INTEGRATION OF GIS COMPONENTS IN URBAN MANAGEMENT APPLICATIONS

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Keywords: Information systems, GIS, Urban management, Analysis, Components, Reusability.

Abstract: This article describes the main functionality that can be included in GIS-based subsystems to be integrated in urban management applications. Our contribution is the description for the first time at the conceptual level of several GIS –based components identified in existent solutions to problems required by the needs of integrated urban management and increased urban quality of life. Analysis of these solutions provides a considerable potential to reduce development difficulties since it makes possible for less experienced software architects and analysts to reuse knowledge that has been tested and validated previously.

1 INTRODUCTION

Geographical Information Systems (GIS) are used in various domains such as natural environment, transportation, public administration, and others. On each of these it is indispensable to create a conceptual architecture for a given problem so that the application requirements can be related to a determined one. The concerned area within the urban management is the city, which is shaped by its own natural and built environment. It has road routes, constructions, open areas, climate, vegetation, population, and others. A city is a dynamic, living body where deep differences exist and need to be managed on behalf of its population's quality of life (Longley et al., 2001). Traditional representation systems, as the maps, are static even if made by a computer (CAD systems) because they represent the situation in the time they were produced. A GIS can generate dynamic maps keeping the reality evolution record from data collected in administrative tasks. To do so, management needs to see the city as a whole, putting aside its different visions and actions over the city. It is unique and sensitive to time changes (Johannesson and Wohed, 1999).Urban management has grown interest into GIS use due to the needs of integrated city management and to increase urban quality of life. However, the first challenge is getting human resources with technical skills to design, implement and maintain systems using GIS technology (Crisman, 1997). This is even more serious with users. Even an expert user usually faces significant difficulties using GIS tools. (Maziero et al., 2006).

In the development of quality-based software architectures with concerns regarding integration into domain and reusability the first observed feature is the great potential to reuse previous solutions (Dobrica and Colesca, 2007) (Dobrica and Ionescu, 2000). In urban management application domain the reuse solutions may be either from different departments inside the same administration, or even from different administrations (Dobrica, 2007). Analysis of these solutions provides a considerable potential to reduce these difficulties since it makes possible for less experienced software architects and analysts to reuse knowledge that has been tested and validated previously. In urban management the basic environment that compose the digital cartographic base may be reused by several applications.

GIS applications have some special requirements, but they must be developed using the same processes as any other information system (Lisboa et al, 1999, 2002) (Brisaboa et al., 2007).

Dobrica L., Ionescu T. and Colesca S. (2009).
INTEGRATION OF GIS COMPONENTS IN URBAN MANAGEMENT APPLICATIONS.
In *Proceedings of the 4th International Conference on Software and Data Technologies*, pages 75-78
DOI: 10.5220/0002260200750078

One of the many processes that are receiving attention is the use of a domain knowledge base that allow software components reuse, which is mainly the domain analysis community.

This paper analyzes several solutions applicable to requirement analysis and conceptual architecture modelling stages. Section 2 presents GIS technology concerns in the context of urban management application domain. Section 3 presents and analysis solutions of GIS components integrated in urban management information systems. Five solutions are described and analyzed based on a comparison framework. They were identified by researching in the literature of the urban management applications domains. Section 4 is a discussion regarding the development and execution environments. It presents possible criteria to be considered when these environments must be decided. The last section concludes with the main contributions and the perspectives over future work.

2 GIS IN URBAN MANAGEMENT

A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions.

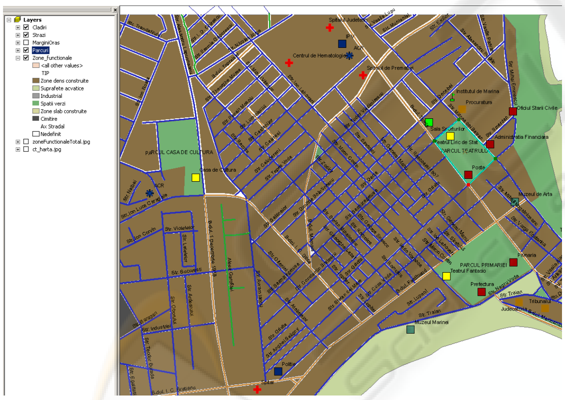

Figure 1: A map document of a Romanian city with several data layers.

