GINISED – Geo-Information System for Support of Evidencing, Maintenance, Management and Analysis of Electric Power Supply Network

Leonid Stoimenov, Aleksandar Stanimirović, Miloš Bogdanović, Nikola Davidović and Aleksandar Krstić

Abstract - This paper presents GINISED – geo-information system which is realized to support of control and management of electric low-power supply network. The paper presents basic functionalities for network management of GINISED system. Also, its integration with enterprise IT systems is described and a use case of calculation of distribution network losses.

Keywords - Geographic Information System, Electric Power Supply Network, Distribution Network Losses.

I. INTRODUCTION

The functioning of companies engaged in the transmission and distribution of electricity depends on the existence of appropriate electric power supply network geo-data [1]. It is estimated that more than 80% of data used in a variety of processes (network design process, data input and update, maintenance and various analysis) has geographic (spatial) component. Therefore, almost any electric power supply company has a need for the existence of specialized geo-information system that should provide mechanisms for collecting, storing and manipulating spatial data.

Geo-Information Systems (GIS) are being widely used for more than forty years. They have found their purpose in environmental monitoring, transportation management, public safety, facility security, disaster management, etc. GIS enables us capturing, storing, analyzing, and displaying geographically referenced information. It allows us to view, understand, query, interpret, and visualize data in a way that is quickly understood and easily shared. GIS technology can be used for scientific research, resource management, and development planning.

GIS applications enable connecting various types of information in the spatial context and generating new information and conclusions on the basis of these connections. GIS enables fast, accurate and unique presentation of network data. GIS output of electric network can be viewed and easily interpreted compared to any other system output. GIS technology promises benefits not only in increasing operational efficiency but also in improving policy design, decision making, communication, and dissemination of information.

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The business processes such as network planning, network study, repair operations, maintenance, network changes, connection, and disconnection are based around a network model. Consider a typical power outage scenario; when an outage is reported from SCADA/DMS or any other real time system, an integrated GIS system with the help of its unique prediction engine can identify the most probable part in electrical network (ex. device, feeders etc.) along with the location of problem immediately. It will also report the network that may have been affected downstream to it. A customer service representative will know quickly what the problem is and be able to tell the customer ap-proximately how long it will take to attend. Meanwhile, crews can go immediately to the scene with the proper repair equipment and make repairs in considerably less time.

GIS can help in day-to-day operation and maintenance as it provides the accurate, reliable spatial and non-spatial information to the utility operational staff. It can help engineer in finding most optimum route to take for inspections or maintenance jobs. In addition to added functionality, integrated GIS may be easier and less costly to support. There is no such requirement of having proprietary hardware, software platform, and special skills for GIS implementation. By virtue of openness of GIS, interoperability is easily possible with other systems.

II. GINISED – GIS FOR ELECTRIC UTILITY

For the needs of PD Jugoistok Niš, CG&GIS Lab, Faculty of Electronic Engineering in Niš, with the support Ministry of Science of Republic of Serbia, developed a geo-information system GINISED [1]. GINISED is a specialized geo-information system which, in addition to standard alphanumeric data concerning electrical parameters of electric power supply network, allows recording, processing, analysis and graphic presentation of specialized information about the electric power supply network, such as spatial data, temporal data, image and multimedia.

The main purpose of GINISED project is to apply modern GIS technologies and approaches in order to develop specialized tools for collecting, editing, visualizing and analyzing spatial data of distribution network. This system has three groups of tools [2]:

1. Tools for collecting (digitizing, computer scanning, recognition and vectorization, using GPS and other specialized devices, etc.) and editing spatial data of distribution networks.

2. Tools for visualizing spatial data of distribution networks in selected geographic area.

3. Tools for spatial analysis of distribution networks, potential or real events in distribution network and risk factors in selected geographic area.

GINISED basic components are:

• Centralized geospatial database – It allows thematic and spatial electric power supply network data storing.

• GINISED Editor – Desktop application for recording, searching and editing spatial and geo-electric power supply network data.

• GINISED Web – WebGIS application that allows quick and easy positioning on a specific geographic area, search and selection of parts of electric power supply networks. This application implements information integration functionalities and uses data from centralized geospatial database.

• (Open Geospatial Consortium) WFS and WMS [3] services and other Web services that provide electric power supply network data.

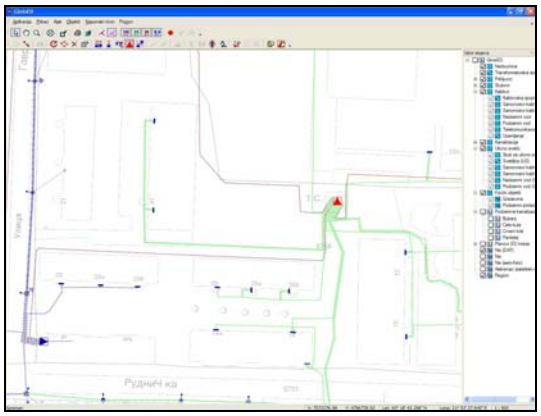

Fig. 1. GINISED Editor

As mentioned before, GINISED platform uses a shared central geo-database that allows integration and dynamic updating of multiple GIS data sources. This database is designed in accordance with broad accepted industry IT standards [4]. It can be extended, rearranged and customized according to customer's requirements. DBMS software can be chosen by the customer from any thirdparty RDBMS vendor (Oracle, SQL server, etc.). This geo-database has to fulfill two contradictory requirements: on one side, it has to be fully flexible, taking into account a wide variety of network elements and configurations, and on the other side, the data management has to be very fast and efficient.

