S.I.T.P.A.C.: A Territorial Information System for A Coruña Province

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Abstract

In this paper, it is presented the experience of the development of the E.I.E.L. application, a software system that allows the creation and exploitation of a huge database with alphanumeric and geographic information regarding local equipment and infrastructures of the municipalities of A Coruña province in the Northwest of Spain. Furthermore, it is shown how the E.I.E.L. application is integrated, together with already existing legacy software, into a general territorial information system (S.I.T.P.A.C.), for the Provincial Council of A Coruña. The S.I.T.P.A.C. is a software layer that will provide such legacy systems with the ability to represent some of their entities in a geographic space, and, at the same time, with a friendlier user interface.

1. Introduction

In this paper, the development experiences in the Databases Laboratory of the University of A Coruña of two geographic information systems for the Provincial Council of A Coruña are presented. The first system, the E.I.E.L. project, has already been developed, while the second one, S.I.T.P.A.C., is in phase of analysis and design.

The aim of the E.I.E.L. project, as detailed below, is the creation of a huge database with both alphanumeric and geographic information regarding the infrastructures and equipment of the Province. Tasks included in the project are, therefore, the design and development of the applications needed for the creation of such database and the maintenance and exploitation of the data stored in it.

On the other hand, the goal of S.I.T.P.A.C. is the integration of a wide data set through a geographic information system, including geographic references to the objects position in the space. Thus, for example, each apartment of the database of "*Impuestos sobre Bienes Inmuebles*", I.B.I. (taxes on building properties), will have among its data, besides the postal address already included, a geographic reference to its position on a map. Among the data that S.I.T.P.A.C. will integrate, we find the database that the E.I.E.L. project is creating, and other already existing databases used by old legacy applications.

With S.I.T.P.A.C. the aim is to keep the old software working (because such software is reliable and has been strictly tested for a long time), but at the same time to provide these legacy systems with a graphical user interface, which makes easier tasks such as launching some processes or visualizing the retrieved information. Moreover, S.I.T.P.A.C. will work as a software layer that surrounds the existing applications, allowing the association of data that were isolated up to the moment. As an example, when an apartment is clicked on a map, it will be possible to visualize alphanumeric data coming from the I.B.I database, data about the occupants coming from the "*padrón*" (municipal register) database or data about the quality and kind of sewage treatment available coming from the E.I.E.L. database.

S.I.T.P.A.C. will allow maintaining and exploiting each one of the databases in the system. That is the reason why the applications for maintenance and exploitation of the E.I.E.L. database are not considered and described as separate applications but subsumed into the structure of S.I.T.P.A.C.

The remainder of the paper is organized as follows. In Section 2, a brief description of the reality of A Coruña province within the global administrative structure of Spain is presented. The E.I.E.L. project is described in Section 3, while its integration into S.I.T.P.A.C. is shown in Section 4. Finally, the conclusions of our work are provided in Section 5.

2. A Coruña Province in the Spanish Administrative Structure

From the administrative perspective, the Spanish territory is divided into 17 "*Comunidades autónomas*" (autonomous regions) and 2 "*Ciudades autónomas*" (autonomous cities). Each autonomous region is further divided into a set of provinces. The total number of provinces in Spain is 50. Each one of such provinces has a local administration that deals with the set of tasks that the Spanish administration has delegated at the level of province. The institution for provincial administration is called "*Diputación Provincial*" (Provincial Council). Each province is further divided into municipalities (counties). Again, each municipality has its own local administration that deals with the set of tasks delegated at its level. Such a subdivision allows the administrations to provide the population with services at different levels. Thus, in the case of the road network, the Spanish administration is responsible of the national roads, provincial councils deal with provincial roads and the municipalities deal with municipal roads and streets. The population of the municipalities is grouped into population centers, which must include at least 10 dwellings or more than 50 inhabitants.

For the scope of this paper, we are interested in A Coruña province, which is geographically located in the autonomous region of Galicia, at the northwest corner of the Iberian Peninsula. A Coruña has an extension of 7.951 km^2, divided into 94 municipalities, and a population, at the 1st of January of 1999, of 1.108.980 inhabitants, spread over more than 3500 population centers.

