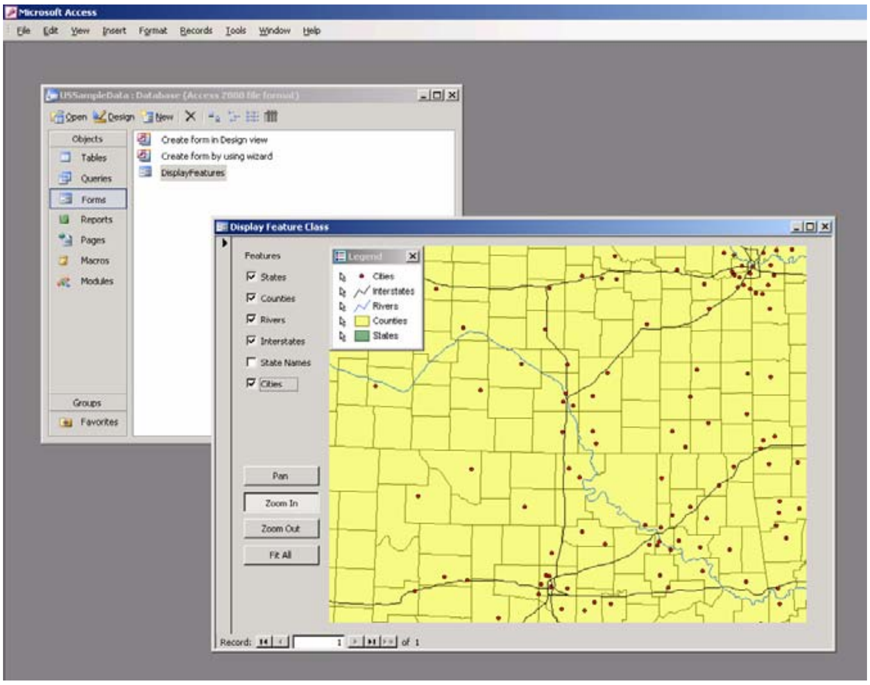
functioning and ensure the application's stability. So, the database operation is not influenced and the users connected in the database and happen to use resources that are set out of function, they keep on working without being disturbed. This procedure would be undertaken by other available resources of this range. What is very important for the data's storage is the fact that the impact in an information system's performance from a malfunction is equal to the loss of the computational power. For an example of a 10 computers range, in case that one of them would be out of function, the database which operates would continue to function with a performance of 9/10. This sounds predictable, but in a database which functions with the technology which is supported on the classical architecture of the non communal availability of resources, the performance will be reduced more in such a case.

- Suppleness: A third benefit is the suppleness in the information system's function which operates with the RAC technology. With RAC technology a database could increase the performance of the raid nodes in two ways: the first way is with the symmetrical allocation of resources in the nodes and the second way is to distribute a different duty at every node. In the first case all nodes share all the tasks of duties in the Database. In the second case they share different tasks. For example, some nodes could be assigned for the procedure of Recovery, Transformation and Loading of Data, while other nodes could be assigned only for the execution of queries in the Database. The current Information System and the applications of producing storage areas of data utilize the two above models in any case, by offering suppleness of operation.

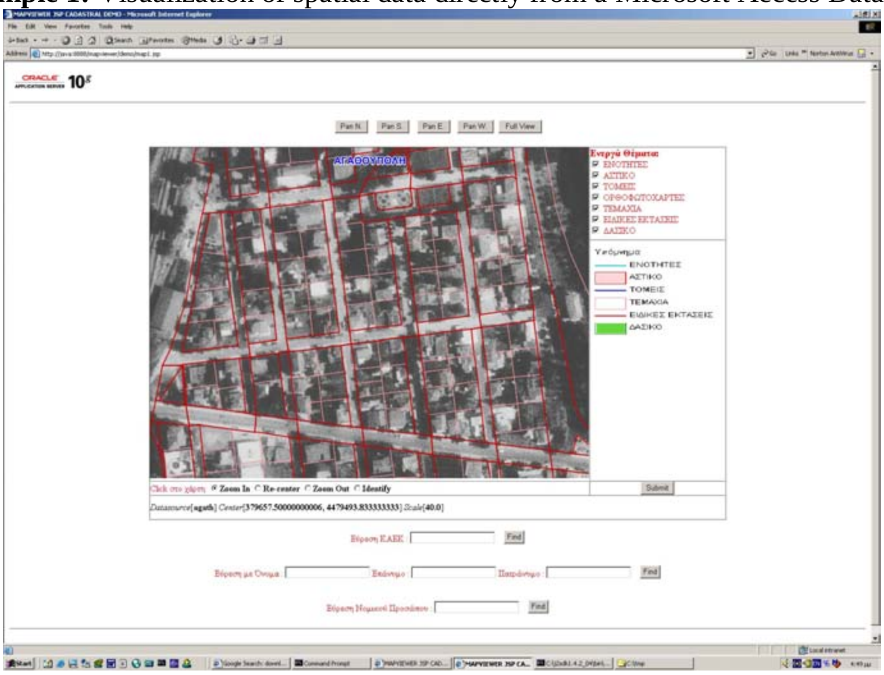
3. DEVELOPMENT OF CUSTOM "OPEN" APPLICATIONS