GINISED system consists of two independent applications: Editor and Viewer. GINISED Editor is specialized tool for geographic editing of distribution network (Fig. 1). It is a desktop application developed in accordance with carefully studied needs and requirements of customers. It is used for creation and editing of geographic schemes of the network, editing parameters of network elements and their connectivity (Fig. 2). It provides multi-user and user-friendly, complete graphical environment for browsing and editing spatial data of distribution network with carefully chosen set of commands similar to popular vector graphic editors, but also with specialization for editing of the distribution networks schemes.

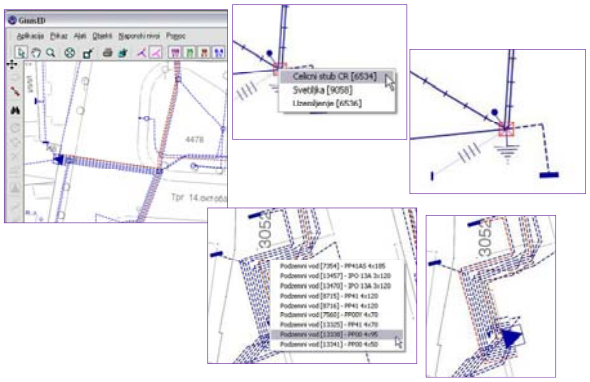

Fig. 2. Editing parameters of network elements

GINISED Viewer is Web GIS application with three-tier software architecture. This application, developed according to modern Web 2.0 standards, delivers feature rich user-interface (Fig. 3).

Fig. 3. GINISED Viewer

III. INFORMATION INTEGRATION AND GINISED

GINISED platform is developed using object oriented ap-proach and modern component technologies. GINISED system was developed using GeoNis platform for the interoperability of GIS applications [5]. GeoNis platform provides the mechanisms and infrastructure for the exchange of information in the environment of local government [6], but can be applied for integration of information on a single company level. This platform is developed for purpose of intelligent integration of information from a number of heterogeneous GIS (geographical and spatial) and non-

spatial data sources [7]. Companies, institutions or their parts that have some information of interest are considered to be data sources. This framework provides means for separating spatial visualization from spatial data sources. This is very important, because, these components make possible development of GIS applications capable to change their data sources and to dynamically build user interface according to user privileges.

Because of its openness, GINISED system is very easy to integrate with other IT systems within a single electric power supply company [7]. A true enterprise GIS for utility company means access to GIS that deals with geographically dispersed assets or customers by every employee. Many utilities consider the GIS system as the "ultimate" source database, acting as a common repository for all enterprise applications. This is done by integrating GIS technology into the mainstream business operations of the company.

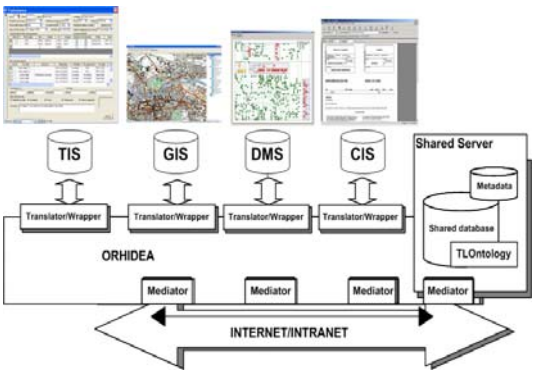

Fig. 4. GeoNis platform for the GIS interoperability

Electric power supply network analysis demands usage of technical information about the electric power supply network elements. In order to implement this analysis, GINISED application uses information from a number of heterogeneous and distributed information sources. The position of GINISED system among other information system is presented in Fig. 4. GeoNis platform is located between GINISED system, which operates as a C3 (Command Control and Communication) module, and relevant data sources. GeoNis environment nodes can be existing applications. For each of those applications, it is necessary to develop translators and domain (local) ontologies. Nodes may also be new applications developed in accordance with the OpenGeoSpatial standards and component software development methodology [3].

Once the Enterprise GIS is implemented it would act as the base system for all the organizational assets, and would cater to the requirements of other departments. The GIS electrical data model is designed keeping this as an important requirement. Enterprise GIS uses a shared central geodatabase that allows integration and dynamic updating of multiple GIS data sources. This considerably reduces the time-consumed for data update, increases the compatibility of data with other systems and also simplifies the translation issues. Since it is based around industry IT standards and web services the non-GIS applications and systems would be able to easily access GIS functionality, and GIS applications. Every system (for e.g. SCADA, Network Analysis, AMR, etc.) in a utility has a specialized role to play. The GIS system is never a substitute to any of these systems, but once integrated enterprise wide, it would enhance their capabilities, hence increasing the benefits.

