Integration of SCADA, GIS, and Call Center Systems for Electrical Power Distribution Management and Planning

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ABSTRACT – In electrical power distribution systems the traditional methods cannot detect the customer fault location in real time and respond to customer complaints at the same time of the outage of the electric power because the required information is scattered among isolated databases. In this paper the combination of Supervisory Control and Data Acquisition (SCADA) and Geographical Information System (GIS) and using SQLCMD against DBSET has been shown to solve this problem better. This paper reducing the response time of the customer waiting when they calling the agent in the call center, creating a model for the integration of real time data in SCADA system against static data in GIS to make online GIS and send data from GIS to CALL CENTER at the same time. The prototype describes the flow of the data between various systems and integrates all in one logical database that contains all data about the customers. The proposed model depends on three major sub-systems: GIS, SCADA, and Call Center systems. The GIS system is base of the model so the change and update in GIS database is available, GIS provides different features like maps, real coordinates and tables. The model contains three different databases, GIS as geo database, SCADA as the real time database and call center as customer information database, all this database will be in one logical global database that contains of spatial information tables, asset information tables, topology information tables, and operation information tables. This method has been shown to significantly improve the accuracy and efficiency of fault detection in distribution networks and to decrease the response time in call centers.

Keywords - Geographical Information System, Supervisory Control and Data Acquisition, Call Center

المستخلص – الاعتماد علي الطرق التقليدية في أنظمة توزيع الطاقة الكهربائية لا يمكن من الكشف عن موقع الاعطال الخاصة ب العملاء في الوقت المناسب، والاستجابة لشكاوى العملاء في نفس الوقت من انقطاع الطاقة الكهربائية وذلك بسبب عدم توفر المعلومات في لحظة العطل في مكان واحد. هذه الورقة توضح ان عملية ربط انظمة التحكم والمراقبة مع نظام المعلومات الجغرافية يساهم في حل هذه المشكلة . وايضا نجد انا عملية ربط النظامين مع نظام مركز خدمات الزبائن يعمل علي تقليل زمن الانتظار والرد بصورة اسرع للزبون. تم بناء نموذج لتكامل البيانات في الوقت الحقيقي بين بيانات تعتمد فعليا علي الزمن مع بيانات ثابتة في نظم المعلومات الجغرافية للتمكن من تصميم موقع حقيقي في الزمن المناسب علي الطبيعة بالنسبة للزبون المتصل ب وكيل الرد في مركز خدمات الزبائن . يصف النموذج تدفق البيانات بين الأنظمة الثلاث نظام التحكم ونظام المعلومات الجغرافي ونظام معلومات الزبائن ويدمجها قاعدة بيانات في مكان واحد. نظام GIS هو قاعدة النموذج لذلك التغيير والتحديث في قاعدة البيانات ، ويقدم GIS ميزات مختلفة مثل الخرائط والإحداثيات الحقيقية والجداول ونظام التحكم والاشراف يحتوي علي قاعدة بيانات خاصة بالزمن الحقيقي لحدوث العطل .وقد تبين أن هذه الطريقة إلى حد كبير تساعد في تحسين دقة وكفاءة الكشف عن خطأ في شبكات التوزيع وتقليل زمن الاستجابة في مراكز الاتصال.

INTRODUCTION

The integration of real time data with the spatial data is very useful because it enables the status of the substations to reflect to the spatial area in real time so the fault in an electric line in a specific area will automatically appear in the call center database and the Call CENTER system answer the calling from this area instead of the agents. The database includes two parts real-time database and enterprise databases. Table 1 shows the comparison between real time and enterprise databases .The electric utilities have various isolated database as shown in Figure 1. The integration of the electric grid will create smart grid that enables all the data to be shared in one site so the

error in data decrease and increase the performance of the electrical network operations also the data will be available to use in planning information systems all this reflected to the decisions making [1].

The real time integration in electrical distribution systems depends on the correct information in time for this reason the nature of the integration should be contains all isolated systems that playing different roles to be in one database .The systems that play majority roles are SCADA for real time and GIS for spatial data.

