The Italian Cadastral Information System: a Real-Life Spatio-Temporal DBMS

(Extended Abstract)

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Abstract. In this paper we describe the technical and organizational solution that has been designed and implemented in Italy to deal with cadastral data management. The system, named "Sistema di Interscambio Catasto-Comuni" (SICC), allows to exchange cadastral data among the principal entities interested in Italy to the treatment of cadastral information, that are Ministry of Finance, Municipalities, Notaries, and Certified Land Surveyors. The system is accessible nation-wide through a WEB-based interface since September 1998 and the effectiveness of its use is demonstrated by the sharp increase in the number of requests managed during the first months: in January 1999 it has been used by more than 15.000 end-users.

Keywords: cadastral data, distributed systems, interoperability.

1 Introduction

Cadastral data are an important example of spatio-temporal data. They have three very peculiar characteristics.

Firstly, from the temporal point of view they have a particular nature, since their changes with time are always of punctual type. Changes to cadastral data in fact never happen in a continuous way, like it usually happens to navigation data for mobile objects (e.g. airplanes, cars, etc.) that are continuously monitored. Hence variation of cadastral spatial values with time are always of discrete nature.

Secondly, cadastral data have an official role in supporting certification of location, shape, and ownership of properties. On these basis, many countries

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determine taxation related to land properties and real estates. Hence it is clear that the utmost care should be put into the management of changes to them. Also, given this official role, all historical changes to cadastral data have to be maintained with the same level of care and are usually queried. Since discussions on legal and economic issues related to the use and/or ownership of land may go on for many years, queries about the past are as important as queries regarding current situation.

Finally, cadastral data are usually managed by many offices, that are geographically distributed and directly deals with data regarding the part of land assigned to them, even if in every country there is some form of centralized coordination and control.

In recent years, with the spread of low cost technologies for cadastral data acquisition, storing and processing, cadastral data are also being more and more used for general planning purpose related to land. The approach is to use cadastral data as a basic geographic information layer providing geo-referencing and descriptive data of objects existing over the land. On this layer more sophisticated and advanced land information systems are then built for the general planning and management needs of institutional decision makers.

In this paper we describe the technical and organizational solution that has been designed and implemented in Italy to deal with cadastral data management.

While working on this issue, we defined a new architectural approach, namely the **Access Keys Warehouse** approach, described more extensively elsewhere [10, 11]. This approach proposes a novel role for the concept of Data Warehouse, namely suggests that a (new kind of) warehouse can be set up to guide and control accesses to the underlying databases. This allows to solve coherence problems always rising up in such a framework with good overall performances and to provide a methodological guidance for the system development.

The SICC system has been implemented using the AKW approach and is being used nation-wide since September 1998. It currently deals each month with more than 100.000 end-user queries.

The structure of the paper is the following. In Section 2 we describe the italian situation in the sector of cadastral data, while we discuss official regulations regarding them in Section 3. The main technical problems are discussed in Section 4, while an overview of the Access Keys Warehouse approach is given in Section 5. Subsequently, Section 6 describes the organization of cadastral data within the system, while Section 7 discusses organizational aspects. Finally, Section 8 briefly discusses the current status of the system and shows examples of interactions with it, while Section 9 concludes the paper.

2 Cadastral Data in Italy

2.1 The Cadaster

The Cadaster, in the italian situation, has the role of being the public registry of real estates and land properties and it was established for fiscal purposes. As

such, it has always been managed at the central administration level, namely by the italian Ministry of Finance. The access key in the Cadaster to data about real estates and land properties is expressed in terms of the unique code of municipality where they are located and of four cadastral codes referring to cadastral maps of increasing level of detail.

From a physical point of view, Cadaster data are managed by the Land Department of the Ministry of Finance through its Land Offices ("Uffici del Territorio") that are present at the level of the about 100 Provinces (one Office for each Province), which are a subdivision of the main administrative partition of Italy in Regions and an aggregation of Municipalities.

The Ministry of Finance, as required by the law, uses Cadaster data to keep record of and to certify location and planimetry of properties. Note that, according to italian law, taxes on real estates and land properties have to be based on their cadastral value ("rendita catastale"), that is strictly depending on location and planimetry of properties.

Furthermore, through its Estate Public Registry Offices ("Conservatorie Immobiliari"), the Land Department of the Ministry of Finance also keeps record of and certify ownership rights and mortgage rights relative to properties. These Offices have a slightly different, but comparable, distribution from the Land Offices' one. There about 120 Estate Public Registry Offices located according to the competence area of Legal Courts ("Tribunali"), approximately corresponding to a Province area but not exactly the same. This is mainly due to historical reasons and to the role played by such Offices in certifying property.

There are three principal kinds of spatio-temporal databases for the Cadaster:

- *geometric* data base ("Catasto Geometrico"), giving the geometric and spatial reference for all kinds of land parcels; it has about 300.000 maps (with scales 1:1000 or 1:2000 or 1:4000), of which approximately one third are in an electronic form, and about 130.000 trigonometric reference points, of which approximately 30% are in an electronic form;
- *land parcel* data base ("Catasto Terreni"): it records about 45 millions of distinct owners and about 90 millions of items of land parcels; records in this data base are directly correlated to records in the geometric data base.
- *real estates* data base ("Catasto Fabbricati"): it records about 40 millions of owners and about 47 millions of items of real estate; sometime the record of a real estate has a direct correlation to a current land parcel in the geometric data base and sometime only the reference to the original land parcel is found.

