BIOGRAPHICAL INFORMATION

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Systems Engineer
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Specific Responsibilities

Responsible for data model design and administration of OutageLink, Duke Power's Centricity outage management system. Coordinates GIS applications for the Power Delivery Application Services Department.

Past Experience

Joined Duke Power in 1986 as a Distribution Engineer. Joined the IT Department in 1994 to develop GIS applications. Served as system architect for Duke's Smallworld GIS implementation before joining the OutageLink project team in 2001.

Educational Information

B.S. - Electrical Engineering, Mississippi State University
M.B.A. - Information Systems Management, University of South Carolina

Professional Memberships

Institute of Electrical and Electronics Engineers
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NETWORK MODELING FOR A DYNAMIC WORLD

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ABSTRACT

GIS data is the foundation of a growing number of utility company applications such as network planning, load management, outage management, equipment inspection and mobile dispatch. However, the data requirements of these applications are quite different. When it comes to GIS data models, one size doesn't fit all!

This paper presents Duke Power's experience transforming "as-built" GIS data into a dynamic operations model for a third-generation Operations Resource Management System (ORMS). The new system replaces a legacy outage management system, provides graphical outage analysis and interfaces with a mobile work management system. The new model was designed to support future applications such as switching management and real-time power flow analysis. Key differences between the two models are outlined and the design process is explained. Implementation tools and methodology will be presented. The discussion will address the benefits and challenges of network modeling in a 24x7 environment.

During system rollout Duke Power experienced a devastating ice storm that interrupted service to 1.4 million customers—twice the size of any previous storm. The restoration effort provided valuable lessons and drove changes in how the new ORMS is deployed. The storm demonstrated that accurate data modeling is essential for emergency preparedness.

THE DUKE POWER ELECTRIC SYSTEM

Duke Power is one of the largest investor-owned electric utilities in the United States. The company serves over two million customers in a 22,000-square-mile area of North and South Carolina. The Power Delivery system includes 13,000 miles of transmission lines and 89,000 miles of distribution lines. The distribution network is composed of over 2,150 distribution circuits, 750,000 transformers and 200,000 protective devices (reclosers, sectionalizers, fuses and switches).

ATLAS GIS MODEL

Development

In the late 1960's, engineers at Duke Power developed the first computer model of Duke's electric distribution network. This mainframe mapping system was designed to identify overloaded transformers and support basic load flow analysis. A digital landbase was created from USGS quad sheets with an accuracy of ±40 feet. Then students performed field surveys to match customers with transformers shown on the new, plotted maps.

In the early 1990's, mainframe GIS technology provided the first graphical displays while new GPS devices allowed for accurate field data collection of all 100,000 transmission structures. Technicians created a traceable model of each substation. However, lower cost and increasing functionality led Duke to migrate its facility data to a new client-server GIS package by the end of the decade.

Design Criteria

The ATLAS GIS system utilizes robust, object-oriented GIS technology to achieve several technical goals:

- Create a single, contiguous model (no tiles) of distribution, substation and transmission assets.
- Provide an intelligent landbase for spatial queries and geographic network tracing (e.g. roads and waterways).
- Support design alternatives and conflict resolution.

The resulting model includes 350 object types, 12 traceable networks and 2,200 geometry types in a single, 40 GB database. Its distinctive characteristics are:

- High level of complexity with numerous objects and attributes.
- Emphasis is on detail, not speed.
- Supports many update users, each with unique view.
- Shows proposed facilities.
- Electric devices are static and show nominal status not current status.

Usage

The ATLAS GIS system is used for map plotting and viewing, distribution transformer load management, transmission structure and conductor reporting, and right-of-way management. It provides data to other systems for circuit analysis, engineering design and outage analysis. Over 600 mobile data terminals receive nightly updates for off-line map viewing.

The GIS model is kept up-to-date by 25 technicians and 200 field engineers. Most of these engineers have a full-function GIS on their laptops for mobile design work.

OUTAGELINK ORMS MODEL

Development

In the mid 1980's, Duke Power developed a mainframe outage management system (OMS). The system provided call taking, distribution outage analysis, assignment and reporting functionality. It featured a hierarchical network model of customer transformers and upstream protective devices. End users could traverse the network by selecting upstream or downstream equipment from a textual display of a given circuit. Each circuit was modeled independently and grouped into one of 32 fixed dispatching areas. Periodically, the OMS model was refreshed with data from the GIS. Data quality problems were regularly referred to the GIS technicians for correction so that the connectivity model grew better and better over time.

