Multi-Vendor Local and Remote Substation SCADA System
White Paper
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Abstract: Northwest Airlines (NWA) installed a new substation to support their Detroit Metro Airport expansion. Even though the 120 kV to 13.8 kV substation and associated Central Generating Facility were needed, they didn't represent NWA's core business. One company was contracted to provide energy services for both the manned Central Generating Facility and the unmanned substation. The substation included a multi-vendor SCADA system to facilitate local and remote monitoring.

Keywords: Electrical Power, Operator Interface Terminal, OIT, Substation, Personal Computer, PC, RSView32, DDE, OLE, OPC, TCP/IP, IED, SCADA, Modbus, Microsoft Windows, PDC, RAS, Diagnostics, Airline Industry…

Customer Profile

Northwest Airlines is a major international airline with several primary hubs. One of these is located at Wayne County's Detroit Metropolitan Airport. Northwest is developing Detroit into a major domestic and international

hub, which includes building a new 1.2 billion dollar terminal. This is part of NWA's ongoing program to improve service and convenience for their customers. In addition to the new terminal with in excess of one hundred gates, the expansion also includes a parking structure, roads, street lighting, and storm water pumping stations along with the substation and other needed facilities.

Customer's Business Problems / Issues

Adding a new terminal will significantly increase the amount of power the airport uses. By taking the terminal construction lead, Northwest also took responsibility for the other additions, including upgrading the power infrastructure. Because power generation and substation operations are not NWA's business, they hired a company to provide the Central Generating Facility and contracted with them to operate the new energy facilities. This operating contract includes the Central Generating Facility together with the substation, which was provided by a second company.

To facilitate substation operation and monitoring from the Central Generating Facility, the design includes a Supervisory Control And Data Acquisition (SCADA) system. The substation and SCADA design criteria has the following characteristics:

- All protective functionality and controls are independent of the SCADA system. However, operator "trip" and "close" commands can be initiated from the SCADA system.
- The SCADA system is built around a personal computer (PC) base rather than a programmable logic controller (PLC) base.
- The SCADA master uses Operator Interface Terminal (OIT) software running under Microsoft Windows to support data sharing.
- The substation uses electronic protective relays with the dual function of providing appropriate protection and sending metering and fault data to the SCADA system.
- The electronic power meters report selected data directly to the SCADA system. These meters incorporate revenue grade accuracy.
- The SCADA system supports local and remote substation monitoring and control. This includes the OIT station in the substation and a dedicated terminal at the

Central Generating Facility, plus the ability to dial into the system from any other authorized computer.

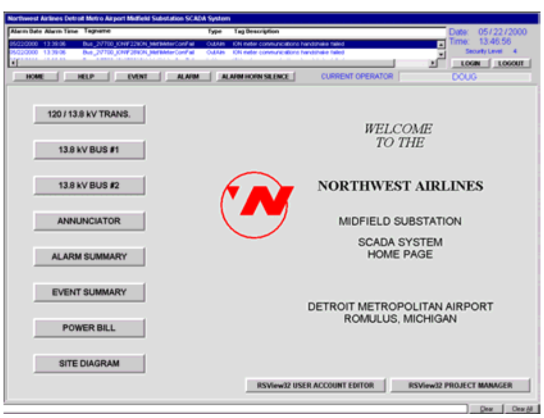
- The system logs “production” data for display on a trend screen or for transfer to a separate software package for analysis and display.
- The SCADA system maintains alarm and activity log data for sixty days. Operators can view any of these files from the SCADA terminals.

The substation supplier had to balance certain device and SCADA features in the design.

Specifically, the power meters were primarily selected for their metering functionality, while the relays were mainly selected for their protection characteristics. Integrating the meters and relays with the SCADA system was important but secondary. These devices were purchased from two different vendors who use different protocols for open communications. Therefore, the SCADA master needed to properly handle intelligent electronic device (IED) to server communications, in addition to the server to distributed OIT communications.

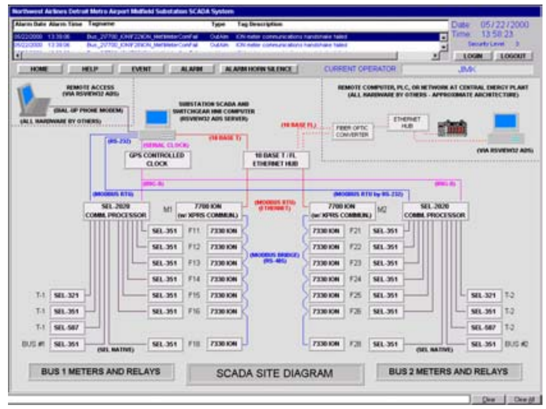
Solution Description

The SCADA system does not provide any automatic control. Therefore, the SCADA master functionality relates to handling



communications, logging data, logging alarms, operator displays, and manual operator control. This functionality lends itself to the PC based SCADA master specified in the design. The OIT software will run under either the Workstation or Server version of Microsoft Windows NT 4.0. However, the distributed architecture used to enable remote monitoring requires some of the network security and reliability features provided with the NT Server operating system as discussed later in this paper.