  In the latter case the geo-referencing of the real estate has to be obtained indirectly by navigating through the history of modifications to the original land parcel: more precisely, the history is found both in the geometric database (for the geo-referenced part) and in the land parcel database (for the descriptive part).

The latter two spatio-temporal databases, collectively known as *income* ("censuari") databases, have moreover a subdivision in *current* database and

suspended database. The current database describes the current and past situation. The suspended database keeps record of changes that have not yet been executed to the current database, because some piece of information is missing or wrongly correlated to spatio-temporal data already stored in the current databases. The size of suspended databases, in percentage over the corresponding current database, is around 10% for the real estate data base and around 15% for the land parcel data base.

Note also that Cadaster databases are not managed at a single central location but at the more than 100 Land Offices of the Ministry of the Finance. This means that there is not a single centralized system, but more than 100 systems, geographically distributed over the whole italian territory.

Also databases storing information managed by the Estate Public Registry Offices are geographically distributed. These are temporal databases, since for legal reasons have to keep track of past owners, containing only non-spatial data. Reference to the spatial location of real estates and land properties, and hence to spatio-temporal databases for the Cadaster is made through a unique cadastral identification code, made up by Municipality code, map sheet number, parcel number and flat number.

The central offices of Land Department, in Rome, have then a role of defining technical and organizational rules for the management and the evolution of Cadaster and Estate Public Registry databases and of coordinating their implementation. From an operational point of view, they have moreover the possibility of cross-querying various databases and correlating them both for coherence enforcing objectives and for institutional purposes (e.g., checking tax declarations).

Typical queries on Cadaster databases are:

- *cadastral certification* query ("Visura Catastale"), requiring a certificate about the location and the cadastral value of a real estate/ land parcel; please note that such a certificate is needed by notaries in all sale acts and buyers pay a fee to obtain it from the Cadaster;
- *planimetry certification* query, requiring a certificate about planimetry of a real estate; such a certificate is often required during sale transactions to check if the current situation of the real estate is coherent with respect to the situation recorded in the cadastral databases;
- *update* query, submitting a request to change, for a given real estate/ land parcel, some piece of information of geometric nature or of descriptive nature.

Every year in Italy there are about 1.5 million certification queries and in on of the largest provinces there are about 100.000 yearly requests.

A typical query on Estate Public Registry databases is:

- *property certification* query ("Ispezione Ipotecaria"), requiring a certificate about the current and/or past owner(s) of a real estate/ land parcel; please note that also such a certificate is needed by notaries in all sale acts and buyers pay a fee to obtain it from the Estate Public Registry Office;

Remember that, given the existence of changes not yet executed on the current databases, suspended databases have also in many cases to be queried. This happens by means of non-standard queries, defined an a case-by-case basis by highly skilled Cadaster database technicians ("Visuristi") of the Land Department.

Also consider that, given that a direct correlation between a real estate and its current land parcel is many times missing, such a correlation has to be established each time this piece of information is needed. This is done as well by the "Visuristi" of the Land Department by means of non-standard spatio-temporal queries.

The number of yearly geometric updates to cadastral databases is about 250.000. These updates always triggers further spatio-temporal updates, since a geometric change affects one or more of the following aspects of a real estate or land property, and past values have to be maintained on-line for future queries:

- property rights and mortgage rights,
- fiscal nature,
- destination and allowable usage.

2.2 Municipalities

A Municipality uses cadastral data mainly for planning and managing land use. For this purpose it refers to cadastral information in terms of toponymy attributes of properties. Hence access key for Municipalities is street name, plus possibly house number on the street and flat number.

Municipalities therefore have their own spatio-temporal databases about real estates and land properties. These are used, as required by the law, to support and manage actions in the following main areas:

- *Toponymy*, giving names to public circulation areas and numbers to accesses from public circulation areas to the inner spaces of buildings and private areas;
- *Fiscal*, defining and collecting taxes for the permanent use of a public area and for the waste collection service;
- *Public Works*, dealing with all maintenance works and management of public buildings and monuments, with all private actions affecting the public land, with the management of public green and public lighting, and with the uses of drinkable water;
- *Land Management*, for environmental planning and control actions, for planning and management of the development of urban areas, for all major building actions affecting private buildings and private areas.

Size of spatio-temporal cadastral databases managed by Municipalities is largely variable, considering that about 6.000 of the 8.102 italian municipalities have less then 5.000 citizens, but 8 of the 20 Region chief towns have more than one million inhabitants.

2.3 Notaries and Certified Land Surveyors

Notaries have the responsibility of ensuring in all sale transactions relative to land parcel/ real estate the correct identification of items that are object of the transaction and of the relative property/ mortgage rights so that the transaction itself and the consequent obligations have full validity.

They use Cadaster and Estate Public Registry databases both in the preliminary phases, when the buyer is investigating the current status of cadastral objects, and in the final one, when the transaction actually happens and required certificates have to be attached to official acts.

Certified Land Surveyors have the responsibility of producing all technical documentation of geodetic or geometric nature required in transactions relative to partitioning or use change of land parcel/ real estate. They also are in charge of preparing the above kind of documents for Land Use Plans defined by a Municipality (for public terrains) or by a private. Finally, they are clearly involved in all local check actions on the actual situation of a land parcel/ real estate conducted by Municipality and local Land Offices to re-establish a correspondence between cadastral databases and reality.