The mainframe OMS was very fast but lacked a graphical display of distribution lines or outages. Again, lower cost and increasing functionality led Duke to migrate to a package solution.

Design Criteria

The OutageLink Operations Resource Management System (ORMS) system utilizes an off-the-shelf software package to achieve several technical goals:

- Create a dynamic, graphical representation of distribution outages and crews.
- Permit load transfers between circuits to be reflected dynamically.
- Create a single operational model that can be managed at multiple levels.

To support a large number of transactions, the ORMS employs a simplified network model containing only those objects and attributes deemed essential. Poles and secondary are omitted and the multi-tier GIS object hierarchy is flattened. Proposed facilities are excluded. The system itself utilizes messaging technology to propagate device status changes to all users.

Usage

The OutageLink ORMS is used for outage call taking, call status, call back, graphical outage analysis, crew dispatch and management reporting. It provides data to a mobile dispatch system and a work management system. Future applications include switching management, real-time power flow analysis and real-time SCADA interfaces. The ORMS model is refreshed nightly from the GIS.

GIS VS. ORMS MODELS

The key differences between the GIS and ORMS models are:

GIS Model	ORMS Model
• High level of complexity with numerous objects and attributes.	• Simplified network model with essential objects and attributes.
• Emphasis is on detail, not speed.	• Emphasis is on speed, not detail
• Supports many update users, each with unique view.	• Supports many operations users who share one view.
• Shows proposed facilities.	• Shows only existing facilities.
• Electric devices are static and show nominal status.	• Electric devices are dynamic and show current status.

ORMS MODEL IMPLEMENTATION

Design Process

The OutageLink ORMS model design began by defining desired current and future system functionality. Then necessary electrical and background objects and attributes were identified. A key assumption was that the GIS would remain the system of record for all source data. Any data cleanup would be performed in the GIS. Temporary objects, such as padmounted transformer elbows, would be created "on the fly" as data was extracted. The ORMS objects were mapped to GIS objects in a two-step process that allowed for intermediate processing to address special situations such as non-graphical connectivity, object subclasses, elbows and bypass devices. The resulting model contains 32 electrical device classes, 6 conductor classes, 50 background classes, 165 annotation classes and 22 attribute tables.

The system loads selected tiles into memory for fast display. An electrical tile or smallest unit of change was defined as one circuit. The background tiles vary in size but have approximately the same number of objects. Test tiles containing all classes were used to validate the GIS interface. Approximately 7 iterations were needed to identify and address translation issues.

<u>Nightly Refresh Process</u>

Each night, the GIS identifies the tiles that have changed then extracts these incremental changes for processing into the ORMS. Each business day, 8 to 12% of feeder tiles are modified and must be refreshed. Each week, 2 to 4% of the background tiles change. The ORMS also processes 20,000 customer changes each night.

<u>Data QA/QC Process</u>

Quality Assurance/Quality Control (QA/QC) scripts identify connectivity errors such as loops, deenergization and parallel conditions in the ORMS. However, most data problems are identified and corrected using automated QA/QC scripts in the GIS.

CHALLENGES

The OutageLink ORMS provides a dynamic model of the entire distribution system. However, the high volume of incremental changes presents a special challenge. The model refresh window is limited by system activity, especially inclement weather. Occasionally, a mass update of GIS objects triggers a refresh of all circuits that can take several days. Close coordination is required to balance the needs of both systems.

During the ORMS rollout, Duke Power experienced a devastating ice storm that interrupted service to 1.4 million customers—twice the size of any previous storm. The restoration effort provided valuable lessons and drove changes in how the new system is deployed. The storm demonstrated that accurate data modeling is essential for emergency preparedness.

CONCLUSION

The Duke Power electric system model evolved over decades of use and many improvements in technology. Today's GIS serves as the foundation of a wide range of applications with different data requirements. The GIS model itself is best suited for complex detail and QA/QC; the simplified ORMS model is designed for dynamic operations. When it comes to data models, one size doesn't fit all.