2006-2301: EDUCATING OUR STUDENTS TO USE ADVANCED COMPUTER APPLICATION SOFTWARE TOOLS FOR MODELING, DESIGN, AND SIMULATION OF ENERGY DISTRIBUTION NETWORK

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Educating our students to use advanced computer application software tools for Modeling, Design, and Simulation of Energy Distribution Network

Abstract

This paper will present a new course organization and contents, and covers topics on educating and teaching our students on how to use advanced computer application software in classroom and laboratory environment to learn and improve their ideas for modeling, simulation, and design of energy distribution systems, especially in the areas of power distribution network. Advanced computer applications will be used for teaching and research in the areas of residential, industrial and commercial systems. The paper will focus on teaching and learning, and covers such areas as course development, organization and content; laboratory equipment and experiments; design concepts and ideas; software tools available; and the student projects. The proper application design using current industry standards and available software will be targeted for teaching.

Rationale for developing a new course

Some major concerns being faced by teaching courses and laboratories in the areas of energy distribution network particularly in the area of power distribution network. Some of these concerns are:

1) Not enough practical hands-on software tools are introduced to the students; and
2) How do we teach our students to model the power distribution network grid system; and
3) How to design and simulate the power distribution network system; and
4) How do we provide as set of decision support tools; and
5) Learn how to better use these software tools so that for example you can affordably and effectively manage outages in the energy distribution networks, given decreasing resources; and
6) Learn how to cost-effectively integrate existing information systems so that they work collectively to support business activities such as diagnosis, scheduling and repair planning.

Course Objectives

The course will focus on fundamental and selected advanced topics for Energy Distribution Network (EDN) management, in particular power distribution network, including system modeling, system integration, information fusion, and criteria in data base selection and design. The objectives will prepare the students with sufficient background for the concepts of EDN management, with enough hands-on experience to model and manage any EDN system, and with enough theoretical background to do independent study and research on EDN system related topics.

Course Organization and Content

The following table describes the organization of the course and its content in detail. Even though this material is designed for a quarter long systems, it can easily be expanded to a semester long systems.

Duration	Description of the course	Application Software
Week 1	EDN Overviews • From Generation to Distribution	
Week 2	Existing EDN vs. Future EDN systems • Problems with existing EDN systems • EDN System Analysis • Future directions and improvements	
Week 3	Substation Design • Substation Components • Using CAD software tool to build the Standards	AutoCAD
Week 4	Switching Selection and Design • Remote Vs. Manual • Breakers • Sensors and their allocation	
Week 5	Load Analysis and Calculations • Load analysis • Load distribution	CYMDIST
Week 6	EDN Models • EDN components • Model selection criteria • Software tools (UML) for models	UML Visio Rational Rose TogetherSoft
Week 7	Information Fusion (Data Systems) • SCADA • CIS • GIS • GPS • AVL • IVR and Trouble Calls	FTAlarm FTDataWin MySQL ArcGIS ArcView ArcSDE LAS 3100 Lassen
Week 8	EDN System Integration and management • Database selection criteria • Database Design • OLEDB, ODBC	MySQL PC Oracle Access
Week 9	Decision Support Tools • Switching coordination • System reconfiguration • Load dispatching • Fault Analysis • Fault Recovery	Any available COTS
Week 10	Students Project Presentations	

Expected Course Outcomes

After the successful completion of this curse the students will be able to:

- Understand an Electrical Distribution Network System, and recognize its properties and characteristics.
- Perform system analysis with an exiting EDN and therefore identify the problems and suggest improvements.
- Understand the operation of substation and thus identify its components.
- Use some computer software tools such as AutoCAD to design standards for substation.
- Choose appropriate switching devices and site selection for modeling an EDN.
- Get familiar and use computer software for load analysis and calculations.
- Model and Design an appropriate EDN system using software language UML.
- Understand information fusion and its impact in EDN, such as SCADA, CIS, IVR, AVL, GIS, GPS, etc.
- Integrate systems, leading to database selection and design
- Identify decision support tools and the requirements such as fault analysis and recovery.