2.4 Interactions

It is hence clear that there is a continuous exchange flow of cadastral data among Municipalities, Ministry of Finance, Notaries and Certified Land Surveyors. More details on their interactions and roles can be found in [9].

In 1995, when the SICC project was started by AIPA to support the implementation of new directions in cadastral data management set forth by new regulations (see Section 3), the situation was the following :

- cadastral data stored in Cadaster are not, in general, up to date with cadastral data stored in Municipalities, and both are not, in general, exactly describing the situation in reality. It has been estimated through a sample of 5% of the overall data, that about 40% of the whole set of data held in Cadaster data bases is not up to date with the reality. Please note that this refers to the *overall* set of data, including both data generated by the cadastral offices and data received from the outside. Data generated inside cadastral offices are usually up-to-date, hence the Cadaster is able to perform its main role. The greatest source of incoherence is in data received from the outside, and the consequence of this is a great difficulty to establish a reliable correlation between a situation represented in in Cadaster databases and a situation represented in databases of other organizations;
- the way cadastral data change as consequence of actions taken by Municipalities, on one side, and by the Ministry of Finance, on the other side, are usually different. This is the main reason for the lack of correlation between data held by Municipalities and data held by Ministry of Finance, notwithstanding the large efforts that are periodically taken to force the correlation. It has been estimated that about 10% of the overall data changes every year.

3 Italian Regulations Regarding Cadastral Data

In recent years a number of laws have defined new organizational approaches for the management of cadastral data. The Law Decree n.557 of 30/dec/93 and the Law n.133 of 26/feb/94 required to set up an information system for cadastral data exchange by means of telematics communication among Ministry of Finance, Municipalities, and Notaries.

They also required that in such a system it should have been possible for Municipalities and Notaries to access databases of the Cadaster and of the Estate Public Registry and for the Ministry of Finance to receive information from Municipalities about the situation regarding its territory.

These provisions were required to allow:

- a de-centralization of services regarding cadastral data and property/mortgage rights,
- the complete automation of update processes of Cadaster databases and of Estate Public Registry databases,
- the monitoring and checking of distributed transactions.

The above regulations were then made more precise by the Labor Decree n.112 of 31/mar/98 establishing that:

- the central government keeps the management of estate public registry databases recording ownership and mortgage rights,
- Municipalities store and manage cadastral data about land properties and real estates existing within their territory,
- the central government maintains addressing and coordination functions regarding cadastral data management; more specifically, functions remaining to the central government are:
  - the definition of classification methods for land properties and real estates,
  - the definition of procedures to compute cadastral values of land parcels and real estates,
  - managing and certifying data about mortgage rights,
  - ruling tax legislation related to cadastral properties,
  - the definition of methods for topographic data acquisition and cadastral map generation,
  - checking data quality during update processes,
  - coordinating distributed access to cadastral data through the unitary network of the Public Administration [2].

From the above description it is clear that in such a work organization the biggest technical problem from the data management point of view is how to ensure the *coherence of the overall (distributed) set of spatio-temporal data*. On one side, in fact, data are going to be independently and autonomously managed by the various organizations. On the other one, data are needed and used also outside the organization producing/managing them and controlling their

changes. Hence the problem is that an organization needs to use some data but has not a full control over them and the way they change.

These clashing situations are likely to produce incoherence in the overall set of spatio-temporal data, sooner or later, with absolute certainty. Since the lack of coherence derives mainly from organizational aspects, then the technical solution has to be designed in a way to match needs and behaviour of the organizations involved. Moreover, the technical solution has to be designed so to ensure the overall system has good performances.

4 How Incoherence is Generated

We now describe a typical interaction among entities that interact in the case of cadastral data to show how incoherence of the overall set of spatio-temporal data may be generated.

A Certified Land Surveyor prepares for a client a request for a variation to an apartment (e.g., to divide a large apartment in two smaller ones). The request is composed by some descriptive data and some geometric data and is stored in a database in the Surveyor's office.

The Surveyor prints the request and send it by registered mail to the pertinent Cadaster office of the Ministry of Finance. The office, having checked that everything has been done according to current laws and that data are coherent with data stored in Cadaster databases executes the update.

The municipality the apartment is located in has an interest in knowing such a change for local tax reasons (e.g., the two smaller apartments are different subjects, from a fiscal point of view, than the previous one). The surveyor has on obligation to get an approval for the change from the Building Service of the municipality before submitting the request to the Cadaster. Of course, until the request is received from the Cadaster the change has not really happened.

But neither the Cadaster office nor the Surveyor have any legal obligation to inform the municipality when the change really happens, i.e. when the request has been accepted by the Cadaster. This is the duty of the owner of the apartment and if he/she forgets to comply with this obligation, the municipalities may never be aware of the change until an inspector is sent to the place to check the situation.

The above example illustrates a case of incoherence *directly* generated during interaction among various organizations. But there is also a more subtle incoherence that can be *indirectly* generated.

Assume that, in the division of the apartment in two smaller ones, one of the two has received a new apartment number which has been registered in Cadaster databases. Assume now the municipality is informed of the change, when it happens, but it discovers that the way the apartment has received the new number is incoherent with municipal regulations for numbering apartments (e.g., the new number is one plus the old highest number in the building while the current regulations require adding a letter to the old number). Note that such a

mistake may have been unnoticed or unchecked in the prior request for approval submitted from the Surveyor to the municipality. In fact, the Building Service of the municipality is not the one in charge of such a check on apartment numbering (the Toponymy Service is in charge) and regulations require that the submission of the change request to the Cadaster only needs the approval of the Building Service.