The applications which are developed in our days for the use through a geographic informational system are always correlated with a software company and its technology. The technology of each G.I.S. software company is special concerning the architecture and its operation, whereas they all can access and process the same data. It can be said that concerning the data, the G.I.S. in their classical form (hardware, particular software, application in the software, data) are "open", but the same does not apply for the applications. In other words, the distribution of a total G.I.S. application is not possible among a wide network of information. The thematic maps, the legend, the analysis tools and generally all the tools of a G.I.S. application are bound to the form that every software company has developed them.

If a new sense is introduced, concerning the technology of the Geographical Informational Systems, that will focus instead on the "open" architecture of the data, to the "open" architecture of the applications and functionality and achieve the independence from the G.I.S. software platform. This fact would mean the ability of the distribution not only of the data but also of the applications through a wide network of distribution in a local level (intranet) or through a wider (internet) informational society, without the existence of G.I.S. software. This proposal could be materialized with the use of modern technologies of Relational Spatial Databases in combination with their own tools, which could make possible the distribution and the allocation of the information through the network. The result is the creation of Relational Spatial Databases which operate installed in a central server and they can allocate not only the information but also the G.I.S. tools which are described and stored in the Database itself. So, data and G.I.S. applications could be served through a network to a client and operate without the existence of G.I.S. software. What is only required is the existence of a web browser. Such a database has the ability to function with all the tools of storage, security, analysis, projection and allocation of the territorial and descriptive information. At the same time, it includes all the necessary for the function of G.I.S. application objects (symbols, maps, keys etc), also the necessary tools (analysis, security, accessibility, historicity, etc). All these are supported inside the Database Core.

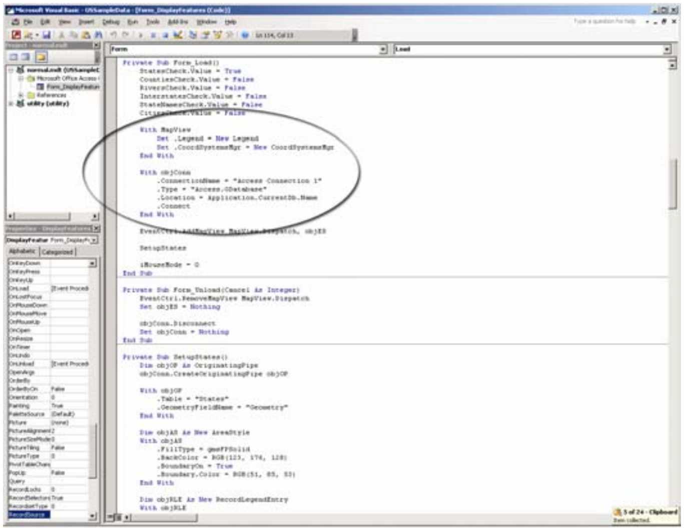


Example 1: Visualization of spatial data directly from a Microsoft Access Database