Regarding the set of tasks that are delegated at the level of each municipality, there is a heterogeneous situation in A Coruña province. There are some very populated municipalities that are capable to collect and manage its own information, while other rural and very sparsely populated municipalities must delegate such tasks to the Provincial Council. As an example, there are some municipalities that have staff and tools to produce their own urban planning, that is, to determine what building land is available and where to build is forbidden. Obviously, the urban planning has a clear influence on the development of new infrastructures, like roads, etc. Some big municipalities have a strict urban planning which leads to the development of multi-annual plans, while some rural small municipalities, without land management, simply use very general rules. A different example is the collecting of some taxes, which is directly managed in some big municipalities and delegated to the provincial council in small ones. As a conclusion, the functionality required from the information systems vary from one municipality to another. This characteristic has a deep implication in the design of S.I.T.P.A.C., as will be shown in Section 4.

3. The E. I. E. L. Project

The "*Ministerio de Administraciones Públicas*", M.A.P (Public Administration Ministry), requires every five years from each *Provincial Council* an inventory of the equipment and infrastructures of the municipalities of the province, together with their characteristics, condition, etc. In order to provide the M.A.P with such detailed information each *Provincial Council* must perform the "*Encuesta de Infraestructura y Equipamientos Locales*" E.I.E.L. (Local Infrastructure and Equipments Survey). To perform the survey it is necessary to send, all around the municipalities of the province, a big team of specialized experts to collect a huge amount of data about infrastructures and equipment.

The set of data required by the M. A. P. includes a huge amount of alphanumeric data as well as some predefined thematic maps, where the condition of several infrastructures and equipment can be visually recognized. An example is a thematic map where the color of each street stretch is determined by the value of its condition attributes. In order to achieve a homogeneous result for all the provinces, the M. A. P. provides each provincial council with a set of questionnaires to be filled with the results of the survey, together with instructions to guide the filling process. The task of the Provincial Council is to gather the data into the questionnaires and to store them into a database whose basic schema is also provided by the M. A. P.

The Provincial council of A Coruña decided to face the problem of the completion of the E. I. E. L. of the year 2000 through a two-year project signed with the University of A Coruña, which has more ambitious objectives. More precisely, the amount of alphanumeric information to be collected from each municipality was extended. Furthermore, besides the alphanumeric data of each item, geographical references are also stored now.

In order to collect the data, three different groups of experts, specialized in water cycle, infrastructures and equipment, respectively, were made. Each one of these three groups is currently visiting the different municipalities, collecting the real data by interviewing the respective responsible staff in the municipality or by direct observation. A fourth group of cartography experts deals with the manipulation of the digital cartography.

Our work involves the design and development of the applications needed to store the data (both alphanumeric and geographic) and to maintain and exploit the final database. That is, our work was the realization of all the necessary tasks to develop the whole geographic information system. Such set of tasks is described in Section 3.2.

3.1 E.I.E.L. Data Model Overview

The data model to be used in the E.I.E.L. project keeps information about a wide set of objects and their relationships. These objects can be classified into the following three kinds, which can be somehow identified with the previous three groups of surveying experts:

- *Water cycle information* (from water collecting to sewage disposal and treatment): It includes information about the characteristics, condition, types, quality, etc. of water sources, water pipes, water distribution networks, water tanks, waterworks, hydrants, fire hydrants, springs, pumping stations, sewage pipes, sewage treatment plants, etc. Furthermore, the quality of the water supplying and sewage disposal systems is measured at the level of population center.

- *Infrastructures*. It includes information about the characteristics, condition, types, quality, etc. of the road networks, electricity networks, power stations, transformers, gas networks, telephone networks, street networks, streetlamps, sidewalks, urban planning, garbage collecting systems, etc. Information about some of such infrastructures is collected at the level of province (provincial, autonomic and national roads, etc.), some is collected at municipal level (municipal roads, etc.) and some at the level of population center (streets, sidewalks, etc).
- *Equipment*: We use the term *equipment* to refer to the set of resources serving to equip a municipality in order to render a service to the population. It includes information about the characteristics, condition, types, quality, etc. of sport facilities, markets, hospitals, educational institutes, slaughterhouses, cemeteries, fish markets, churches, town halls, cultural centers, morgues, hotels, parks, street markets, fire stations, etc. Information about equipment is collected at the level of population center.