Table 1: Compares Between Real Time and Enterprise Databases

no		Real time DB	Enterprise DB
1	No of Transactions Per Second	>100000	<1000
2	Latency Measured	microseconds	milliseconds
3	Management	centrally (administration, backup)	distributed for redundancy and speed
4	Business	Burdened with layers of business logic support	timing control
5	Data Formats	heavy weight (xml)	fast binary

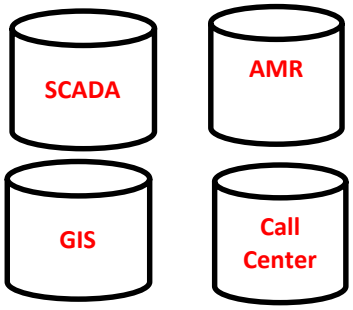

Figure 1: Isolated Systems

ISOLATED SYSTEMS DESCRIPTIONS

Geographical Information System (GIS)

Figure 2 shows the GIS structure, which is a computer-based system designed to collect, drawing, editing all equipments from their real coordinates to be in computer software to be easy for management, and analysis. GIS is used in different utilities so in electrical distribution is very important for reflecting all the network in computer software .GIS is used to link the complete electrical network assets from generation to the last point in the distribution network.

Supervisory Control and Data Acquisition System

SCADA is an acronym for Supervisory Control and Data Acquisition. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and energy, oil and gas refining and transportation. Figure 3 shows the SCADA systems transfer of data between a SCADA central host computer and a number of Remote Terminal Units (RTUs) and/or Programmable Logic Controllers (PLCs), and the central host and the operator terminals [2].

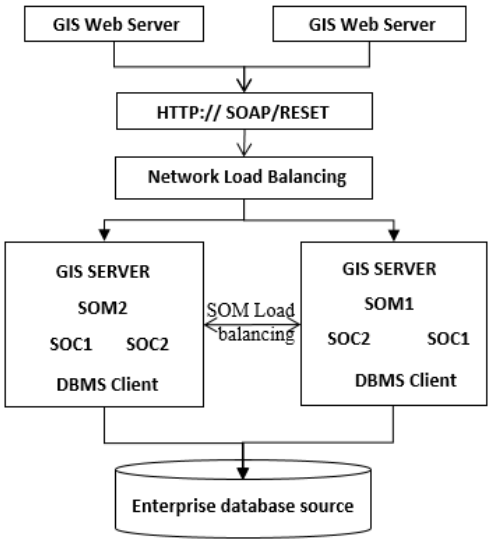

Figure 2: GIS structure

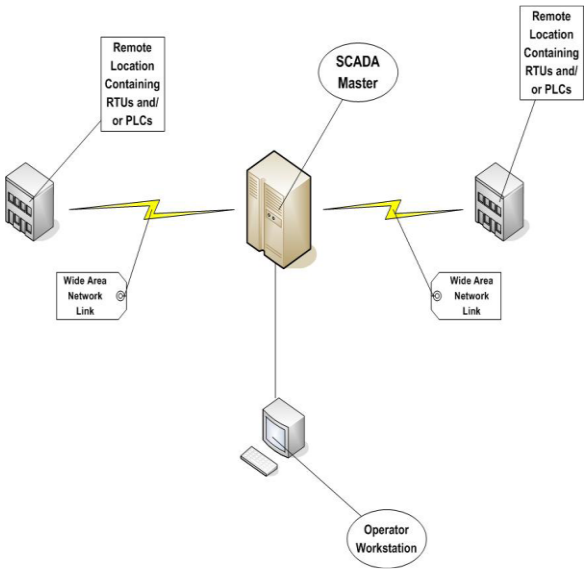

Figure 3: SCADA structure

Call Center is an application that handles incoming calls as efficiently and economically as possible. It answers calls and then routes the calls to agents that most closely meet the needs of the caller.

These three systems are heterogeneous and have very different natures and requirements. The electric distribution network should be in one interface because all operations are joined together but there are challenges represents in the ineffectiveness of island systems leads to a decrease in the performance, availability and scalability of data and that is represented clearly in:

Timely Access

The operation of access to information in time is core for the grid network so the detection of the fault location and answering the complaint from the customer depend mainly on the time.

Data Maintenance

the duplication of data in electrical grid means that the SCADA real time database separate in site so all the operation of the distribution substations isolated from the location of the feeders and transformers that will be in GIS database also the customer complaining information will be in various database. The problems of the integration of real time data are:

1. The database management system (DBMS) operation is based on the hard disk so the process for the transactions may take time.
2. The web services incapable to connect to the database at real time and send the transaction at real time.
3. The planning for operations and building real-time analysis database for the distribution grid not available because all the systems are isolated from each other.

LITERATURE REVIEW

Integration applications have been generating significant interest. In electrical utilities there are some previous papers focused on the integration of enterprise databases using different formats (windows providers, xml, export tools, etc.). Also, there is another methodology the Enterprise Application Integration (EAI) is used to integrate various applications as the middleware and it is used as the tool that used in the business-level but the user can not go deeply on the details of the applications, and there are no timing controls in this methodology [5]. On the other hand, there is another methodology using interfaces to integrate SCADA with GIS, this integration method depends on each software structure. The SCADA structure is complicated and the developer use only the interface, also the GIS is commercial software and very expensive and the developer find a limitation to design integration interface that used to cover the electrical distribution business needs because the nature of the needs not static [6].