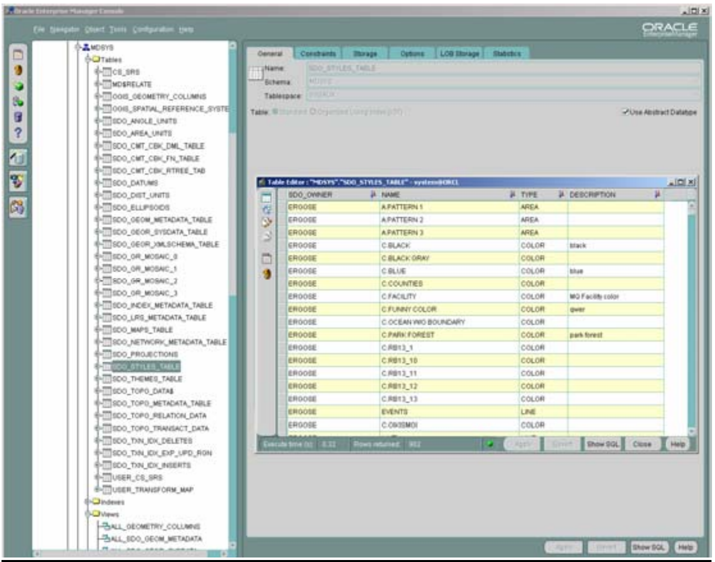


Example 2: Visualization of spatial data directly from an Oracle Database

This Relational Database schema includes all the descriptive and spatial information, all the G.I.S. tools (keys, symbols, tools of enlargement, etc), also all the necessary functions for the operation of a G.I.S. application (finding of a spatial entity from descriptive information, localization of a territorial spot on the map, etc). The most important is that the entire above are saved in the same Database either as data or as metadata in a table. For example, the information for the definition of a symbol of the G.I.S. map is stored as metadata in a database table, so that it could be evaluated through a network of computers, without the existence of third programs and applications. Thereby, with the network exchange of information, what could be transferred is beyond the data, the function of a G.I.S. application, as the application itself.



Visualization of spatial data directly from a Microsoft Access Database is done by defining symbols inside the database core using code



Visualization of spatial data directly from an Oracle Database is done by defining metadata inside the database core

4. GREEK CADASTRAL ORGANIZATION L.I.S.

It is believed that the choice of such a technology from Organizations who deal with very large data sets is the only way so that they can function effectively by using at the utmost the abilities of the current technology. Such an Organization is the Greek Cadastral Organization (Ktimatologio S.A.). When the Cadastre would be completed at the phase of the on-line operation, it would have to fulfill the needs of a L.I.S. with the abilities of storage, processing, administrating and analyzing 33 million of titles concerning real estate in a geographical area of 131.6 thousand square kilometers. The total of the descriptive and spatial information would be at the size of terabytes and in any case the principles of designing the Cadastral L.I.S. would have to follow up the above theories, in order to be successful in its operation. Another important factor is the ability of a successful and effective operation of the System on a national level. For this reason, the technology's application of Cadastre's L.I.S. would have to fulfill not only the "open" form of data but also the "open" form of the application. The main reason for this purpose is the exploitation of database technologies which have not yet been exploited by the tools of G.I.S. software. Besides, it has to be referred that the obtainment of independence at the client workstations by a certain G.I.S. software of the market for the total of hundreds Cadastral local offices which will operate, they will decrease significantly the cost of the installation and operation of the Cadastral L.I.S.

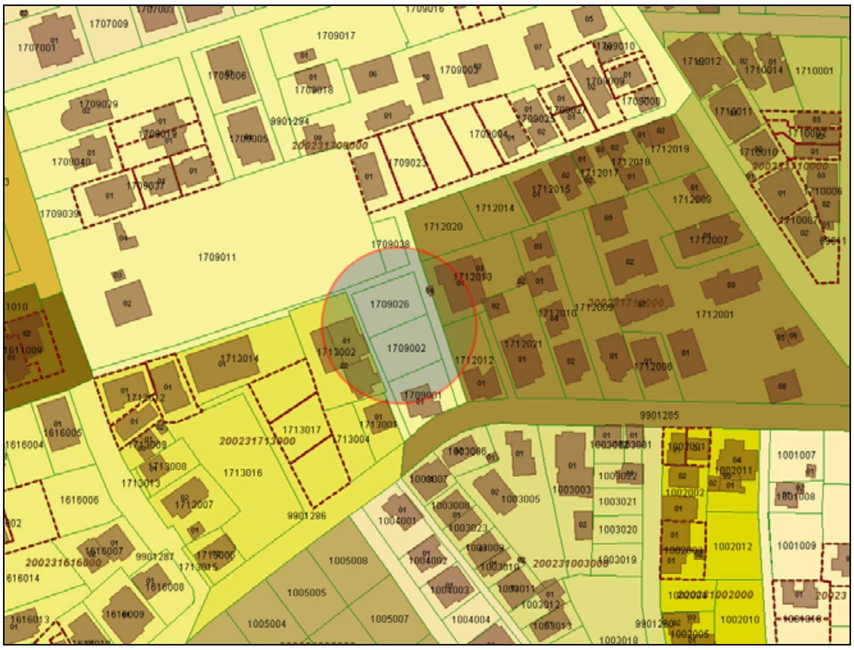
The application of the modern Database technologies for the L.I.S. of the Greek Cadastre, through a materialization of RAC architecture, could satisfy at the utmost the requirements of storage, management, processing and analysis of the descriptive and spatial data. This architecture would satisfy the financial demands of the deployment of the Cadastral L.I.S. The system would be independent from expensive G.I.S. software licenses and it would be scalable to satisfy the growing needs, providing all the necessary tools for the on-line operation.