IV. APPLICATION FOR LOW VOLTAGE NETWORK LOSSES CALCULATION

On the basis of developed GINISED system, which allows the integration of information from different IT systems in the PD Jugoistok Niš, a prototype application for calculation of losses in the low voltage (LV) network was developed. GIS module holds the central part in the application for the calculation of electricity losses. It is a downscaled GIS application that has retained only the minimum of required GIS functionalities. This application visualizes spatial data of electric power supply network and provides users with a simple interface to GINISED information inte-gration system.

For the purposes of analysis and calculation of losses, data from three different information systems is currently being used. Other systems as information sources will be added with the further development and improvement of the application.

GIS system is used as a source of data related to LV net-work topology and technical description of LV electric power line sections (section length, section resistance, electric power line type, type of conductor, conductor diameter etc). LV network spatial data was recorded in the field and is being regularly updated. LV network GIS data is related to information about consumers. CIS system contains consumer information. Integration of GIS and CIS allow determination of con-sumer's exact position on LV electric power line. It also allows determination of geographical location of connection that the consumer is related to. This enables easy identification of all customers related to particular LV electric power line.

When all consumers related to a particular LV electric power line are identified, their unique consumer codes are used as input data to obtain their daily load characteristic diagrams from AMR system. AMR system uses modern electronic consumption meters. These meters allow storing of load characteristic diagrams for a period of time (load profile). Hence, load characteristic diagram is imposed as one of the basic analytical data for the calculation of energy balance and LV electric power line losses [8]. Figure 5 shows typical load characteristic diagram.

Based on technical information related to LV electric power line (section length, type and diameter of the conductors) and consumer load characteristic diagram, losses calculation module determines losses on a particular LV electric power line.

Losses calculation module is not based on approximate

methods. Instead, it uses recursive method for calculating the electric current that flows through each LV electric power line section [9]. This module uses LV electric power line data topology as graph (from the transformer station to the end consumer). This graph consists of transmission facilities, sub facilities and consumption meters related to company clients. Based on unique customer codes, daily load characteristic diagrams are obtained from AMR system. If daily load characteristic cannot be obtained, particular consumer is related to one of standard load characteristic diagrams.

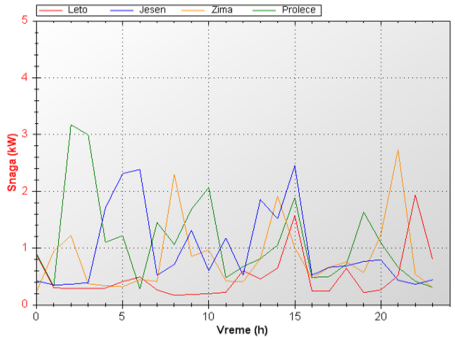

Fig. 5. Typical load characteristic diagram

Figure 6 presents data related to a particular LV electric power line used for calculation of electricity losses. It is possible to alternate LV electric power line section parameters (electric power line length, electric power line type, conductor type, number of cores and conductor diameter) and analyze how these changes affect the percentage of technical losses. It is also possible to define standard load characteristic diagrams for all four seasons.

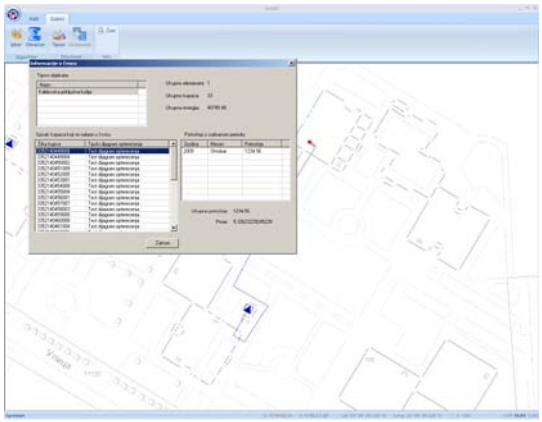

Fig.6. Application for calculation of electricity losses

V. Conclusion

Current Electrical Utility business trend is characterized by, change in market conditions, regulatory requirements/policies which require utility to achieve greater competitiveness and effectiveness. Utilities are beginning to see a need for IT business systems to collect, store, and publish various types of data, sharing data among them and to maintain consistency of data. Number of disparate systems exists to achieve specific tasks. Most of the utility companies implement IT systems like SAP, SCADA, DMS, AMR and GIS for their business operations. But, these IT systems are working in isolation with each other and data is main-tained and accessible to only those who use these systems. The main objective is to efficiently integrate IT systems within the enterprise, and GINISED GIS represents the step toward enterprise application integration within PD "Jugoistok", Niš.

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