GIS organizes geographic data so that a person reading a map can select data necessary for a specific project or task (Figure 1). A thematic map has a table of contents that allows the reader to add layers of information to a basemap of real-world locations. With an ability to combine a variety of datasets in an infinite number of ways, GIS is a useful tool for nearly every field of knowledge. GIS maps are interactive. On the computer screen, map users can scan a GIS map in any direction, zoom in or out, and change the nature of the information contained in the map. They can choose whether to see the roads, how many roads to see, and how roads should be depicted. Then they can select what other items they wish to view alongside these roads such as gas lines, rare plants, or hospitals. Some GIS programs are designed to perform complex calculations for tracking storms or predicting erosion patterns. GIS applications can be embedded into common activities such as verifying an address.

Implementing a complex computer system in a large organization is challenging. Ensuring that each work process is clearly understood and modelled accurately requires a lot of time and attention. Complex implementations often get delayed and sometimes completely stalled from lack of industry, product, and system experience. Several methods are considered to ensure success when implementing new business systems. Among the most important works we can mention the efforts of the Open Geospatial Consortium (OGC) and ISO standards in defining software components to be reusable in many GIS applications (ISO/IEC 19101, 2002) (ISO/IEC 19107, 2003).

3 COMPONENTS AND URBAN APPLICATIONS

This section is a description of reusable solutions that could be considered for GIS-based technology subsystems for urban management.

3.1 Work Order Management

In order to design this subsystem an important factor to consider is the decomposition in units of the organization of the public department. The components of the subsystem are: *Concrete Operations Component*, *Alley Lighting Component*, *Streets Inspection Component* and *Streets Repairing Component*. The last mentioned component has been conceptually obtained by extending functional features of the *Concrete Operations Component*.

3.2 GIS for a Development City

The functionality of this subsystem is customized for searching for parcels, closest hydrants, plans, streets, and engineering drawings; viewing sale deeds and drawings; report generation; and creating mail-merged letters for notification. The application consists of four main components. *Component for*

Municipal Officials is obtained through a customization of the application framework that is provided by the integrated development platform. The customization must satisfy the requirements of municipal officials. *Component for public access* consists of Web sites for public access. *Component for emergency management services* is design based on the component libraries provided by the integrated development platform. The *Fire Inspection Component* implements the logic of an user interface that lets fire inspectors without any GIS training or experience easily add data.

3.3 Management of the Natural Resources

The management of the natural resources requires maintenance, protection, and replacement of trees (ESRI, 2006). Also it requires the identification of hazards, such as dead branches that overhang parking spots, streets, or sidewalks, and the remedy of these hazards in a timely manner before they cause injury or damage to property. Examples of hazard identification are locations where tree roots are lifting sidewalks and driveways, situation especially important to the elderly. Mainly the *GIS Subsystem for Urban Management* performs a detailed and comprehensive street trees inventory. The inventory tracks data regarding species, size, location, and tree condition. It is important that this information must be easily accessible for managing the maintenance priorities of the tree crews.

3.4 Analysis of Urban Traffic

A GIS-based traffic analysis subsystem may produce spatially oriented diagrams of accidents where they happened, whether at intersections or midblock. Midblock accidents are accidents that occur between intersections. In order to provide such a capability this subsystem must query a database for all the accidents that have occurred at a selected intersection or midblock location. The data stored in the database contains all the characteristics of an accident, including accident type, vehicle direction of travel, street names, vehicle manoeuvres, and so on. The subsystem analyzes each accident and places it in the appropriate location on the map. The map view can include any additional features that the analysts want to evaluate. These features might include edge of pavement, road centerlines, or signs. An urban traffic analysis subsystem help to improve the safety of the citizens and the function of the city roads by providing an accurate diagram of the places where these occur and by identifying factors that contribute to their occurrence.

3.5 Workflows and Data Management

A new organizational strategy moves geographic information system (GIS) functionality away from desktop software and onto the Web (Colesca and Dobrica, 2008)(ESRI, 2007). This makes the management of updates and adjustments to the GIS easier. Four components are considered. These are *Inspector Activity List Component*, *Public Works Management Component*, *Thematic Map Generator Component*, and *Mailing Address Report Component*. *Public Works Management Component* is obtained by generalizing *Gas Valve Maintenance Component*. *Thematic Map Generator Component* provides a Web accessible user interface. The first two components give access to property and utility data, respectively. The third component creates real-time maps of utility assets, and the last on is used to notify residents of upcoming construction.

4 DISCUSSIONS

The selection of the development environment for the GIS-based subsystems depends on the achievement of the following important technological constraints: (1) it should allow the integration of the current Web practices into the components of the GIS subsystem; (2) it should provide access to a library that enables the creation of a customized GIS component that solves problems; (3) it should provide users the ability to manage map layouts so they can control and manipulate maps effectively. Also the integrated development platform is established such that it allows seamless integration and interoperability with various database technologies.