The experience in developing Cadastral Studies in Greece has shown that an important parameter for the successful deployment of the Cadastral L.I.S. is the quality control procedures. What is required for the smooth operation of the Cadastre is a coordination of procedures from the three main Departments of Ktimatologio S.A. (Quality Control, G.I.S. and Legal Issues) as well as security issues regarding the transactions of the procedures. This parameter could be satisfied with the use of new database capabilities that are not supported by today G.I.S.

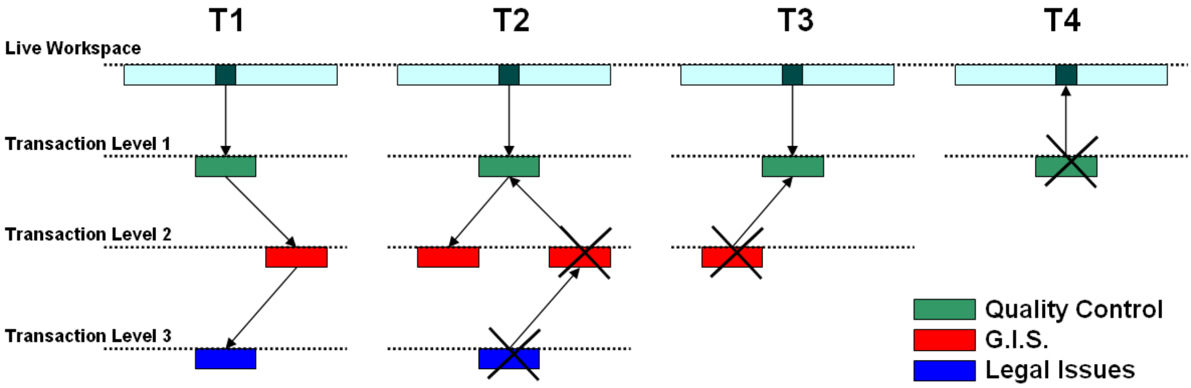
Some G.I.S. technologies use "optimistic" locking of the records in a database, and only in one transaction level. Some G.I.S. vendors apply this functionality directly inside the database core, while others use middle-client software. In this transaction management model, when a user "locks" a record of the database, this record cannot be edited by another user until the first one finishes his session and commits his changes. The technology of "pessimistic" locking allows that several users can edit the same record, but in the end someone has to make the decision of what data will be put back into the "live" database. Specific G.I.S. software Vendors have started using this capability, but this is done by one transaction level.

The Greek Cadastral L.I.S. design uses “optimistic” locking in the transaction management model. That means that when a user edits a specific record, no other user can work on this record until the first commits his work. But taken into account that transactions in a Cadastral Database are long, (days, even weeks to complete due to complex legal issues regarding properties or lack of topographic designs), this transaction management is not suitable for the proper operation of the Cadastral Organization. But even if “pessimistic” locking is used, then all users that edit the same record (G.I.S. users, Quality Control users and Legal Issues users) could work simultaneously, but at the end someone would have to decide on what changes of all should be put back into the “live” workspace of the Cadastral Database.

What is required for an ideal workflow in the Cadastral Organization Procedures is the use of a new transaction management model in G.I.S. functionality based on “altruistic locking”, in multiple levels of transaction management and in specific hierarchy. Let’s describe this by the following example:



Let’s assume that a merging of parcels act comes into the Cadastre Organization as a standard application from a citizen that owns two neighbored parcels. This happens in a specific time T1.



In time T1, the Cadastre Organization begins the merging procedure. The departments inside the Organization coordinate for the merging procedure as follows: Legal Issues Department check the validation of the legal titles of the merge and legal specification validation, then G.I.S department merges the spatial polygons and checks for topology validation and finally Quality Control Department checks for any specification variations on this specific act and validates the whole procedure.