The SCADA system’s foundation is the collection of data into the master. The substation has two main transformers with each one feeding a bus. Each bus has seven installed feeders and



space reserved for one more bus in the future. In addition, there is transformer protection, a bus-tie breaker, and additional breakers from generators at the Central Generating Facility. The SCADA system uses the relays and meters as IEDs, with a total of sixteen meters and twenty-two protective relays providing the data. The SCADA master collects this data from all of the IEDs using serial communications, although the relays and meters use different protocols.

The power meters use Modbus RTU encapsulated into an Ethernet TCP/IP packet while the protective relays use the RS-232C serial version of Modbus RTU. These protocols require two different drivers, which normally increases the communications overhead. The OIT software can receive data by either dynamic data exchange (DDE) or a newer method based on Microsoft’s Object Linking and Embedding (OLE). Communication servers using OLE for Process Control (OPC) are designed to provide a data interface that is more robust than DDE. Part of this design is the ability for one OPC server to support more than one driver, allowing multiple protocols while minimizing the overhead on the server PC. This configuration is available for the two protocols on these IEDs. The OPC server provides the relay and metering data to the OIT software package running on the SCADA master computer.

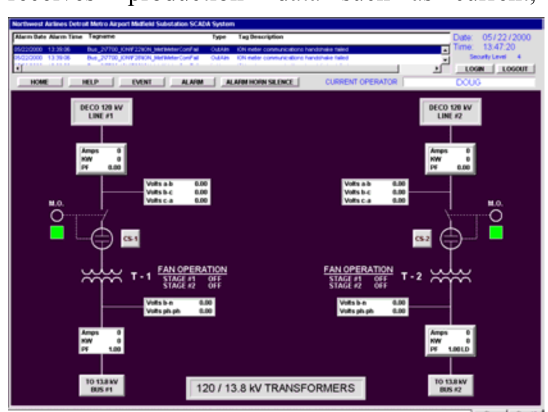
Once the data is in the OIT PC, the operators need the ability to access it either locally or from a remote location. Although many software packages provide local operator interface features, very few integrate support for remote monitoring and control. One that does is Rockwell's RSView32 operator interface package with the Active Display System (ADS) extension. This package uses Internet technology to enable client computers to view displays that reside on the server. Using this system, all of the screen and database development is done on a single computer, the SCADA master computer. This is also configured as the ADS server. Local control is provided by the normal OIT package similar to a stand-alone system. The differences with a distributed system relate to identifying which operator logs in from each of the possible client computers. The visibility of any control function is linked to this information so each operator has individualized control access, even when several operators are using the SCADA system at the same time. Although the visibility is linked with the computer the operator is using, the operator's security level and system access is independent from any particular terminal.

The Active Display System server needs the security of a Windows domain to ensure reliable screen and data delivery to the clients. Therefore, at least one computer on the network must be running Microsoft Windows NT Server and be configured as the Primary Domain Controller (PDC). The SCADA master PC is configured as the PDC for this system, even though the ADS server and PDC can be separate computers. This configuration was selected to expedite development. The Central Generating Facility network characteristics were not known during development since the substation and SCADA system were designed and installed before this facility was completed. The PDC also provides secure access control at the operating system level and coordinates with the OIT software security system. Data and files can be shared within this security over Ethernet or by a dial up RAS (Remote Access Support) connection.

One diagnostic feature is the protective relay's ability to store characteristic data at the time of a fault. The event data can be viewed on a PC connected directly to the relay, but this does not provide remote monitoring as intended for the SCADA system. The relay makes a portion of this event information available to the communication system so the SCADA system can retrieve it. Even a subset is a large quantity of data, so the communications are configured to

