Development of Telecom GIS Application Using an Active, Object-Oriented GIS Environment

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ABSTRACT

This paper presents our approach to the building an active layer on-top GinisNT. GinisNT is a scaleable, object-oriented environment for the development of GIS user applications. In paper we describe the architecture of GinisNT and architecture of Active Mediator layer. In Active Mediator project we research the best manner of coupling active behavior with existing database system. Also, paper shortly presents GeoTT, a telecom GIS application. GeoTT will be used for performance testing of Active Mediator.

1 Introduction

Geographic information systems are computerized systems for managing data about spatially referenced objects. GIS differ from other types of information systems in that they manage huge quantities of data, require complex concepts to describe the geometry of objects and specify complex topological relationships between them [1]. In addition, GIS data are typically used by various groups of users with different views and needs.

Most current geographic information systems assume and present the static world. Information that exists in the spatial database may be updated over time. Thus the sense of geographic changes and dynamics through time is not evidenced, maintained and represented with GIS. Also, geographic information systems are not capable to detect the changes in spatial database. This limitation of current GIS capabilities has recently become the focus of growing research interests within GIS community [2].

New generations of applications, such as GIS, have much more demands in comparison to possibilities, which could provide traditional database management systems. The very important demand is time capability to answer to state changing in database. Solution for these demands is the active database systems [3,4,5,6,7]. Section 2 of this paper describes basic capabilities of active database systems.

The research group at the Computer Graphics and GIS Lab at the University of Nis, Yugoslavia has been developing GIS software for eight years now. One of the research directions pursued has been the development of GIS architecture suitable for the implementation of end-user GIS applications under very limited resources. This paper presents our approach to the building active layer under an existing OO GIS environment called GinisNT [8,9,10,11]. GinisNT is a scalable, OO environment for the development of GIS applications that is built on top of a relational DBMS the usage of which is made transparent to the user completely [12,13,14]. The goals of our research activities are defining ADBMS architecture, identifying the need for mediators in telecommunication network management, adding the active rules to the GinisNT spatial database and realize the active mediator level which perform active behavior of the GinisNT. In this paper (section 3) we present the architecture of GinisNT and discuss its components. This section contains details of the Active Mediator prototype, which provides the active functionality for the GinisNT environment.

Many applications use the concept of time. In telecommunications time is important as well. To support applications such as telecom GIS, DBMS need to have some support for time. In an ADBMS it is desirable have active rules that can access the time when event occurred. A temporal DBMS usually has extensions to the basic relational operations to support queries that use the time dimension. Part 4 of this paper presents GinisNT temporal extension.

Also, this paper presents the GeoTT - Geographic Information System of the Telecom Serbia, with the special accent on its use in the telecommunication network maintenance and line faults locating and repairing. The system accomplishes all user needs for management, planning and the maintenance of all telephone networks. It is based on the latest scientific achievements in the area of information technologies such as object-relational and active database systems. The system was developed in GinisNT environment. GeoTT uses Active Mediator and temporal extensions of GinisNT to perform maintenance, efficient work scheduling and accurate capacity planning of telecommunication network.

2 Active databases

Active database management systems (ADBMS) have been developed to support applications with detecting changes in database [3]. This includes support for specifying active rules that monitor changes to data, and rules that perform some control tasks for the applications.

Traditional DBMS are passive because application program initiated operations or user explicitly invokes them. Applications send request for operations to be performed by the DBMS and wait for answers. However, ADBMS are event driven systems where changes in database can be monitored by active rules. An ADBMS operation can be invoked, not only by events that have been generated by users or application programs, but also by external events such as changes of input values or time event.

Active database systems are primarily database management systems with the main task of storing large amounts of data and providing efficient access through a query language. Active rules are primarily used for monitoring changes in database. The rules can directly access data stored in the database.

In [3] required and optional functionality for an ADBMS is presented. Required functionality includes support for creating, modifying, activating and deactivating ECA (Event Condition Action) rules. The ADBMS must support event monitoring and storing events in an event history.

Two different approaches have been distinguished in incorporating of active behavior in databases. The first of them is using new systems/prototypes. However, it makes leaving existing systems and resources. The better approach is to expand existing database system with active behavior.