When the municipality receives the communication of the change it will try to have the Surveyor and the Cadaster change their databases according to such a regulation. But since most probably Cadaster databases will already have been updated by then and since this issue of apartment numbering is not something the Cadaster has, by the law, to really care about, no action will be taken and the incoherence will remain.

5 An Overview of the Access Keys Warehouse Approach

To technical solution allowing to solve the coherence maintenance problem is provided the **Access Keys Warehouse** (AKW) approach. This is a novel architectural approach of general value, discussed in more detail elsewhere [10, 11], allowing to smoothly develop, in a cost-effective way, cooperative information systems supporting interaction among autonomous organizations.

This approach gives the possibility of taking into account the impact on performances during the rightsizing phase and to define the system according to these requirements. Other approaches based on principles and techniques from, e.g., classic distributed DBMSs [1], or object-oriented DBMS [3], or standard data warehouse techniques [4], could not provide adequate solutions to our requirements [10, 11].

We now informally describe, at a high abstraction level, the AKW approach.

The technical device allowing to control the evolution of the overall system so to ensure distributed databases are always up-to-date with the original sources of data is a mapping among the data items existing in the relevant distributed databases.

This mapping is created and maintained by the system services of the AKW approach, and is realized through an **exchange identifiers database**. This is a *data repository* containing, *from a virtual point of view only*, all data items that can be found in various databases of a distributed systems. From a physical point of view most of data items remains at their locations.

The consequence is that with the use of the exchange identifiers database one needs to propagate variations only for access keys and not for every data items changing its value.

The *exchange identifiers database* is physically built, but contains only *access keys* and *logical links* for data items in the various databases of the distributed system. The access keys are attribute names, selected from the existing attributes in the underlying databases: the main rule in order to select them is that their concatenation constitutes a unique identifier for the data item. Logical links provide the access paths to the physical (distributed) databases where further

data elements about the identified data can be found. Hence attributes in the exchange identifiers database act towards distributed databases as access keys: their value is used to query distributed databases. Hence they are **not** physical pointers, and the distributed databases maintain their independence and transparency both with respect to location and to implementation.

A system implemented according to the AKW approach has therefore also an *access management* role, guiding accesses to the distributed databases referred by the logical links so that accesses are minimally intrusive, have a minimal impact on their performances and correlations required for coherence maintenance internally to the distributed databases can be efficiently executed.

In the design of the exchange identifiers database attribute names have to be selected for it with two criteria:

1. the set of selected attributes has to be small enough so that its materialization can be efficiently managed and queried;
2. the set of selected attributes has to be large enough so to be able to contain all access keys needed to deal with coherence maintenance issues internally to the distributed databases while keeping their performances at an acceptable level.

The exchange identifiers database is populated using data existing in the various distributed locations. Values of access keys are supplied by the organizations involved in the interaction while the correlation of these values is knowledge added during the design and materialization process of the exchange identifiers database.

A **Supplier** is any entity generating a data item and/or entitled to change it, while a **User** is any entity interested to use a data item for its own purposes. The exchange identifiers database keeps a record of which are Users and Suppliers for the various data items.

A given organization can be, of course, both a Supplier and a User, even for the same data item. The Supplier of an attribute name in the exchange identifiers database is the only that can insert, modify, or delete values for that attribute in the database itself.

The active part of a system based on the AKW approach features two main components, each of them providing a class of services:

- *application services*, allowing Users to access data items they need, and allowing Suppliers to change data items or to generate new ones, both in a punctual way (i.e., one at a time) and in a batch one (i.e., a set at a time);
- *system services*, to keep coherence among the various sources of data items and of changes to them, to avoid incoherence during updates from Suppliers and their dispatching to Users, to certify answers to Users queries, to implement security and access right controls.

6 Data Organization

Cadastral data managed by SICC can be accessed by means of four classes of keys, that are specific of Cadaster and Estate Public Registry databases:

- *identifier codes for cadastral objects*: these are expressed in terms of Municipality code, section code (within the Municipality), map sheet number, parcel number and flat number;
- *identifier codes for subjects having rights on cadastral objects*: these are given name, family name, and fiscal code for people, and company code ("Partita IVA") for organizations;
- *identifiers of cadastral documents*: in terms of kind of document, protocol number and date,
- *attributes of cadastral objects*: these concern toponymy and geometric or geographical location

Cadastral data have then to be correlated with data stored in other databases at the Municipalities, that normally use other classes of keys. The most relevant databases in Municipalities for dealing with cadastral data are:

- *resident people database*: using as access keys given name, family name and fiscal code;
- *building works license database*: using license identifiers;
- *street database*: using toponymy codes;
- *technical office database*: using map codes of the Municipality land usage plan.