Assessment Methods

Weekly homework problems, small projects assignments and demonstrations, final team project presentations, and exams. Conduct formal and peer reviews and workshops for software applications and testing

Overall Energy Distribution Network Architecture

The energy distribution systems, regardless of their size, tend to have similar concerns with respect to information technology. Most utilities depend upon computer systems for managing their maps thru using Geographic Information Systems (GIS). Many have Supervisory Control and Data Acquisition (SCADA) systems for remotely managing sub-stations and main switches. Most have Interactive Voice Recognition Systems (IVR) which automatically logs the calls of customers reporting outages. The difficulties come when these systems have to work together, for example in the control room during an outage. A dispatcher watches the trouble call and SCADA systems field trouble calls, and coordinates the repair actions of linemen. The dispatcher is actually performing much of the work of integrating and fusing information together and, and manually synthesizes the solutions. It is possible to support these tasks with systems designed to perform the integration and fusion automatically. The solution synthesis can also be supported with appropriate tools.

At the beginning of the course, the overall energy system distribution is introduced. The topology of a typical power distribution network at the main feeder level just coming out of the substation typically would look like figure 1. This figure represents the topology of the electrical grid system at the high voltage level and deals only with the switching devices such as Circuit Breakers (CB) and Remote Switches (RS). The filled rectangle represent closed remote switched and empty rectangle represents open switches. This will aid us later on to build the model of the power distribution system at the high voltage level with the associated switching devices.

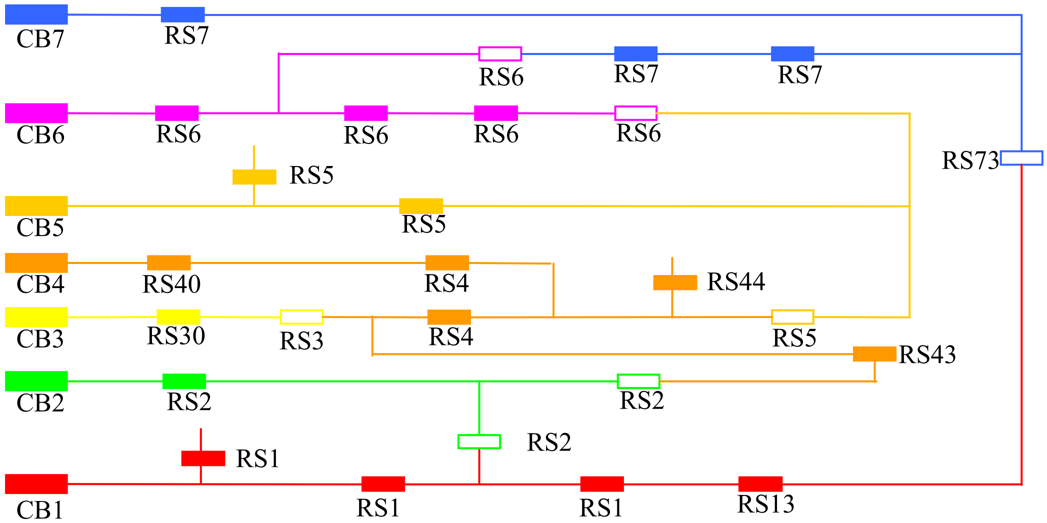

Figure 1. Energy Distribution Network at the main feeder level

The overall architecture of a typical power distribution network that combines both the high voltage line and low voltage line is followed from the starting point at the substations[1] as illustrated in figure 2. The power is first generated at the power generation plant and then transmitted thru transmission lines into the substations. Our goal here is to teach the students how to model the energy distribution from the substation all the way to the consumers. Figure 2 suggests that a typical energy is being distributed from the starting point as the followings: Substation (SUB) to Circuit Breaker (CB) to Remote Switch (RS) and/or to Manual Switch (MS). It then at different points (different phases) will be distributed to different sections going thru sectionalizing switches. Then it will be Fused (F) possibly at different places at the lateral level. At this point then we can tap thru transformers (T) to the consumers (LD). All the connections between the components are established thru conductor line (LN).

