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Developing an Algorithm on the Reporting Of Outages in the Electricity Distribution System with GIS Integration

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ABSTRACT

Modern Electricity Distribution Systems can use many auxiliary management and analysis systems actively and effectively, as well as communicating these systems with each other and obtain more specific and quality results. It is of great importance that systems such as OMS or DMS, which are used in this context, that have tasks such as management and analysis of outages in the Electricity Distribution System, are integrated with GIS, which contains spatial and non-spatial data in relation, and allows many spatial analyzes on these data. Especially the creation of a geometric network by obtaining the topologies of spatial data by GIS creates a connection model for the analysis of data with network characteristics and allows many analyzes to be performed. In this study, the algorithm for analyzing and reporting an outage in Electricity Distribution Systems with GIS integration is discussed. Considering that the Water and Gas distribution systems have similar characteristics with the Electricity Distribution Systems, what is stated in the study is also valid for these sectors.

1. INTRODUCTION

Electricity Distribution Systems assume the distribution role of a region's electrical energy need. The scope in this role is to transfer the electrical energy from the transformer centers to the demanders by adding the energy produced in the production facilities with medium and low voltage network elements to the distribution system under control. Many different information processing systems are used to fulfill requirements of Electricity Distribution Systems.

Considering that all elements in a dense and complex network such as Electricity Distribution Systems have spatial characteristics; It is understood that using GIS is a necessity for analysis, data management, graphic viewing and querying processes.

The Energy Market Regulatory Authority (EPDK) requests some tables from the relevant institutions regarding the Service Quality Regulation (2012) (URL3) on Electricity Distribution and Retail Sales. With the reporting created using these tables, controls are made regarding the practices, supply continuity, and the rules to be followed on the basis of commercial and technical quality.

In Electricity Distribution Systems, there are indices such as System Average Outage Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) that show the quality and reliability of the system and reports containing these indices. These reports are produced over the interruptions in the system and are regularly monitored in accordance with the applicable legislation.

Systems such as SCADA, OSOS, which are established to monitor and control the electricity network remotely, give warning signals for the de-energized region. The interruptions of these warning signals are processed in the database of the same system. Subsequently, reports are produced with the relevant data and the status of exceeding the limits determined for the relevant parties is analyzed both in this state and through other reports derived as a result of integration between other systems.

GIS, in which the topology of spatial data can be created and analyzes can be run by transforming it into a geometric network structure, constitutes the main data part of many reports to be obtained. The data generated in systems such as OSOS and SCADA at the moment of the interruption comes from the cabinets, transformers and feeders where these systems receive signals. The network elements in question are given unique codes

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defined both in the field and in the GIS data, and GIS integration is provided with this setup.

In case of any interruption, customers affected by the said integration can be identified and notified (Emiroğlu et al., 2007). Here, determination of customers affected in case of outage is possible with the network connection model created and stored in GIS. In addition, systems such as SCADA, DMS, OMS can produce many results, such as the state of energy flow on the network, the summary of the network elements affected by the outage, the grouping of the affected customers and the approach to find the real fault point using the grid connection model (Yıldırım, 2020).

2. SYSTEMS AND INTEGRATIONS

Many advanced information systems are used to manage and analyze processes in Electricity Distribution Systems, and to report analysis results.

Geographical Information Systems (GIS), which presents spatial and verbal data in a related way, serves many spatial analysis. It is able to create and analyze a very valuable connection model for infrastructure systems, thanks to its ability to store the topology of spatial data inside and transform it into a geometric network structure.

Modeling of the infrastructure and superstructure network networks in our world is possible with geometric networks. Electricity distribution networks are one of the flows that can be modeled by creating a geometric network (Anonymous, 2020b).

Supervisory Control and Data Acquisition (SCADA) is an information system tool used for remote monitoring, control and protection of the network in distribution systems processes (Taylor & Kazemzadeh, 2009). As a result of the integration of this system with GIS, a change to be made in the SCADA system that will affect the switch positions will be sent to the GIS side and change the flow direction of the geometric network. This is an important condition for accurate and precise reporting on the GIS data and using the geometric network.

Outage Management Systems (OMS) is an information processing tool that can perform operations on many processes, such as combining failure notifications delivered by customers, enabling analysis and estimation of interruptions, managing fault teams accurately and effectively, and determining reliability criteria (Taylor & Kazemzadeh, 2009). Nowadays, OMS and GIS integration has become a project that must be implemented for the development of Electricity Distribution Systems processes. Realization of this project provides positive feedback to the relevant institution in terms of customer satisfaction, practical and effective process management.