Since the EIEL project surveys only municipalities with less than 50000 inhabitants[1], there might be (and actually are) infrastructures and equipment that are not surveyed because they are placed in one of those *non-surveyed* municipalities. Nonetheless, these elements might render a service to a population center in a neighboring surveyed municipality, and such a relationship should be represented. Therefore, it is necessary to distinguish through the model between surveyed and non-surveyed elements. About the first ones we collect the full set of data, whereas only information about their existence is collected for the second ones.

Due to the size of the data model and space requirements we are not going to describe it here in more detail. Instead, interested readers can find a more detailed description in [9].

3.2 System Description

In this section, we describe the different tasks that are necessary to perform the E.I.E.L. project. This set of tasks, which we will see in the following sections more briefly, is described in Figure 6.

3.2.1 Database Creation Tasks

The Database Creation tasks involve the creation of a wide database with the data collected during the survey. This step has been divided into five subtasks, which may be done concurrently by different groups of specialized users. We describe below these subtasks, together with the software modules that we developed to accomplish them.

3.2.1.1 Geographic Data Insertion Subtask

It involves the introduction into the database of the collected geographic data. The result of the present subtask is a digital cartography of the municipality in process containing the geographic objects of interest. To simplify the creation of the geographic objects, a digital cartography of some municipalities is already available. However, the quality of such cartography is far from being the desirable and some modifications must be done in order to obtain a clean and error free cartography. Once the available cartography is cleaned and

[1] Municipalities with more than 50000 inhabitants deal directly with the Central Government instead of the Provincial Council.

imported from its original CAD format, it is ready to be used as a base to create the set of geographic objects of interest for the project.

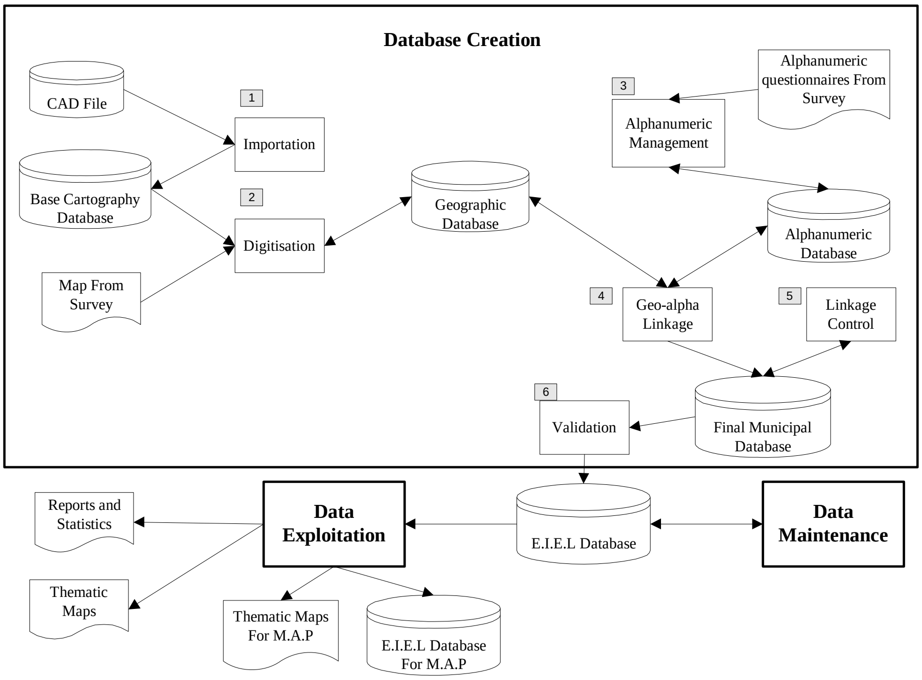

Figure 6: Data flow through E. I. E. L. application modules.

Although the three specialized user groups collect all the geographic information, it is the cartography users group who inserts it. The *Importation* and *Digitalization* modules, shown in Figure 6, support this subtask. The *Importation* module allows to import the available cartography (CAD File) to a *Base Cartography Database*, which has the final format used by the GIS. The *Digitalization* module, on the other hand, uses as input the *base cartography* and the *field maps* where each group of specialized users has collected the geographic data and produces the *geographic database*, where all the geographic data of the municipality are stored. For that purpose this module provides functionality for drawing geographic objects using as context the *base cartography* (e.g. roads, water tanks, etc.) and for classifying geographic objects from the base cartography into the appropriate tables of *the geographic database* of the municipality (e.g. classify buildings into hospitals, markets, etc.).