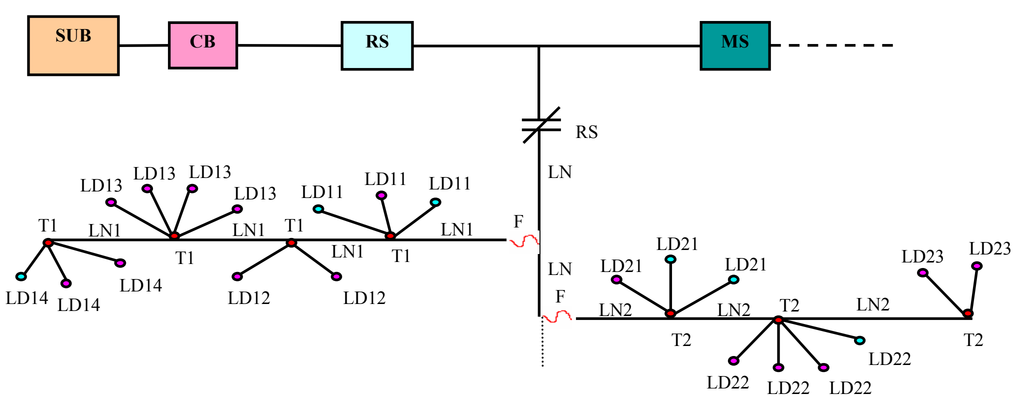

Figure 2. Overall architecture of Energy Distribution Network

Data Systems

The Data Systems provide additional information about the network configuration, the customers, and the health and fault status of the circuit. The status information can be thought of as instrumentation of the circuit. For example, a SCADA system will provide remote monitoring of currents, voltages, and switch positions of various remote circuit components (direct measurements). An Automatic Vehicle Locator (AVL) system will locate the construction and repair crew on the field, therefore, making scheduling easier. An Interactive Voice Response (IVR) or trouble calls system will respond to customer phone calls and log service outages (observations of customers). A Customer Information System (CIS) database contains address and contact information of customers, service location, and billing information (additional information about the network and customers) that can be used in matching phone numbers of trouble calls to locations in the electrical network. Refer to Figure 3.

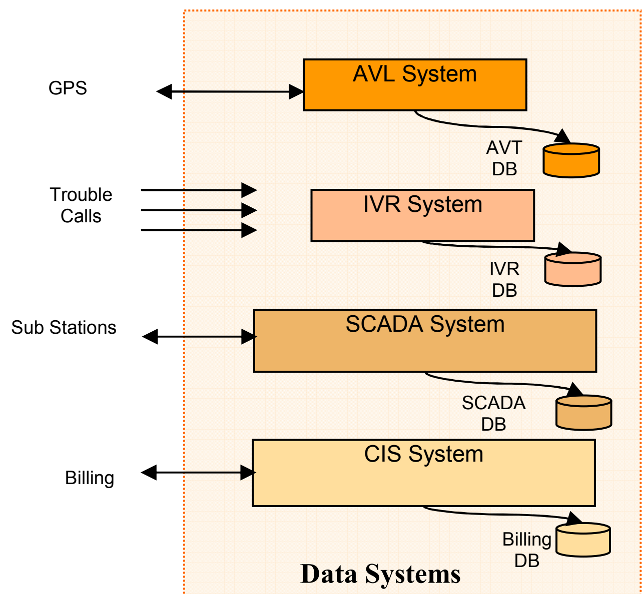

Figure 3. Data Systems for a typical Energy Distribution Network

Table below is a summary of some typical application software that we can use in our classroom to aid us in teaching the materials related to the data systems. The prices are considered to fit the budget of a typical student. However, some other software may be researched and considered.