We now discuss typical services that SICC is able to support regarding exchange of cadastral data among Land Department of Ministry of Finance and Municipalities. They are described from the Municipality side:

- communication of changes in the usage or in the composition of a real estate, obtained from the owner's declaration or from a Municipality direct inspection;
- communication regarding a change in the internal structure of a real estate, obtained from the owner's declaration or from a Municipality direct inspection;
- sending cartographic data acquired during field campaign executed for municipality purposes;
- sending toponymy variations;
- sending changes to street layout and their connection network;
- signaling errors found by Municipality in data stored in the Cadaster databases;
- sending list of resident people subject to house municipal tax and asking for correlation with income tax databases at the Ministry of Finance;
- sending request for changes submitted to the Municipalities by Notaries and Certified Land Surveyors;

- sending request for changes regarding cadastral objects managed directly by the Municipality;
- asking to the Land Department to approve changes in real estates classification for fiscal purposes;
- asking to the Land Department to issue certificates about descriptive and geometric attributes of cadastral objects;
- interacting with other Public Administration organizations in the view of a better coordination for land management and planning, also for local tax legislation purposes.

The technical device allowing to address the above requirements is the *exchange identifiers database* introduced in the previous section.

In the case of SICC such a database contains about thirty exchange identifiers, selected among the more than two hundred attributes relevant for cadastral information in the various organizations, during a refinement and prototyping phase that has involved all the main entities interested in Italy with the treatment of cadastral data.

The exchange identifier database for cadastral data is then organized in four layers, each containing access keys of different type for the elements in Cadaster, Estate Public Registry, and Municipality databases. Namely, the four layers are:

- *descriptive*, containing all descriptive attributes used as access keys for cadastral objects and subjects;
- *cartographic*, containing all cartographic attributes used as access keys for cadastral objects and toponymy objects;
- *localization*, containing access keys for trigonometric reference points (i.e., the "maglia dei punti fiduciali" = network of geodetic reference points) and topographic map sheets: it hence allows to access geo-referencing data for cadastral objects;
- *correlation*, keeping correlation among the access keys in previous three layers and other databases.

Each of the above layer establishes a correlation among access keys referring to different databases. Hence each of the above layer contributes to the process of maintaining the overall coherence. In particular, the correlation layer allows to check coherence among the other layers and among the corresponding databases referred by them.

Note also that each of the above layer is spatio-temporal, since in each of them is made reference to information changing with time (e.g., the owner of a parcel, the shape of a parcel, and so on).

Once that in the various layers the values of the various access keys for the same piece of cadastral information have been inserted and validated, it is relatively easy to transform accesses and updates to a given database in references for other databases.

This approach based on the exchange identifier database allows to satisfy two important and always conflicting requirements:

- to decouple information systems of the various organizations, so that the role of each organization in governing its own databases is fully respected;
- to allow the synchronization among changes to data in the various distributed databases, thus avoiding to lose coherence in the overall set of spatio-temporal data.

7 Organizational Aspects

There are three main entities interacting among themselves through the exchange identifiers database of SICC:

- *End-user Information System*: a person working in a Municipality or a Notary or a Certified Land Surveyor, who accesses SICC by means of his/her workstation at three different levels of interaction:
  - to *browse* through cadastral databases to get acquainted with what kind of information is available for his/her purposes and at which level of detail; for this kind of interaction the security subsystem only keeps a record of data exchanged;
  - to ask and to receive a *certificate* regarding the current or the past status of a cadastral objects, in itself and in relation with subjects and cadastral documents; this kind of interaction is certified, i.e. the written output of SICC has a full legal value;
  - to submit *update* proposals for changes to cadastral objects; on this kind of requests the system executes a number of checks, to verify all information submitted are coherent with the situation currently recorded in Cadaster databases and are compliant with regulations;
- *Technical Management Center*: this is the operational arm of the Land Department of Ministry of Finance managing the Cadaster; it is physically made up by the Data Processing Centers of the various Land Offices and Estate Public Registry Offices. It performs the following functions:
  - to manage all queries from the end-users, first accessing the exchange identifier database to get, depending on the end-user provided identifiers, the access keys for the relevant local cadastral databases, and then issuing the corresponding requests and activating the procedures (technical and/or organizational) corresponding to the kind of query (i.e., browsing, certification, updating) issued;
  - to act as technical reference point for all the end-users that are under its geographical area of competence, providing the necessary service certification levels (i.e., security, accounting, quality, and so on).
- *Land Department Information System*: this is the reference point for all Technical Management Centers, from which it receives update requests relative to end-users the Centers have the competence on. It executes the following actions:
  - to send back, after having executed checks required by laws and regulations, validation notes for the submitted update requests;

- to directly provide certification services, for which the Technical Management Center has acted as a collection and refinement point;
- to carry out the cross-checks with other Ministry of Finance offices and/or other organizations to guarantee the overall quality of update processes.

Clearly, remote access to official data is an issue requiring an adequate level of security. The Land Department, as an organizational structure, carries out the necessary security check activities, for both its Computerized Information System and the Technical Management Centers. It also ensures security and consistency of execution for the access procedures to Cadaster databases and the organizational procedures controlling their use.

For what regards external entities, that is Municipalities, Notaries and Certified Land Surveyors, security is currently only managed by means of a user-id/ secret-password mechanism. It is currently being planned the introduction in the SICC system of public-key/ private-key mechanism to encrypt exchanged data together with an electronic signature procedure to ensure a certified identification of end-users. This is made possible by recently introduced italians laws and regulations regarding electronic document management and exchange[5].

8 The Current Status of SICC

8.1 Status

The first prototype of the SICC project was implemented in 1995 by AIPA and the italian National Research Council. This prototype proved the feasibility of the technical solution and of the organizational model proposed.