3.2.1.2 Alphanumeric Data Insertion Subtask

It involves the introduction of the alphanumeric data that are collected and inserted by the three groups of specialized users. The *Alphanumeric Management* module, shown in Figure 6, supports the present subtask. It allows insertions, updates and deletions in the tables where the collected alphanumeric data are stored. It takes as input the questionnaires filled by the experts and produces an alphanumeric database, whose schema is the result of eliminating the geographic attributes from the data model. Three different applications (one for each group) were implemented. For making them user-friendly each screen of their user interface resembles the questionnaire used to collect the data that it is going to manage.

3.2.1.3 Geo-alpha Data Linkage Subtask

It links the alphanumeric data of each item with its corresponding geographic reference in the digital cartography, storing all of them as different attributes of the same entity. The *Geo-alpha Linkage* and *Linkage Control* modules support the subtask. The *Geo-alpha Linkage* module allows a specialized user to join, interactively, the alphanumeric data from the *alphanumeric database* and the geographic data of the *geographic database*. Through such join process the *final municipal database* is constructed. The *Linkage Control* module, on the other hand, allows to check the linkage process, and to undo it if needed.

3.2.1.4 Validation Subtask

It involves the validation of the data from a given municipality. There is just one module to support this subtask, the *Validation* module, which allows a reviser to validate the final database of the municipality by checking if several conditions hold. If the data are correct and the reviser is satisfied with the quality of the data, the database can be copied to the final database where the data of all the municipalities will be stored, that is, the *E.I.E.L. database*. Note that there exist some geographic objects, like roads, rivers, railway lines, etc, whose geometry may extend through several municipalities. The pieces of them contained in each municipality are created separately as different fragments, so whenever one of such geographic objects is inserted into the E.I.E.L. database, the *Validation* sub-module must check whether a fragment of it already exists, and in such case join both fragments into one geographic object.

3.2.1.5 User Management Subtask

It involves the management of the user accounts for the applications implementing the previous set of modules. Each time one application of the systems is started, a user login and password is required. Only users with the required privileges can enter a given application. Besides, by storing information about the user whenever a tuple is inserted or modified, it is possible to know who is the responsible of each piece of information inserted in the system. Therefore, if an error in some value is detected, the process of contacting the user who inserted the data to correct the error is simplified.

As a final remark for the whole *Database Creation Task*, although a unique subtask allowing the insertion of geographical objects together with their alphanumeric information, one object at a time, would be simpler, the previous subdivision has the following advantages:

1. It allows each specialized group of experts to collect and introduce its data concurrently.
2. Specialized cartography users do not need to worry about alphanumeric characteristics of objects, while the remainder users do not have to worry about geographic data insertion.
3. It allows cartography users to have a global (geographic) vision of each municipality.
4. The expert who performs the *Geo-alpha Data Linkage subtask* behaves as a supervisor of the data introduced through the *Geographic* and *Alphanumeric Data Insertion* subtasks.

3.2.2 Database Maintenance Tasks

The *Database Maintenance* task involves the insertions, updates and deletions of data in the database once it has been created by the previous task, in order to keep its information up to date. Such modifications may be caused mainly by two reasons: changes in reality that must be reflected in the database and correction of errors that may be detected in the future.

The insertion of new tuples, now both alphanumeric and geographic attribute values must be provided. Alphanumeric values may be inserted in classical forms, while geographic values must be inserted through a digitalization graphic user interface. For updates and deletions, a previous step that locates the object to be updated or deleted must be done, which involves two sub-steps. First, a query, which may include both alphanumeric and geographic conditions, is issued to select a subset of the elements of the table. Then one tuple of the query result is selected. Once a tuple is selected it is either updated or deleted. Additional functionality may include the possibility of updating or deleting all the tuples resulting from the query.

3.2.3 Data Exploitation Tasks

The *Data Exploitation* task involves the exploitation of the information collected during the survey. It includes the generation of thematic maps, alphanumeric reports and statistics, as well as the generation of the database and the thematic map printouts required by the M. A. P. every five years.