Execution environment selection is another issue of concern. A decision regarding this must consider the reuse of existent assets of the current information system of the organization (for example, the reuse of the data server that contains databases of other applications). Execution environment selection may consider a mobile one (laptops, PDAs) and wireless communication solutions. Some of GIS components are designed to provide Web access to the city citizens that can use them for various services such as information retrieval or to send requests regarding public domain quality usage. Subsystems that integrate GIS-based technology often require a higher level experienced personal. Under this circumstances training activities must be planned.

Data models for urban management applications are customized based on a general model. All data are stored in the relational database. So, the data transfer among standalone software applications can be realized directly through database connections. Since the relational database supports relationships between its tables, feature-to-feature spatial connections can be set up among the GIS data layers together with linking and joining of external data tables

5 CONCLUSIONS

In urban management information systems there is a high potential of reuse of solutions that have been applied with success in other departments of the same organization or other cities. One particular property of GIS subsystems is that usually the data handled by these subsystems have a strong relationship among each other, because they describe geographic phenomena about one specific geographic region. The data type set that usually creates the geographic data for one GIS subsystem has a conceptual structure alike other GIS subsystems. This particular property makes GIS subsystems strong candidates to benefit from reuse of existing designs.

Our study has an immense potential to improve municipal management applications using GIS, as well as reduce time and therefore costs in stages such as requirement analysis and software architecture conceptual modelling. However, for this approach's success it is necessary to create a cooperation culture among researchers and system developers. Reusability of a good and practical documented solution is a very attractive and useful idea. A good solution doesn't need to be original and innovative, but much important is that this solution should be a tested and validated one for well known problems. In urban management applications domain there are no unique problem solutions. Knowing the best practices that have been a success for other cities is an advantage.

ACKNOWLEDGEMENTS

This work is partially supported by the Romanian research grant CNCSIS IDEI no. 1238/2008.

REFERENCES

Chrisman, N., 1997, *Exploring Geographic Information Systems,* NY: J. Wiley & Sons.

Cardona, L. F. M., 2007, Using ethnographic techniques to describe requirements engineering processes in geographic information systems workgroups, In *ICEIS 2007*, INSTICC Press.

Colesca S.E., Dobrica, L., 2008, Adoption and Use of E-government Services: The Case of Romania, Journal of Applied Research and Technology, Vol. 6, No. 3, December 2008, pag. 204-217.

Dobrica L., Ionescu T., 2000 Software System Development and Evolution Based on Improvements of Non-Functional Quality Attributes, *U.P.B. Sci. Bull., Series C*, pg. 87-98, Vol. 62, No. 3.

Dobrica, L., Colesca S.E., 2007, An approach towards competitive cities in knowledge-based societies, *Procs. of the IADIS International Conference e-Society 2007,* IADIS Press.

Dobrica, L., Considerations about cities' websites evaluation, 2007, *Procs. of the IADIS International Conference e-Society 2007*, IADIS Press.

ESRI, 2006, *GIS best practices for public work*.

ESRI, 2007, *GIS for Sustainable development*.

Longley, P. A., M. F Goodchild, D. J.,Maguire,and D. W. Rhind, 2001, *Geographic Information Systems and Science*, John Wiley& Sons, 27–58, New York.

Lisboa F., J, Iochpe, C.; Borges, K., 2002, Analysis Patterns for GIS Data Schema Reuse on Urban Management Applications, *CLEI Electronic Journal,* 5 (2).

Lisboa F., J, Iochpe, C.; Beard, K., 1999, Specifying analysis patterns for geographic databases on the basis of a conceptual framework, *Procs. of ACM Symposium on Advances in GIS*, Kansas City, USA.

Johannesson, P.; Wohed, P., 1999, *The deontic pattern – a framework for domain analysis in information systems design*. Data & Knowledge Engineering, Vol.31.

Maziero L.P, Slutter C.R., Garcia L S., Ehlers C.P, 2006, Evaluation of user interfaces for geographic information systems: A case study, in *ICEIS 2006*, INSTICC Press.

OGC, http://www.opengeospatial.org

ISO/IEC 19101, 2002, Geographic Information—Reference Model, International Organization for Standardization.

ISO/IEC 19107, 2003, Geographic Information—Spatial Schema, International Organization for Standardization.

Brisaboa, N. R., Cotelo-Lema, J. A., Fariña, A., Luaces, M. R., Paramá, J. R., Viqueira, J. R., 2007, Collecting and publishing massive geographic data, in Software: Practice and Experience, 37(12) John Willey & Sons, Sussex (Gran Bretaña), pp 1319-1348.