Then SOGEI, the italian company managing the computerized information system of the Ministry of Finances, developed a second prototype, with a better degree of integration among cadastral data and services. This prototype has been put into operations in peripheral offices of Neaples municipality in May 1997.

It was then subsequently validated, through the involvement of about 100 Municipalities ranging from Region chief towns to very small ones and a small sample of notaries and certified land surveyors, for about one year [6, 8].

Finally, in September 1998 the engineered system, named SISTER [7] and developed as well by SOGEI, has been put into nation-wide operation.

Access to the system is through a WEB-based interface and the effectiveness of its use is demonstrated by the sharp increase of requests managed by it during the first months. In the month of January 1999 there has been already more than 100.000 cadastral certification queries. Remember that such a query is usually paid by its final user.

The WEB server is a multi-processor machine: one processor is dedicated to the exchange identifier database management, a second processor manages Intranet services (i.e., communication among Technical Management Centers and between them and the Land Department Information System), while a third one

takes care of Internet requests with the relative security level (HTTPS protocol). Applets, written in JAVA, interact through the TCP/IP communication layer with the transaction management subsystems in the Data Processing Centers of the various Land Offices and Estate Public Registry Offices to send user data for queries and to receive results.

The final phase of the whole project is running in 1999 and aims at extending the range of services provided to end users.

In the following pages you can see hardcopies of screens during a real interaction with SICC through the WEB. In some case values used in the queries have been partially hidden in respect for the privacy of subjects involved.

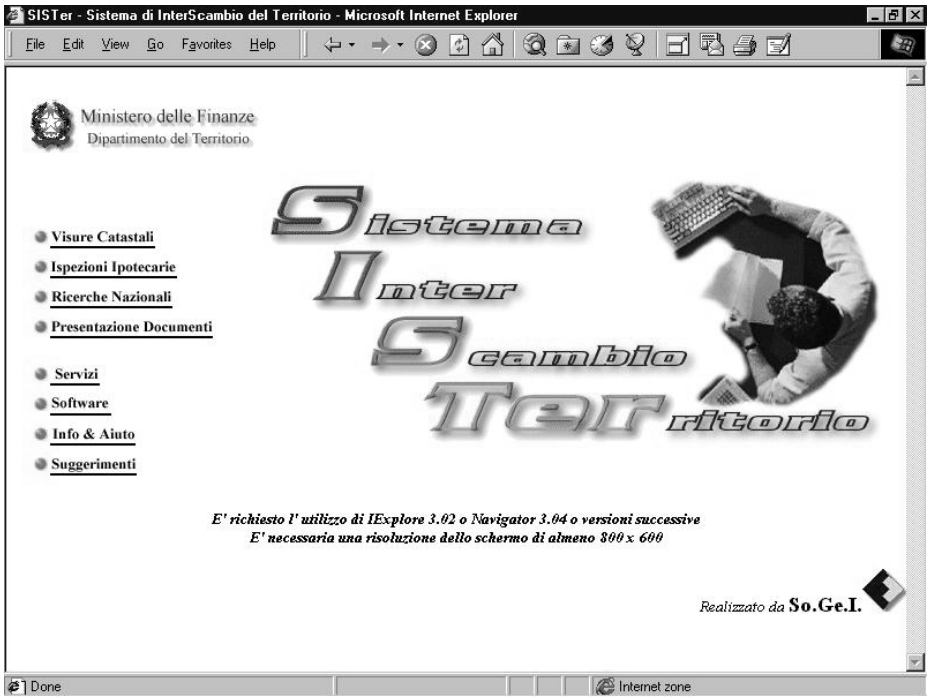

Fig. 1. The initial screen of the system.

8.2 Examples

We now present three examples of real-life situations where Cadaster data are involved and for each them we first present how the case is treated without SICC and then how it is now being managed using it and which is therefore the innovation in the provided service.

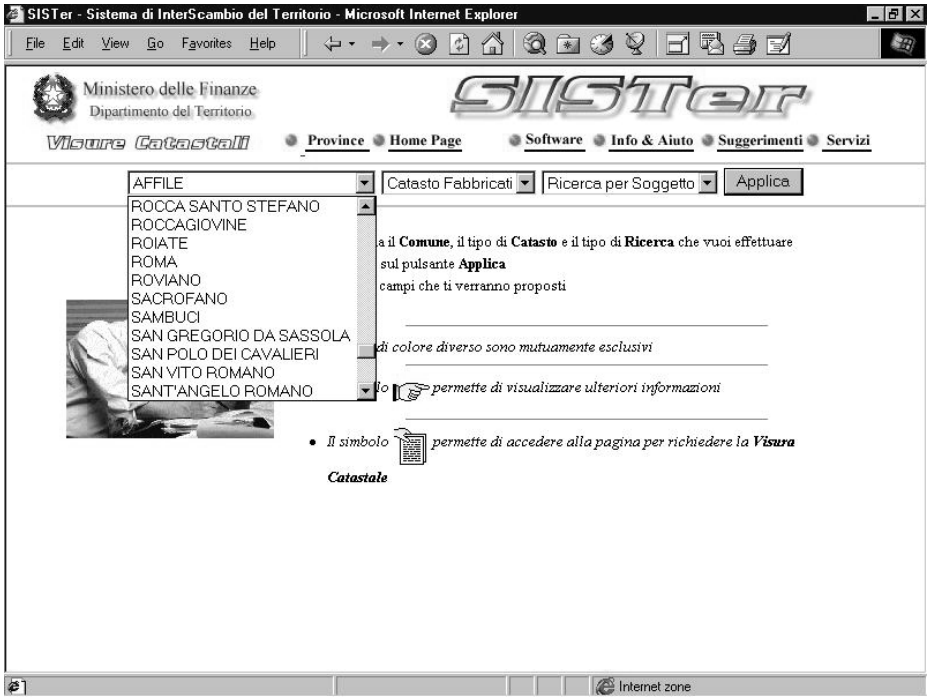

Fig. 2. Choosing the type of search.