For the scope of this paper, a *map* is considered as a set of graphic elements (each one with a set of visualization properties, like color, style, filling pattern, etc.) obtained from another set of geographic objects, where the visualization properties of each graphic object is obtained as a function of the alphanumeric attributes of its correspondent geographic object. The Data Exploitation Module allows the users to generate predefined maps and to define, in an ad-hoc manner, maps from the information in the database. Such maps can be visualized on the screen, printed out or even exported to some kind of graphic file format, like images or CAD files. It also provides functionality for the generation of predefined or user-defined alphanumeric reports. Such reports may range from simple queries to complex statistical data analysis.

4. Integration into S. I. T. P. A. C.

The S.I.T.P.A.C., which stands for *"Sistema de Información Territorial de la Provincia de A Coruña"* (A Coruña Province Territorial Information System) will be a general information system, where some existing legacy systems of the Provincial Council of A Coruña are integrated with new applications like the *E.I.E.L. management* application. With such integration S.I.T.P.A.C. provides legacy systems with the ability to manipulate geographic references of some of their entities and with graphic user interfaces suitable for the management of such geographic references.

This information system emerged as an attempt to take advantage of the provincial geographic database resulting from the E.I.E.L. project and the technologies available in the area of geographic information systems to:

1. Provide some already existing legacy software with new functionalities, like the ability to manipulate geographic references of some of their entities, new user interfaces, etc.
2. Provide the *Provincial Council*, the municipalities and the general users with new services. Some of such services access some pieces of information through the World Wide Web.

The goal of S.I.T.P.A.C. is, therefore, to provide both the Provincial Council of A Coruña and each one of its municipalities, with a work environment, which makes easier the management (i.e., storage, maintenance and exploitation) of a huge heterogeneous set of both alphanumeric and geographic data.

In the following sub-sections, S.I.T.P.A.C. is described. Some preliminaries are introduced in Section 4.1, while the system architecture is explained in Section 4.2.

4.1 Preliminaries

4.1.1 Current Situation

One of the most important issues to bear in mind during the analysis and design of S.I.T.P.A.C. is the situation of heterogeneous characteristics found in the municipalities of A Coruña province. As an example already shown in Section 2, there are some big municipalities that have capabilities, and even software systems, to perform a wide set of tasks, like urban planning for example. However, some other small municipalities have delegated the majority of its tasks to the *Provincial Council*, thus, their software needs are clearly lower.

Regarding the existing legacy applications already working in the municipalities and Provincial Council, only the "*Rentas/Padrón*" (Income taxes/municipal register) and "*Gestion Tributaria*" (Taxes management) applications will be considered. The former is used by the majority of the municipalities to deal with the management of both the municipal register and the several taxes collected at the municipal level. The later is used by the Provincial Council to deal with the management of the several taxes collected at the provincial level. The goal of S.I.T.P.A.C. regarding such legacy software is to keep them.

The heterogeneous situation among the municipalities applies also to the set of data about infrastructure and equipment available in each municipality. Thus, some municipalities can provide a very detailed set of data while others cannot. For example, some big municipalities have detailed data about the water supply network, even with cartography in digital format, while other small municipalities cannot assert with precision where a water pipe is.

4.1.2 Required Functionality

Beyond the functionalities already available in the existing legacy systems, both the municipalities and the *Provincial Council* require the insertion into S.I.T.P.A.C. of additional functionality. Such functionality includes the following:

- Maintenance and Exploitation of the E.I.E.L. database. This functionality has already been described in Section 3. Only the Data Maintenance and Data Exploitation tasks are included into S.I.T.P.A.C.
- Tools to store and manage data regarding urban planning. Such data include both current and future plans. In addition, users must be able to study and design new plans with the available functionality. Such functionality must allow, for example, analyzing the impact that a new plan may have in the needs of development new infrastructures, like water supply systems, roads, etc.
- Tools for the management of information like tourist information, monuments, etc. Such information must be available through WEB, together with other information from S.I.T.P.A.C. that may be interesting to publish.
- Tools for the management of information regarding the immovable assets. Such information includes the owner of each dwelling and the corresponding information about sales and buys.

Note that it can be clearly identified a set of specific functionalities which are common to all the previous tools. Such functionality includes:

- The management of the privileges and access grants of different types of users.
- The maintenance of alphanumeric data.
- The maintenance of geographic data.
- The generation of thematic maps required by the users.
- The generation of various kinds of reports and statistics from the data stored.