The whole merging procedure will be performed in a way that according to the Departments hierarchy, workspaces are being created on the database server in transaction levels, and versions are created for the records that are to be merged in leveled workspaces. Each transaction level operates in a way that all edits are performed on the version of the records that are being merged as described on the upper transaction level. In this way, all changes that are committed by transaction level n+1, apply in transaction level n. And because each transaction level is hierarchal, therefore commit of edits is conflict-free.

Between T1 and T2, we see that Legal Department commits edits in the record on one Transaction Level below G.I.S. Department, Transaction Level 3. That means that commit of Legal Department edits updates G.I.S. Department version of the records being edited. Before T2, another user of G.I.S. Department starts the topology validation of the new merged parcel, but the version of the parcels being edited will change after commit by Legal Issues Department user and commit of the other G.I.S. Department user. In T3, G.I.S. Department commits topology edits and then in T4 Quality Controls completes the whole procedure by committing specification validation work. In this procedure, all three departments can edit simultaneously specific versioned records. But there is a specific department hierarchy followed, ensuring that the final commit and change of the record in the database, is without any conflicts that need to be issued by someone.

5. NEW G.I.S. CAPABILITIES

5.1 Altruistic Locking

The type of locking in the database that needs to be used inside the database core for the transaction management is described as “altruistic locking”. This type of locking is a newly introduced capability of transaction management for spatial databases, and is more advanced than optimistic or pessimistic locking used by today spatial databases. Pessimistic locking does not allow a record to be edited in two or more continually refreshed workspaces. This setting ensures that there are no conflicts between parent and child workspaces. Optimistic Locking allows a record to be edited in two or more continually refreshed workspaces. If differences occur between parent and child workspaces, the record is considered to be in conflict, and the conflict must be resolved before the child workspace can be merged or refreshed. What is needed as a solution for the above example requirements is a locking mode that ensures that when a user completes his work in his workspace for specific records and even if he hasn't committed the workspace, these records version can be used by another workspace (the upper in hierarchy workspace). This type of locking is called "altruistic locking". Optimistic and pessimistic locking use the database commands "lock" and "unlock". Altruistic locking introduces the command "donate", by which a (versioned) record can be donated to other workspaces for access, even if the working workspace is not committed. The donate function informs a database scheduler that access to a data item is no longer required by the transaction that has currently locked the item. So, the item can be donated for access to another transaction. This achieves concurrently execution of transactions without conflicts. The donating transaction is free to acquire other locks in the future, so that lock and donate operations do not need to follow the classic two-phase rule of "lock and unlock" in optimistic and pessimistic locking.

5.2 Implicit Savepoints

In addition, modern databases use "savepoints" in these transaction management models. A savepoint is a point in a workspace to which record changes can be rolled back, and to which users can go to see the database as it existed at that point. This function is mostly exploited in the business model of the Cadastral Agency from all three main departments. Savepoints are usually created in response to a business-related milestone, such as the completion of a design phase or the end of a specific request such as the merging procedure described. In modern databases, savepoints have "history" option that timestamp changes made to all rows in a version-enabled table and save a copy of either all changes or only the most recent changes to each row. In this way, a database server can keep all changes when version-enabling a table, keep a persistent history of all changes made to all row versions, and enable users to go to any point in time to view the database as it existed from the perspective of that workspace. "Implicit savepoints" are savepoints that are created automatically whenever a new workspace is created. An implicit savepoint is needed so that the users in the child workspace get a view of the database that is frozen at the time of the workspace creation.

6. CONCLUSIONS

Using multi-level transaction management in altruistic locking mode and implicit savepoints inside the database core achieves a successful spatial database design for the Cadastral L.I.S. Multi-level transaction management in altruistic locking mode and implicit savepoints are not supported by today G.I.S. and are introduced as Mr. Konstantinos Daniilidis Ph.D. thesis. Taken into account all the above mentioned reasons for the development of the Cadastral

L.I.S. using modern database technologies without G.I.S. software, this final parameter requires this technology for the integrity and security of the procedures.