Distribution Management System (DMS) is used for the management of interruptions in distribution systems and also for reporting as a result of the management and analysis of planned or routine network operations. The need to transfer the energy obtained from production facilities such as renewable energy to the distribution systems and to carry out the demand-forecasting processes, which have increased in intensity with this development, increases the importance of DMS (Taylor & Kazemzadeh, 2009). GIS, in which data is obtained and managed with high accuracy and precision, is of great importance for DMS to provide maximum benefit (Chakravarty & Wickramasekara, 2014). With the integration of DMS and GIS, it will be possible to identify the regions and subscribers affected by the processes to be carried out or the connections to the distribution system. In addition, the connection model will be updated over the new network structure and power analysis can be performed.

As stated above, the capabilities of these systems will provide more benefits as a result of the integration they will create with other systems (Sekhar et al., 2008). This situation will return to the institutions as the optimum management of the processes and reaching the maximum level of earnings. Integration method should be selected by evaluating many criteria such as applications, systems and corporate policies that are or will be used by the relevant parties. As each integration method has advantages and disadvantages, these features are a reason for preference for the institution (Zhang et al., 2019).

Corporate Application Integration will provide added value by associating the applications in the organization and the databases that these applications process. At the end of the said process, there will not be duplicate data in the systems except for the integration areas, so the updating and maintenance needs of the data will be reduced and costs will be minimized (Singh & Caceres, 2004).

Each investment is carried out in order to provide profit for institutions. However, the success of the investment and therefore the gain to be made depends on a comprehensive and careful process analysis strategy. Defining the processes completely and placing the processes considering their relations with each other should definitely be done before deciding on the integration method (Dönmez, 2013). With the integrations to be made through these processes, business processes will be optimized and the efficiency and dominance of the working personnel will increase significantly.

The Common Information Model (CIM) method used by electrical distribution systems includes the relationships, classes and attributes of objects (Singh & Caceres, 2004). The first method that comes to mind as integration using CIM standards is to perform point-to-point integration by using relational connections between databases designed in accordance with the standard. The point-to-point integration method to be built between databases generally has a good connection performance and is implemented quickly. This method is found to be insufficient in terms of performance and maintenance when improvements need to be made on the database and new systems need to be included in the integration. The method should be implemented among limited systems or used temporarily until a more suitable method is adopted (Dönmez, 2013). Even if this integration method is not used completely, it will be beneficial to design the database structures of the systems that will require integration in accordance with the CIM standard design.

In summary, the Enterprise Information Architecture (EIA) method is one of the architectures that allow multiple data sharing support, and stands out with its flexibility and speed. Systems are communicated with each other by using a third software in architecture. Corporate information systems structure generally consists of commercially diverse applications and systems. Considering this difference, realizing the integration between systems with a third software is the first challenge to be encountered in the process.

Enterprise Service Bus (ESB) is a software architecture that controls and directs system data to communicate with systems. There is no need for a code writing such as EIA architecture and a third software for this communication. Communication between systems is carried out by the transmission of messages or data in a structure similar to a physical computer bus. Messages and data must be transmitted in a format that each system can understand. A common planning should be made for all systems within the institution before moving to the ESB architecture. One of the main disadvantages for this architecture is the difficulty of finding comprehensive ESB developers.

It offers a Service-Oriented Architecture (SOA) method for the integration of separate types of systems in distributed environments (Dönmez, 2013). The most prominent features of SOA; Independence from systems and platforms can be defined as usability, reliability, flexibility and ease of maintenance provided that the services created meet the conditions specified in the required applications. In this architecture, unlike EIA, there is no need for a third software and transactional communication and data transfer methods are preferred instead of collective communication and data transfer principles. Of course, these features brought by SOA bring some needs with them. Its features such as security principles and being independent from systems extend the response times of services and require high performance hardware. Although this situation requires an important upfront investment, it creates extra costs. In addition, many transactional services to be created in each system in accordance with the needs may cause the service management to become complex.

3. ALGORITHM

The required information per deduction can be obtained by many methods derived from verbal tables prepared specifically for the subject or from a geometric network created using GIS data or from the cooperation of these two methods. The methods in question and the way these methods work manually or automatically can be determined after evaluating the relevant institutions and the systems and data they have. When all the related processes of Electricity Distribution Systems are examined, it is seen that the most appropriate method is to create a service that operates at specified periods or instantaneously using geometric network data. With this method, no extra intensity will occur in the processes, and the desired information can be obtained with high precision as a result of interruption.