Also there is another package used to integrate SCADA with GIS is called AM/FM/GIS. it is provides powerful capability to manipulate both graphic and non-graphic information facility mapping (FM) ,it is used to integrate with geo database to transfer all spatial data and connect with SCADA database to transfer the status of the electric grid and use the result for analysis [7].

In the electric distribution systems, the needs to integrate information regarding the distribution network topology against signal data that in the distribution substation is important for power flow analysis, network planning, line loss analysis [8]. The Power Supply has implemented the integration of distribution SCADA and GIS using emerging integration technology. This avoids data duplication and data redundancy in various systems. Thus, the overall maintenance and support cost would be considerably reduced. The distribution SCADA system provides the real-time data for the power distribution GIS system, and enhances the capabilities of GIS [9].

The integration of SCADA and automatic meter reading (AMR) it is enable to read the status of the feeders and send it to the control room also this data can be integrated with GIS systems to see the distribution grid because the SCADA application can not cover all the electric grid and the behavior of the SCADA only to monitors the change in distribution substations this integration provides accurate and smart grid pictures [10].

MODEL DESIGN

The memory is the core part of a real-time database. Its functions cover the database data model, data operation, real-time resource management, and network communication. RDBMS are designed to operate in the strict environment of real-time systems with strict requirements for resource utilization, and are ready to provide the performance and reliability required by real applications.

In implementation of the RDBMS for SCADA system all signal sent from the concentrator in the substation to the remote terminal unit and the data will be in the memory so all operation and monitoring recovered at the real time [11].

The integration of the distribution management systems needs to know all the parts about the systems that play roles in the electric grid and the infrastructure and format required for exchanging the information. That means it should depend on real time databases because it has the capability to send the request in time unlike the enterprise database.

Distribution GIS realizes the static model (distribution equipment, feeder, diagram) management. Distribution SCADA system realizes distribution network real-time monitoring and control. Distribution GIS serve as the enterprise equipment information input platform and provide equipment, network topology, for the distribution ledger, network topology, connection diagrams, and other basic information. Distribution SCADA provides real-time information.

The model, shown on Figure 4, depends on three major sub-systems, GIS, SCADA, Call Center systems and the Integration Framework. The integration design principles are divided into two groups. The first group consists of the configuration of the utility network by creating new features in the GIS database, new topology and a unique code shown in Figure 5. This design depends on the GIS system which contains the circuit topology (where components are, how they are interconnected, and some service, or customer information).

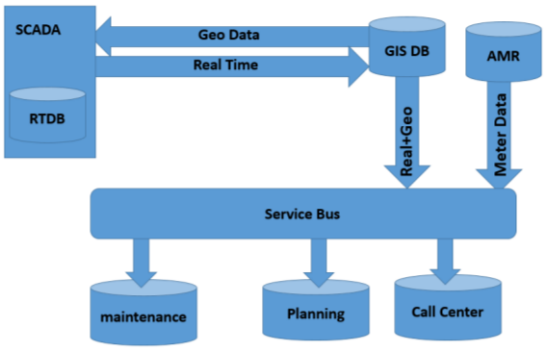

Figure 4: The integration model

Figure 5 GIS configuration topology

The major goal was to design Master GIS database that has availability to modify and create the tables and change the structures when any new change in business appeared in distribution network .GIS database systems store the grid information in a standard format. Also, has a facility to maintain, control, and generally manage the network. The design provides additional information about the network configuration.

The customer information database contains address and contact information of customers, service location, and billing information and other information that can be used in matching phone numbers of trouble calls to locations in the electrical network and the fault status of the grid. The second group of principles represents in the real time operational data in SCADA that obtained, in the electrical distribution system and integrated with the GIS database at the same time.

The model information uses DbSet.Local for in-memory stub data, based on parameter and link parameters with SQLCMD QUERY to send the unique feature code like (lines, cables...) to SCADA real time database this query access the data that is currently in-memory and return the status of the equipment in SCADA to GIS database. After that, the script sends the changes automatically to the CALL CENTER database.

RESULTS AND DISCUSSIONS

Integration of GIS with SCADA is an increasing trend. This increases operator efficiency with one system and eliminates the need to go to multiple systems with potentially different data. The integration SCADA, GIS and call center systems make adequate preparation for using mixture of data that has various natures to achieve one goal.

The SCADA database responsible of signal and status of the substations and medium voltage transformers, GIS has capability to draw the entire distribution grid in one interface with accurate locations like transformers, feeders, poles and meter location.