System	Description	Company	Software	Price
AVL	Automatic Vehicle Locator using GPS	Q-GPS Trimble	LAS 3100 Lassen	$240 N/A
IVR	Interactive Voice Response and trouble calls	NCH	IVM	$ 84
SCADA	Supervisory Control And Data Acquisition	FastTrak	FTAlarm FTDataWin	Free Demo
CIS	Customer Information System	MySQL	mysql	Free

GIS and FM systems

These systems are usually present in utilities, in varying forms. A Geographic Information System (GIS) contains a model of the circuit topology, i.e. where components are, how they are inter-connected, and some service, or customer information. Since a major goal is to promote open systems concepts, the overall integration framework is designed to work with GIS systems which store the circuit topology information in a standard format, such as a commercially available database (SQL Server, Oracle, Sybase, etc), or in files with either a published format or with standard access drivers available (OLEDB, ODBC, etc). Facility Management (FM) systems are used to design, maintain, control, and generally manage the network. Examples of these are work order management systems, which are used to update the GIS model as the circuit is extended and maintained, and load engineering analysis packages. Refer to Figure 4.

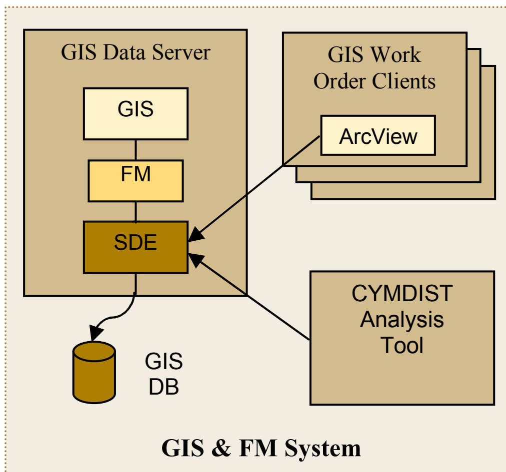

Figure 4. GIS and FM Systems for a typical Energy Distribution Network

Table below is a summary of some typical application software that we can use in our classroom to aid us in teaching the materials related to the GIS and FM systems. Again, the price is a reflection of a typical budget for the students. Some other software may be researched and considered.

System	Description	Company	Software	Price
GIS	GIS software for topology	ESRI	ArcGIS	Free demo
FM	Facility Management	ESRI	ArcGIS	Free demo
SDE	Spatial Data Engine	ESRI	ArcSDE	Free demo
ArcView	View of work order	ESRI	ArcView	Free demo
CYMDIST	Distribution System Analysis	CYME	cymdist	Free demo

Decision Support tools

The decision support tools will be a set of software application tools that are available either thru COTS (commercially off the shelf) and/or designed and hand-written by the students. The decision support tools are basically the brain of the system that makes intelligent and sometimes complex decisions. Some of these are:

1) Diagnostic and Outage analysis
2) Switch coordination
3) Repair planning
4) Restoration time
5) Catastrophic analysis
6) Network integration decisions
7) Load analysis
8) Phase analysis
9) Load dispatching
10) Facility management
11) Crew scheduling
12) Network reconfiguration

Figure 5 illustrates some of the task that will be part of a decision support tool.

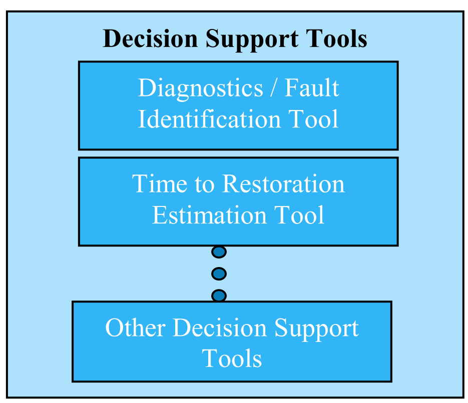

Figure 5. Decision Support Tools for a typical Energy Distribution Network

Modeling Paradigm

A well defined "modeling paradigm" for energy management network is a very important task that must be accomplished. A modeling paradigm is the language with which we will represent the system models. This will allows us to express the system structure, components, and functionality in a comprehensive form. Therefore, to properly model any large, complex energy distribution system, a model builder must describe the system's entities, relationships, and energy flows clearly. This modeling environment must constrain the model builder to create syntactically and semantically correct models. Before any system is built, issues such as what is to be modeled, how the modeling is to be done, and what types of analyses are to be performed, must be formalized.