The positions of the switching elements in the inventories of the Electricity Distribution Systems (open / closed) can be changed as a result of maintenance, repair, malfunction and investment works. Since this situation will also change the flow direction of the geometric network consisting of network data, instant operation of the analysis service is important for producing sensitive and highly reliable results (Yıldırım, 2020).

An outage in the network is detected by systems such as OMS or DMS and recorded in databases. There is a unique value in the outage data structure that will allow integration with GIS. This value will be processed or transmitted to the outage analysis service created by the GIS and the analyzes will start. The information or data required as a result of the analysis will be transmitted to the desired environment in the specified format.

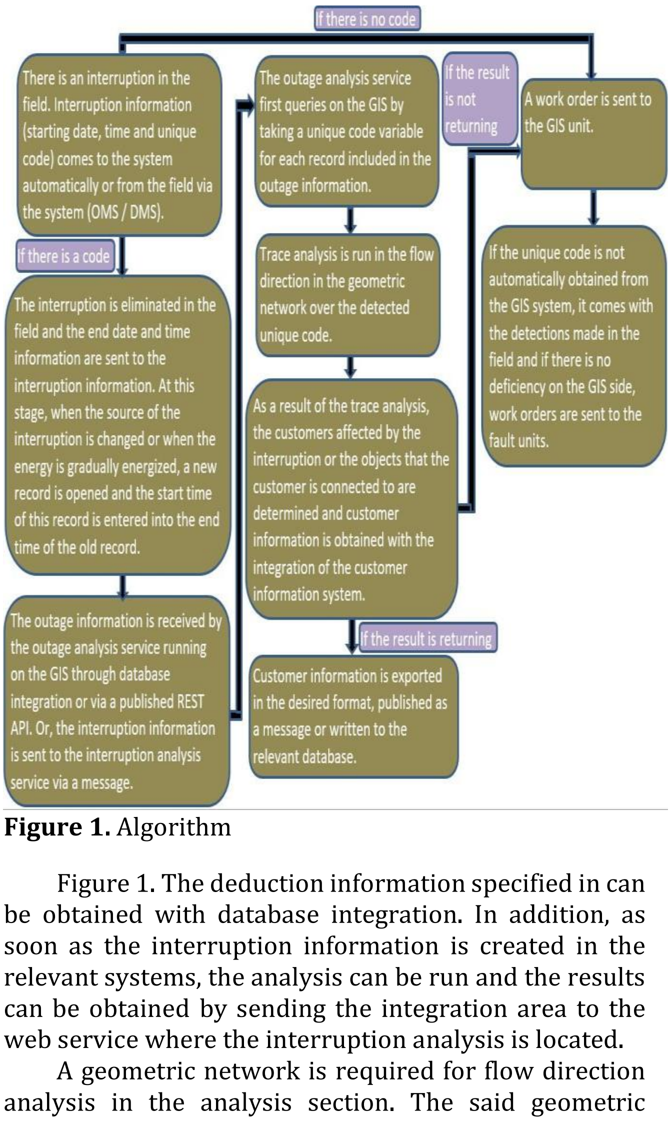

Figure 1. Algorithm

Figure 1. The deduction information specified in can be obtained with database integration. In addition, as soon as the interruption information is created in the relevant systems, the analysis can be run and the results can be obtained by sending the integration area to the web service where the interruption analysis is located.

A geometric network is required for flow direction analysis in the analysis section. The said geometric network is produced in GIS and many processes such as trace analysis can be performed in the flow direction or reverse.

The information or data produced as a result of the analysis can be sent to the relevant fields of the database from which the interruption information is received, as well as to a separate format or structure. In addition, analysis result information can be published as a message and can be used by many clients in accordance with their systems.

4. CONCLUSION

Many data processing systems are used to perform, manage and analyze and report processes in Electricity Distribution Systems. As these systems serve their own purposes, they can produce much more beneficial results and processes by communicating with other systems through integration. The integrations to be realized must be in accordance with the needs and current situation of the relevant institution.

Monitoring and reporting of an outage in Electricity Distribution Systems through systems such as OMS / DMS is carried out in today's technology. It is of great importance to report the number of subscribers affected per outage according to the quality and reliability criteria carefully followed by the relevant institutions and higher institutions. For this reason, it is necessary to integrate GIS and outage or distribution management systems, which can create, protect and analyze the connection model.

In this study, an algorithm is presented on how GIS and OMS / DMS systems can be operatively integrated to obtain the number of subscribers per outage.

With the integration solution produced by realizing the said algorithm, the subscriber and network elements that will be affected by any interruption can be detected instantly and reliably in accordance with the processes. Reports expected for the outage will be produced and actions can be taken to provide corporate-customer benefits.

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