Change in the Internal Structure or Usage of a Real Estate

Consider the case of a change in the internal structure or usage of a real estate, that is made known either from the owner's declaration or from a Municipality direct inspection.

without:

- no information is sent to the Cadaster;

with SICC:

- Municipality, after having inspected the place and having possibly noticed mismatches with request presented (by the owner or its delegate), sends through SICC an update advice to Cadaster, containing Cadaster identifiers of the real estate and of the subject(s) having rights on it, and a description of changes,
- Cadaster, when receives through SICC the update request from the owner or from the Municipality, executes on its databases the required changes (e.g., classification of the real estate), after having checked everything in the update request matches with the previous update advice and no incoherence is introduced in Cadaster databases;

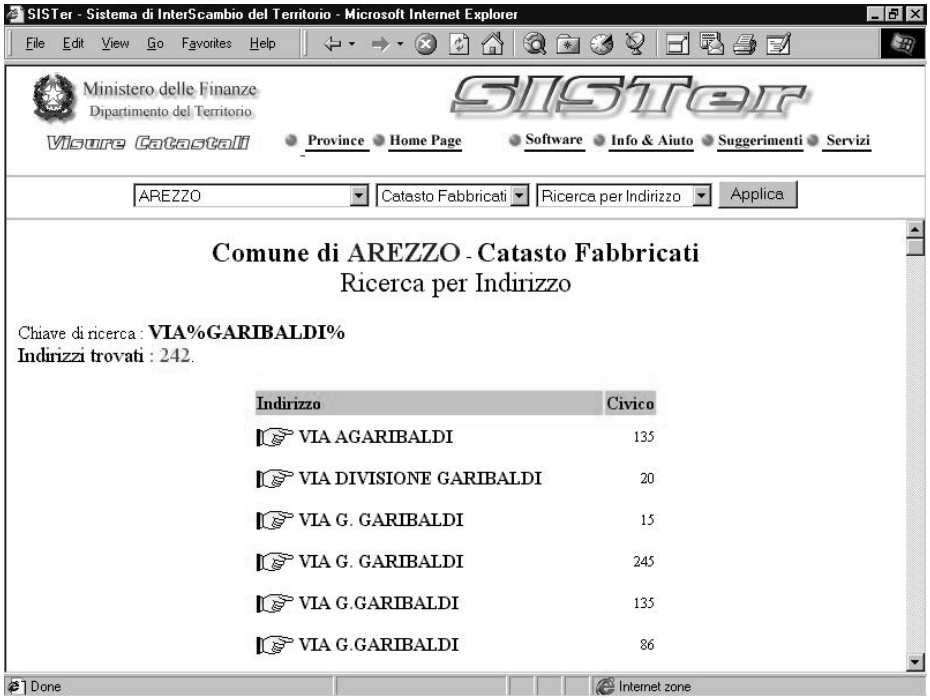

Fig. 3. Querying the real estate database with a partial address.

innovation:

- the owner can submit all documents required for the changes to the Municipality only,
- it is possible to cross-check coherence between changes to Cadaster databases and authorizations given by a Municipality to change internal structure or use of a real estate,
- it is possible to avoid fiscal evasion deriving from avoiding to submit the update request to the Cadaster.

Signaling Errors Found in Cadaster Databases

Consider the case of an error found in data stored in the Cadaster databases either by the person having rights on the cadastral object or by the Municipality during a direct inspection.

without:

- the person having rights or the Municipality presents an update request to the Cadaster, possibly attaching documents showing evidence of the found error and how it should be corrected,