Real-time analysis would allow the electric distribution planning department to know, in detail what is happens and would allow the electric engineering team to take best action through the change in the distribution grid (Figure 6).The utility would be able to keep its Real-time analysis that allows engineers and operators to shift from static operations (based upon predicted scenarios) to active monitoring and control of the distribution grid.

Calculated present and very near term future values for voltage and current for grid elements that are not measured and monitored in real time. The platform provides powerful capability to manipulate both graphic and non-graphic information. It is an integrated distribution information system with automated mapping and facility management based on GIS platform. It integrates graphic representation of information with spatial relationship and information management for distribution system facilities.

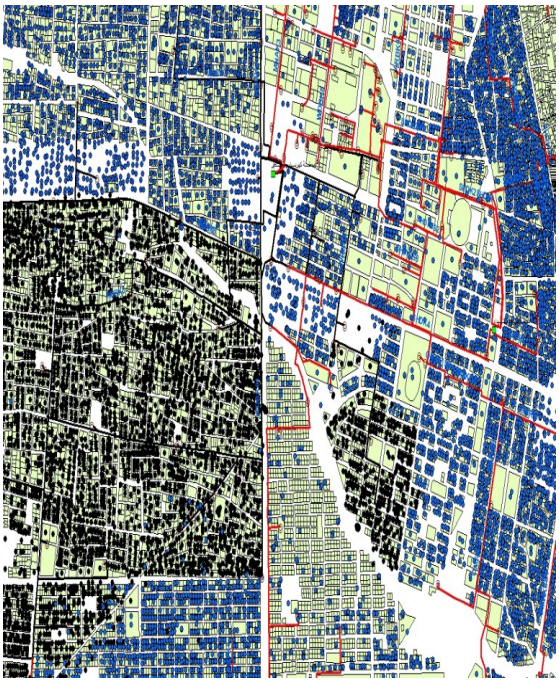

Figure 6: Display of the outage customer

a. Integration framework design to create online GIS
b. Outage location in distribution network by selecting coordination of the features protective to minimize the effort of searching a fault location on the network.

c. Get real-time information from the server of SCADA, such as telemetry data and power flow etc. showing them on the GIS based feeder map?
d. Determines the location of the feeder and the area which suffers a power outage.
e. Expectation of overloading of transformers along a feeder.
f. Fault diagnosis and finding the source of faulty system behavior.
g. Within no more than 7 seconds the status of the customers will be changed in customer services database (Figure 7).
h. The results obtained from a practical experiment prove that the system integration is effective, low cost and fast, as well as suitable for real-time application.

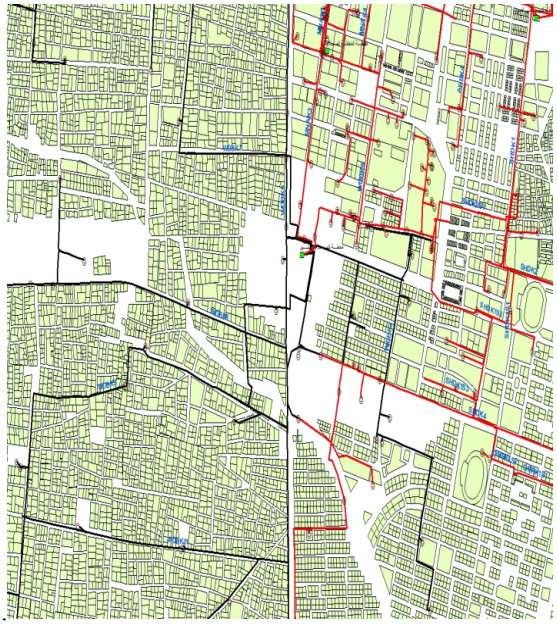

Figure 7: Black line is outage and red is not

CONCLUSION

The Data Base Management System becomes the source of information for Customer Services and the Maintenance and Repair Services of the electric distribution at the real time of the fault.The integration of the systems in on logical data base is also structured to provide easy and fast access to various user information.

The integration of these three systems would support decision-making by providing the right information at the right place at the right time.

The integration of the real time database of the SCADA and static database in GIS with CALL CENTER database open new side for new applications in electric distribution management to optimize the distribution network fault. SCADA serves as control and monitor over the distribution network and continuously monitors the integrity of the distribution network together with the remote synchronic-sensors to generate detailed information about the state of the network. The synchronization of the SCADA monitoring operation with the spatial data in GIS provides an accurate picture of how the actions of the outage happened. The wealth of information generated becomes a source and basis for new and advanced control functions designs that improve the customer satisfaction and the reliability of the energy delivery system.

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