4.2 System Architecture

In order to provide the functionality presented in the previous section, the S.I.T.P.A.C. system was designed as shown in Figure 7.

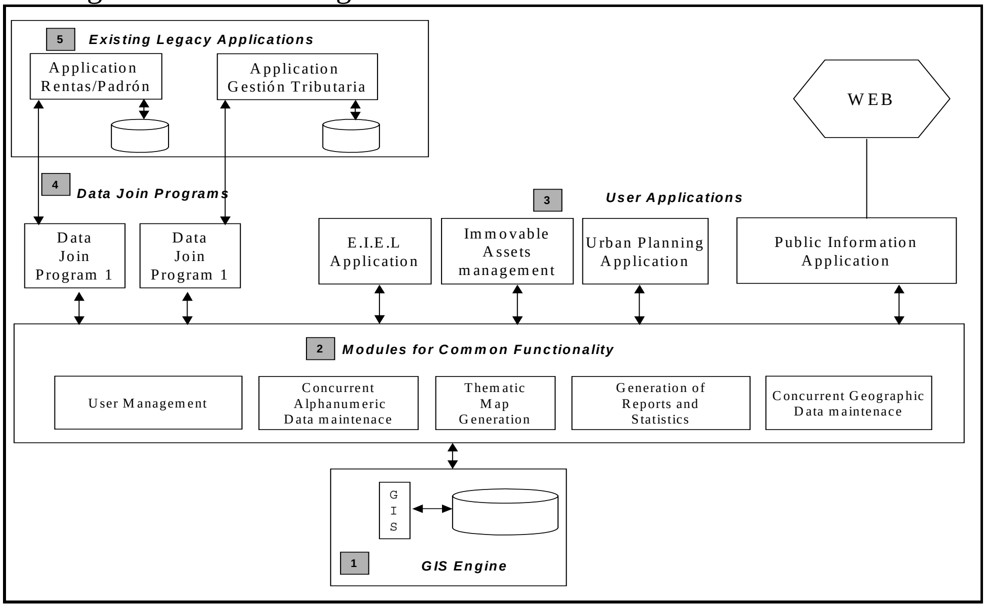

Figure 7: S.I.T.P.A.C. Software Architecture.

As it can be observed, the system architecture is organized in three software layers. The advantage of this modular design of S.I.T.P.A.C. is the increase produced in its scalability. Thus, new user applications that include geographic objects may be included in the system without having to modify the already existing ones.

4.2.1 User Applications

The functionality required from S.I.T.P.A.C., as presented in Section 4.1.2 has been classified into a set of different user applications, again, in order to provide the system with a modular structure. Such modular structure will allow the future expansion of the system with new user application without having to modify the current ones. Thus, the set of user applications to develop include:

1. ***E.I.E.L. management application***: This application automates the *Database Maintenance* and *Data Exploitation* tasks of the E.I.E.L. project. Those tasks have already been described in Section 3.2.
2. ***Urban Planning application***: It provides the functionality needed to generate and manage urban plans. Such plans will provide a classification of the land of each municipality into disjoint surfaces, depending on its usability.

3. ***Public information Application***: It allows the management of information which is interesting and worth to be publicly available. Such information includes tourist services, monuments, etc. and some other information coming from S.I.T.P.A.C. that the municipalities may want to publish. The whole set of information will be available through WEB by means of predefined queries.
4. ***Immovable Assets Management***: It allows the management of the information related with the collecting of taxes on Immovable Assets. Such information includes the identification of the owner of each dwelling together with the set of information related with sales and buys.
5. ***Data Join Programs***: These programs, one for each existing legacy application, behave as interfaces between the legacy systems and the S.I.T.P.A.C. modules of common functionality. They allow, therefore, to combine the data coming from each legacy system with data, both geographic and alphanumeric, coming from other applications integrated into S.I.T.P.A.C. Thus, as already explained, such data combination will enable to select an apartment on a map and get, besides its geographic position, information about it coming from the E.I.E.L. and information about it occupants coming from the "*Padrón/Rentas*" application. The functionality of such programs will include:
   - Link the information regarding the same object that comes from S.I.T.P.A.C. and the legacy system.
   - Visualize the geographic information stored in S.I.T.P.A.C. related with each specific object of the legacy system.