In conclusion the choice of modern database technologies for the development of Greek Cadastral L.I.S. without G.I.S. software, using altruistic locking transaction management and implicit savepoints ensures:

- Scalable inexpensive cost of the System
- Very Large Database efficient operation
- Efficient management of Information
- Fast and reliable operation (native)
- Benefits in security and integrity (No mid-clients)
- Development of the L.I.S. inside specific financial limits
- Real Application Clustering (Scalability, Availability and Suppleness)
- "Open" Application
- Operation without expensive G.I.S. software licences and complex user interface on a national level
- Security issues regarding the transactions and the procedures
- Multi-level Transaction Management
- "Altruistic" locking in Transaction Management
- Implicit Savepoints for the Business Model operation
- Successful coordination in the procedures of Cadastre's Inner Departments

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- Developing a Corporate Business Intelligence Portal, Steve Vandivier, Avanco International Inc (White Paper)

BIOGRAPHICAL NOTES

Konstantinos Daniilidis

Academic Diplomas

- Diploma by National Technical University of Athens, School of Rural & Surveying Engineering. Studies started: September 1991. Graduation: February 1997. Grade: 7,10.
- Diploma Project: «Development of a tourist servicing Land Information System with multimedia support. Application: Digital Tourist Guide of Athens», publicated in «TA NEA» newspaper on Tuesday 11/3/1997.
- Ph.D. elaboration in National Technical University of Athens, School of Rural & Surveying Engineering. Subject: «Multilevel transaction management and savepoints in open application LIS. Application in the Greek Cadastre».

Professional Certifications

- GPS Specialist. Diploma «GPS Certificate Program» 24 hours by Intergraph Co. between 25/4/05 and 28/4/05.
- Seminar diploma «Mobile Resource Management Solutions» 8 hours by Intergarph Co. at 23/4/05.
- Intergraph Geomedia Technology specialist. Diploma «Geomedia Certificate Program» 24 hours by Intergraph Co. between 12/5/04 and 14/5/04.
- Diploma «Geomedia Webmap» 8 hours by Intergarph Co. at 15/5/04.
- Diploma of Quality Management Inspector EN ISO 9001:2000. Seminar 42 hours by TUV Austria Akademy between 25/6/03 and 29/6/03.
- Ministry of Environment and Public Works Record of Studies (Rec No 16536) - Surveying Studies (category 16) , grade B΄, Enviromental Studies (category 27) , grade A΄
- Diploma in seminar of «Modern Project Management» by Advanced Quality Services at 15/11/02.
- National Accreditation Center for continuing Vocational Training Record (Rec No 400485), in theory and practice of categories 2293 (Cartographers, Topographers–Geometers and Surveyors) and 2410 (Didactic Personnel of higher Academic Institutions).
- Seminar diploma 40 hours GIS ESRI Arc/Info by I.EK.E.M. T.E.E. between 9/12/96 and 20/12/96.
- Seminar diploma 30 hours «ESRI ArcView GIS», by Marathon Data Systems.
- Seminar diploma AutoCAD design 60 hours by Parsers School for Computer Sciences, between 25/2/92 and 31/3/92.
- Diplomas in computer programming by Constantinou Computer Studies: GWBasic, GWBasic Files, GWBasic Graphics, Turbo Pascal 4, Turbo Pascal 4 Files and Turbo Pascal 4 Graphics during 1987-1989. Diplomas grades: 100%.

Professional Experience

- Rural & Surveying Engineer (Planitiki S.A., Geografiki S.A., ITCC - Papasavas S.A., Intergraph Hellas, Marathon Data Systems, A&M Architects)

- Certified Teacher of Computer Seminars (*Primus Business Education Center, Interface Business Education Center, 01 Computing Business Education Center, I.M.E.& E. Business Education Center, B.C.A. Business Education Center)*
- Ph.D. Candidate – N.T.U.A. scientific contributor (Teaching practice in «Cadastre» and «Cadastre and Land Information Systems», Teaching practice in «Cadastre and Valuation», at the after-graduate Master Program "Geoinformatics" in School of Rural & Surveying Engineering, Supervisor of 14 Diploma Projects, Assistant in teaching and examinations of the course «Great Geodetic Exercises» in School of Civil Engineering, Development of Land Information Systems for local government, tourism, networks, religion, archaeology, etc.)

Professional Unions

- Technical Chamber of Greece –Cadastral Scientific Committee
- Hellenic Union of Rural & Surveying Engineers – member of the Administrative Board
- Ministry of Environment & Public Works Record of Engineering Works (Rec No 16536)
    - Surveying Engineering Works (category 16) , grade B΄
    - Environmental Engineering Works (category 27) , grade A΄
- TUV Austria ISO Certification and Technical Auditing (Cert. No 03.0897.02/08)
- National Accreditation Center for continuing Vocational Training (Rec No 400485)
- FIG International Federation of Surveyors
    - Commission 3 – Spatial Information Management
    - Commission 7 – Cadastre and Land Management)

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