Before we proceed with the paradigm definition, we must think about interconnectivity of components, which as a whole will form the topology of the energy distribution network. We will use Unified Modeling Language[2] (UML) to define the paradigm. We will build a meta-model (a model of the modeling paradigm) using UML class diagrams to specify the objects (components), attributes (features), and their relationships. For a modeling user interface we can use any graphical modeling representation tools such as Microsoft Visio, IBM Rational Rose, Borland Togethersoft, GME[3], etc. We use UML because it is a well-known and widely accepted modeling language, and end users can more easily participate in and contribute to the modeling language specification process.
Figure 6 illustrates a connectivity model of a power distribution network starting from substation all the way down to the consumer levels.

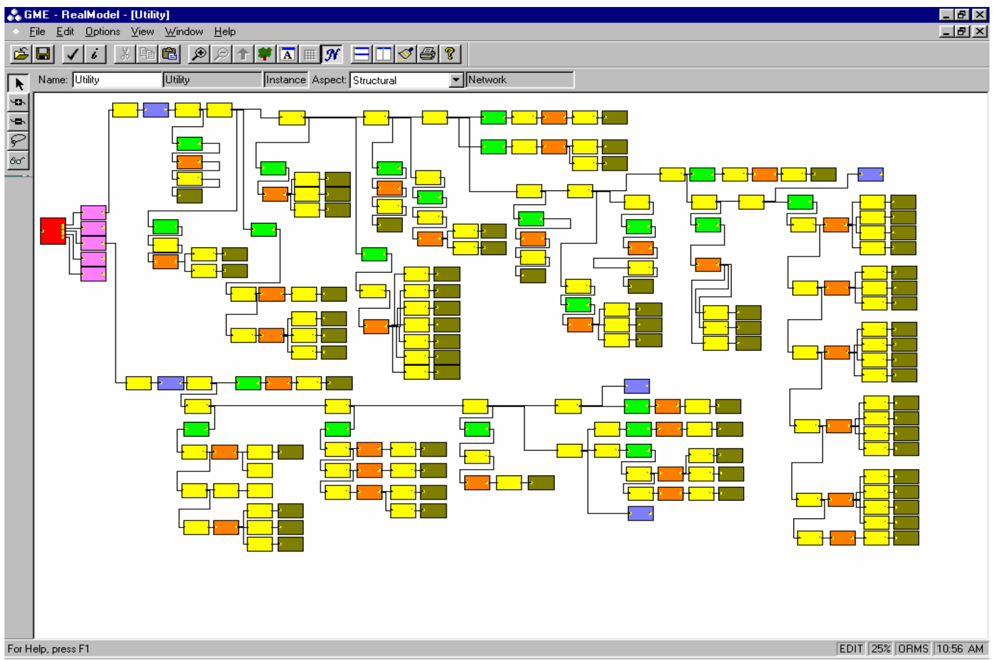

Figure 6. A model representation of a substation and all its connected components

Conclusion

It is very important for our students studying in the areas of energy distribution network to be well informed and introduced to the basics and overall concepts and operations of energy distribution network system. As the size of the energy distribution network system grows, the problem of decision making on day to day operations becomes obvious. This scaling issue has presented a problem and therefore a challenge to the energy distribution network industries. By developing the above mentioned course the students will have enough understandings and techniques to take on the challenges that are facing today's energy distribution network systems.

Bibliographic Information

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