There are two approaches of coupling active behavior and existing database systems [4]. The first one is layer architecture, which makes new layer on-top existing database. The new layer implements the active behavior and database is treated as a black box for active layer. The second approach is integrated architecture, which means internal change of DBMS kernel. The advantages of the layer architecture are reduced time of implementation and the possibilities of using the existing database resources.

3. Architecture of GinisNT Active Mediator layer

GinisNT provides the basic GIS functionality found in commercial GIS software, with the additional advantages of flexibility and the ease of development of end-user applications. GinisNT provided support in OO modeling and design of the GIS application. OO model for the application can be developed by selecting some of the existing spatial and non-spatial classes from GinisNT class library, specifying new classes by inheritance from the existing ones or by developing completely new classes. The components of the system map the OO model of the application being developed into the relational schema and create necessary relations. As object creation, instantiation, update and retrieval operations are provided automatically, the user is not aware of the relational database used on the internal level. The architecture of GinisNT with Active Mediator layer is shown in Figure 1.

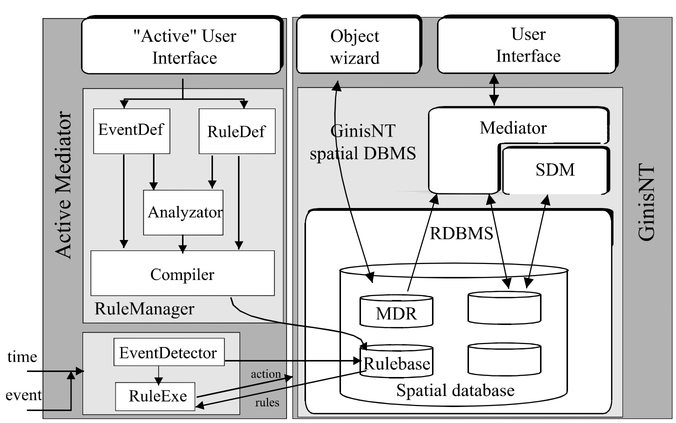

Figure 1. Architecture of GinisNT with Active Mediator layer

ObjectWizard is an OO CASE tool in which end-users can develop OO applications. ObjectWizard supports modeling phase, performs automatic mapping of the OO model of application into the relational schema, creates all the necessary structures in relational database and also stores definition of the application in the metadata repository.

User-defined schemas are stored in the Metadata Repository (MDR). The existence of MDR frees a user from the burden of memorizing database schemas and corresponding access mechanisms. ObjectWizard stores definitions of classes and corresponding information about tables in MDR when the classes are mapped into the relational data model. MDR also supports schema evolution. Users can easily change schemas even without changing underlying code manually.

The user interface provides means for communication between end-users and their applications, including the functions for displaying data (both attribute and spatial data). The user interface is configured automatically using information from MDR.

The Mediator [12,13,14] is component that interfaces between the end-user, metadata repository and the database. The Mediator manages attribute data (alphanumeric and other descriptive data), while spatial data is handled exclusively by the Spatial Data Manager (SDM). Mediator provides data persistence, version control and schema evolution. This component of GinisNT provides run-time application support by interpreting user demands, invoking appropriate methods and generating database operations.

As it can be seen on figure 1, the user could use only “passive” features of GinisNT environment using the users interface services. If the user uses active functionality, the possible effect of this action could be seen through GinisNT user interface. The active behavior is incorporated in Active Mediator using ECA (Event-Condition-Action) rules, which are part of database scheme [15]. The rules are defined at the same level as classes of application. This approach provides flexible control in different kinds of operation (low-level, methods, programs)

Besides C++ language as a GinisNT spatial database DDL, Active Mediator provides the Rule Definition Language for defining events, conditions and actions. The Active Mediator have to be capable for automatically and effective detecting primitive and complex events. After event’s detection, the Active Mediator performs rules associated with happened events.