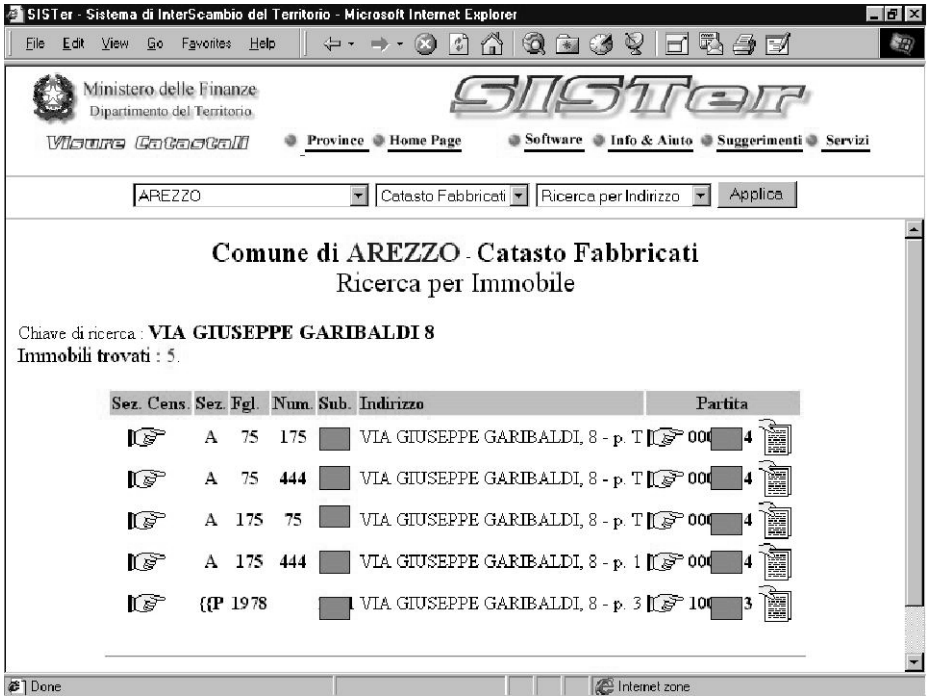

Fig. 4. Querying the real estate database with a property identifier.

- Cadaster, after having checked validity of the request and its attached documents (possibly using previous documents related to the same cadastral object) and having checked coherence of the changes implied by the request, updates its databases;

with SICC:

- the person having rights or the Municipality presents an update request directly to the Municipality offices, possibly attaching documents showing evidence of the found error and how it should be corrected,
- Municipality send an update request to Cadaster through SICC,
- Cadaster, after having executed its checks as described in the absence of SICC, updates its databases;

innovation:

- a change in Cadaster databases is activated by means of a request presented at Municipality offices.

Change Requests by Notaries and Certified Land Surveyors

Consider an update request submitted by a Notary or a Certified Land Surveyor to the Cadaster.

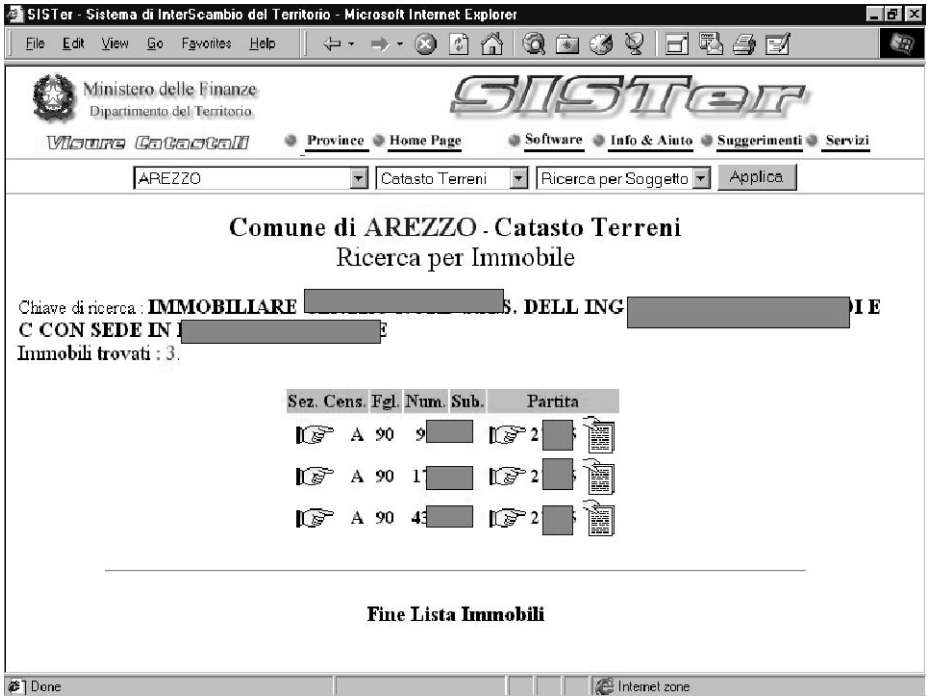

Fig. 5. Querying the land parcel database with a subject.

without:

- cadastral documents describing the current situation have to be obtained from Cadaster and Estate Public Registry, through of a direct request to them,
- cadastral documents with update annotations have to be presented at the offices of Cadaster and Estate Public Registry,

with SICC:

- Notaries and Certified Land Surveyors may ask cadastral documents describing the current situation through Municipality offices,
- Notaries and Certified Land Surveyors present update requests in electronic format at the Municipality offices only,
- Municipality send requests to Cadaster and Estate Public Registry through SICC,
- Cadaster and Estate Public Registry, after having executed their validity checks, update their databases;

innovation:

- a change in Cadaster databases is activated by means of an electronic request presented at Municipality offices.

Fig. 6. Asking for a certificate.

9 Conclusions

In this paper we have discussed the spatio-temporal DBMS "Sistema di Interscambio Catasto-Comuni" (SICC), allowing to exchange cadastral data among the principal entities interested in Italy to the treatment of cadastral information, that are Ministry of Finance, Municipalities, Notaries, and Certified Land Surveyors.

Such a spatio-temporal DBMS allows a de-centralized management of cadastral data while allowing, at the same time, to keep the coherence among distributed databases during updates.

The system is accessible nation-wide by end-users through a WEB-based interface allowing them to query directly relevant databases. Through the use of a novel architectual approach, namely the **Access Keys Warehouse** approach [10] the system is able to check for validity all update requests and to accept only those matching with information currently stored in the (distributed) cadastral databases.

To the best of authors' knowledge this is the first time that a real-life working DBMS is able to guarantee this kind of performances in a scenario of such a complexity.

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