4.2.2 Modules of Common Functionality

As already mentioned in Section 4.1.2, there is a set of common functionalities that the majority of the user applications must support. Such functionality will be implemented in a software layer immediately behind of the user applications. Such software layer will provide all the user applications with such functionalities, preventing this way from having to implement it in each application and, more important, making the system more scalable. Thus, new applications may use the common services without having to implement them again and new common services used by new applications may be included in the system without having to modify the current user applications.

The present software layer includes the following set of modules:

1. ***Concurrent Geographic data Maintenance***: It will enable the users to modify the geographic data stored in the system. Note that even if a user has the maximum privileges, if she is using the E.I.E.L. application, she will not be allowed to modify urban planning geographic information. Among the functionality included in the present module, it is worth mentioning the capabilities to check geographic restrictions whenever a geographic value is modified. Thus, it will be interesting to check that a road is not modified to cross an area where the contour lines show that the slope is too high. In addition, there are some geographic values that are generated from other ones. As an example, a road line may be generated from the set of road stretches (stored as areas). Such derived information must be recalculated each time the source one is updated.
2. ***Concurrent Alphanumeric data Maintenance:*** This module is the alphanumeric counterpart of the previous one. It will enable users to update the alphanumeric data managed by each user application. Again, the module will check the correspondent user privileges and will not allow users of one application to update data belonging to other applications.

3. ***Thematic Map Generation****:* It will allow the users of each application to generate the desired thematic maps with the geographic data belonging to the application. Thus, an E.I.E.L. user will not be allowed to generate maps with taxes information coming from the urban planning application. Such thematic maps may be either predefined or defined by the user in an ad-hoc manner. The thematic map generation has already been described for the E.I.E.L. application in Section 3.2.3. The considerations explained there apply also to the case of the remainder user applications.
4. ***Generation of Reports and Statistics****:* It will allow the users of a given application to generate, either predefined or user defined, reports and statistics from the information relative to such application. Again, its functionality has been briefly explained in Section 3.2.3 for the case of the E.I.E.L. The considerations explained there apply also for the case of the remainder user applications.
5. ***User Management****:* It will allow the user administrators of each application to insert, modify or delete its user accounts. Thus, the management of the users of one application will be isolated from the management of the others. Besides the privileges assigned by this module, it will be necessary to define in each municipality a set of workstations, each one also with a set of assigned privileges. Thus, when an user is inserted, he can be assigned a workstation where he is going to work. This mechanism will make much simpler the definition of user accounts with the correct privileges.

4.2.3 Geographic Information System Engine

This software layer will include general tools to store and retrieve the whole set of data used by all the applications. Such information will be processed and given to the upper layer in the required format. Two commercial tools support the development of the layer. On the one hand a database management system will deal with all the tasks related to data storage and retrieval while, on the other hand, a geographic information system engine will treat geographic data in order to provide the upper layer with the required maps.

Regarding the information stored in the database, it will include both classical alphanumeric data and geographic data in vector format. Both types of data will be stored in the database in a uniform way.

5. Conclusions

In this paper, we have presented the development experiences of the E.I.E.L. project and its integration into the S.I.T.P.A.C. system. Thus, we have described the set of tasks performed for the creation of a huge database with information about infrastructures and equipment of the municipalities of A Coruña province. Furthermore, it was shown how the management of such huge database is integrated, together with already existing legacy software and other new applications, into the modular and scalable S.I.T.P.A.C. system.

Among the conclusions emerging from the previously presented experiences, we want to highlight the two following issues:

1. The new technologies available in the field of geographic information systems, allow the integration of some old reliable legacy systems with new applications that manage geographic objects. Such integration provides such legacy software with new functionalities, including:

- The ability to manage geographic references of some of their objects.
- Graphic user interfaces that make easier tasks like the visualization of the previous geographic references.

2. Beyond the classic database features, like query languages, concurrence control, transaction management, etc., obviously desired in the commercial geographic information systems, we found of special interest some specific functionalities that are not yet included:
   - The ability to check complex integrity constraints whenever a geographic objects is modified or inserted in the database. We have already mentioned the possibility to check if the slope of a given road is not too high. The information about the slope would be obtained from the contour lines.
   - The capability to define derived attributes by applying complex geographic algorithms to already existing ones. Such derived attribute would be automatically updated by the systems whenever one of the attribute from which derives is modified.

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