The basic components of the Rule Manager layer is presented on figure 1 also. The Rule Manager provides all necessary tools for definition of active behavior. The RuleDef is a tool for rule definition, examination and connection with events, which are defined with EventDef component. EventDef is checking syntax and semantics of rules (using Analyzator functions) and suggest to the user how to correct the mistake. In this phase the EventDef component may define only primitive events but not complex events or transaction. After syntax and semantics checking, The Compiler translates ECA constructions to object definitions in GinisNT environment.

Event Detector controls all relevant events defined by user. After detection, the Event Detector sent message to the Rule Executor. This component read rules definition from the Rule Base. Every rule with signalized events is triggered and it could be activated. After that, rule condition is tested, and if the conditions are satisfied, the action can be executed. The Event Detector in this phase provides detecting only for primitive events.

The active features are integrated in existing object-oriented model. At this stage, rules and events is modeled as classes and implemented in C++. Using GinisNT services, the definition of events and rules are kept in GinisNT database as objects.

4. Temporal extension of GinisNT system

GinisNT temporal extension [16] is based on temporal hierarchy with class Temporal feature as a top-level class, and multiple inheritance as one of the core concepts of object-oriented paradigm. Temporal classes for time instant, time period, time duration, and complex time object are specialized from the base. The class definitions include appropriate temporal data such as year, month, day, hour, minute, seconds, etc, temporal reference system, as well as temporal topology operators and general purpose temporal functions. The class of particular spatiotemporal object is specified via multiple inheritance from appropriate feature class describing its spatial properties and the temporal class describing its temporal characteristic. Thus, according to mechanism of object-oriented inheritance, the spatial and temporal dimensions are integrated within single class abstraction in addition to concentrate thematic attributes and operations specified for that class of spatiotemporal objects.

5. GeoTT application

National Telecommunications Company of Serbia "Telekom Srbija", department of Nis, is responsible for providing local, long distance and international telephone services. Operational area of Department of Nis covers 4600 km^2 and includes about 60 larger inhabited places. There are 65 telephone exchanges, which provide local, long distance and international telephone services for about 100000 subscribers in this area. The total TT (telephone telegraph) cable length is 995.88 km, with 960 terminal blocks and 5495 manholes. 266356.3 km of pipes is built in cable conduits (cable sewerage system). About 160 people work in the Department for local network exploitation and maintenance and 10 people work in the section for technical documentation maintenance. This section maintains documentation for 172 cable routes.

Planned maintenance, efficient work scheduling and accurate capacity planning of telecommunication network are all critical to network performance and reliability. Any of the actions on the network can not be realized without network technical documentation, so the quality and the documentation manipulation may affect in the cost and efficiency of the network maintenance.

Because of that, Department of Nis Telecom required a powerful, flexible system, which would be able to integrate various sub-systems. Having in mind mentioned facts, Computer Graphics & GIS Lab at the University of Nis developed the specialized geographical information system, named GeoTT, to the Telecom Serbia. GeoTT is a specialized system for graphical inventory of the local TT networks. This system provides the following activities [17]: (1) geographic background preparing; (2) input, maintenance, retrieving, and displaying local TT network data; (3) document generation; (4) statistical report production; (5) user's requirement processing; (6) coupling GeoTT system with other information systems from the environment.

The user interface chosen for the GeoTT system uses direct object manipulation, WYSIWYG, icons, menus, and other up-to-date, advanced techniques, which contribute to communication facilities, successful choice of desired function, or setting certain parameters (figure 2). Geometric entities stored in database could be previewed, edited, and printed. The TT structure is permanently evolving. The new subscribers' telephone numbers are added, new cables are laid, new exchanges are put into operation, new external terminal blocks, and connection and junction boxes are also added. All these changes are directly entered into the GeoTT system database.

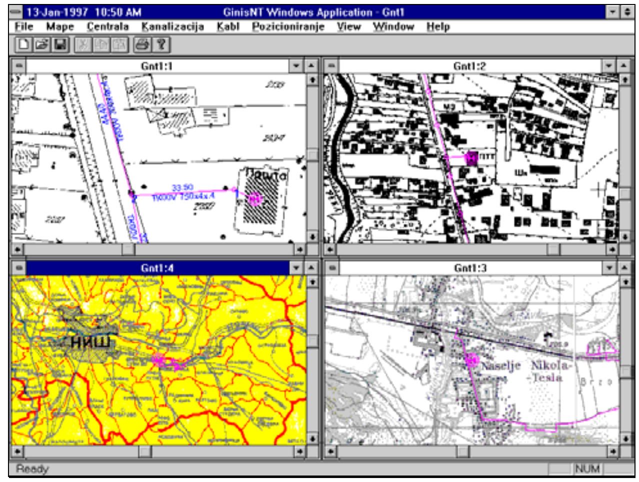

Figure 2. GeoTT user interface

In the sections for TT network maintenance, GeoTT system helps with fault locating, as well as with statistical management. GeoTT enables operators to navigate trough entire TT network structure to pinpoint the TT network part on local maps their are interested in. Operators could choose this part on the basis of any data on TT network or subscribers (for example, telephone number, external terminal block address, subscriber's name or address), or on the basis of any geographical data (coordinates or view list). If the operators do not have any of this data, he could scroll or zoom any part of the TT network, overview the TT network in many windows (multiply document interface) with different scales. Map-based screens allow the network to be viewed 'in place' on the relevant urban maps (Figure 2).

In GeoTT database the active rules are defined for different simple or complex events. One of them is simple event, which check and verify adding/updating data in GeoTT database. The complex events can activate different kinds of procedures. For example, adding new subscriber in GeoTT database may cause updating of all corresponding data in terminal block tables; changes in data about telephone exchanges can reflect in numeration of all corresponding telephone numbers. Also, GinisNT Active Mediator is applicable in bridging GeoTT database and databases in other Telecom parts. The events in GeoTT database can be time related. Time related events could be used for signalizing of time relevant changes of data, such as data about subscriber accounts.

6. Conclusion

Active temporal GIS would improve understanding of the dynamic geographic processes caused by man, the nature or both, provide methods for detecting and analyzing trends and cycles in geographic phenomena, an would enable prediction of the future geographic states.

The telecommunication networks consist of the infrastructure and the equipment needed to provide different telephony services. There are many different needs for DBMS in the area of telecommunications. Also, there will be a need for integrating different heterogeneous databases in telecommunication networks. Future telecommunication networks will have very complicated monitoring tasks that need to be supported. Because of that, the role of Active DBMS is very important. Using an ADBMS to store network data makes it possible to monitor changes to the network data through the database. The GeoTT is a great example of telecommunication network application.

GeoTT system presented in this paper is intended to input, store, retrieve and show data on the TT network. GeoTT is open, object-oriented, specialized information system based on a new accomplishment in the object-relational and active database and GIS technology [10-16]. The tool, which could be effectively used in the TT network evidencing, management and maintenance is obtained thanks to these technologies.

GeoTT system with its spatial and active dimensions (provided by GinisNT environment) provides many advantages compared with the traditional solutions. Some of these advantages are:

- GeoTT gives control of the entire TT network infrastructure up to the telephone cable pair.
- GeoTT integrates the most important technical estimates (distance calculating, coordinate translating and the other ones).
- GeoTT offers automated transfer of data from the acquisition device to the database.
- GeoTT offers precise data interpretation, graphics and many views on data.
- Data security is on the highest level.
- Data consistency is provided.
- Maintenance process is very simple and fast.
- GeoTT provides spatial queries and analyses.

In the next phase of development we propose using mobile information. We could transfer any part of the TT network in mobile computer and the maintenance team could use this information in the field for decision making in a particular situation. Maintenance team inputs data on each intervention on a particular place into a mobile computer. At the end of a day this information is downloaded into the main database. The section for subscribers' relationship will use the information, which are now placed in rib and terminal block documents. GeoTT makes possible the decision making about the future subscribers' relationship. Technicians could determine all the possible solution and choose the best one without going out into the field.

We also plan to upgrade GeoTT with functions, which will offer dynamic monitoring and control of the TT network developing. In this way, GeoTT system will provide daily accurate data. There is one more phase in the TT network life cycle. It is planing and designing. GeoTT will help develop of new TT networks.

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