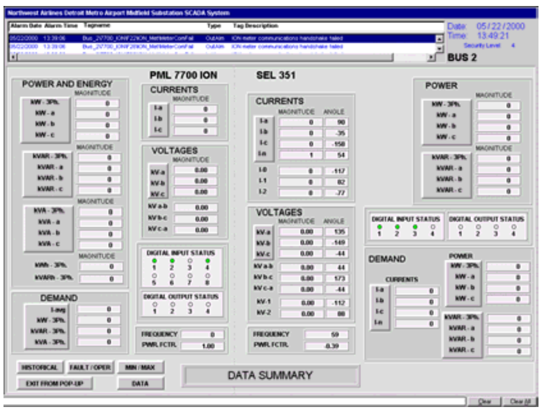
only request this data when an operator opens that screen or requests an update. This function illustrated a limitation on the ADS system. For efficient display, the event screen contains all of the event data for one relay with controls so an operator can scroll through the events. However, this makes the screen and data set very large. Even though it works on the server, the screen times out when loading onto an ADS client. This remote function is important, so a second event screen is now part of the system. This screen contains a smaller subset of the events for the selected relay and is the actual screen displayed on a remote station. It provides the most recent events at the remote terminal and refers the operator to the substation terminal for older records.

In addition to the events, the SCADA system receives "production" data such as current,



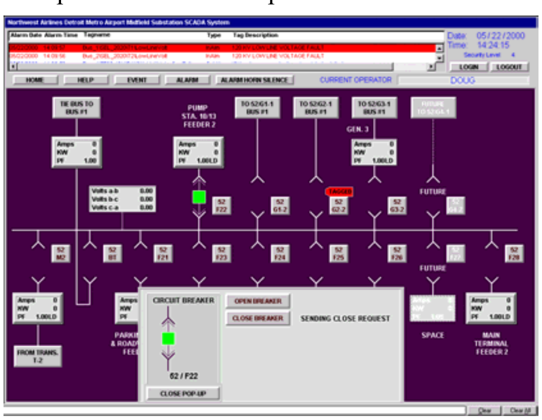
voltage, power factor, VARs, etc. from the power meters. Many of the same values are also reported by the protective relays. The one-line diagrams on the SCADA system give the operator an overview of how the power is being used. These screens are divided between the main transformer screen and a screen for each bus. Where data is available from multiple sources, the meter data is normally used. If the SCADA master detects a meter communication failure, the display automatically switches to the relay data.

Clicking on the summary data for a feeder opens a more detailed set of data screens for that feeder. This set of screens provides an in depth



view of the data, including a side-by-side comparison of the meter and relay data. On the transformer primary where there is no meter but there are several relays, the relay data is laid out for comparison.

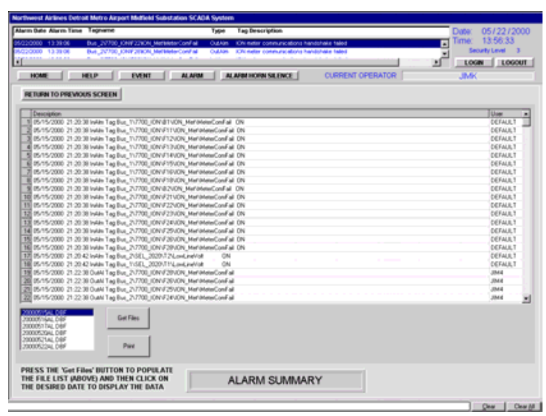
The one-line displays also provide access to the breaker control pop-up with proper operator security. This pop-up normally displays buttons the operator can use to open or close the selected



breaker. However, these buttons are meaningless when a breaker is racked out. In this case the “open breaker” and “close breaker” buttons are hidden and instead the pop-up has “tag-out” buttons. When the operator clicks on the “tag breaker” button a flag is set in the SCADA system indicating that the breaker is tagged out. In addition, a text window opens for the operator to enter an informational description of why it has been tagged out. Later an operator can use this same secured window to click on the “un-tag breaker” button to clear the flag and associated text. This “tag out” is not a substitute for proper lockout / tag-out procedures, but it can be used in conjunction with those procedures to let remote operators know what is happening in the substation.

The OIT software allows selected data to be saved in log files for future viewing and analysis. The native format for the data files is dBase-IV, which is a format that many database and spreadsheet applications can import and interpret. This supports two methods for viewing the data. The operator can use the trending built into the OIT package or use a third party application such as Microsoft Excel or Access. These data files can be transferred to any other computer with appropriate network access. Therefore operators and others can use applications for viewing, printing, and data analysis virtually anywhere, providing a true distributed architecture.

One important SCADA function is recording the operator activity and system alarms for future review. This system is configured to record operator activity such as SCADA system



security, manual breaker “trip” and “close”, and “tag-out” status for a breaker or switch. The log also records the name of the operator who took the action. A new dBase-IV format file is created each day and the files are stored for sixty days before the oldest file is deleted. Any of the stored alarm or activity log files can be accessed from either the server or from an ADS client computer, thereby making the system consistent with the desire for remote SCADA monitoring and control. Just like the datalog files, these files can be copied to other computers on the network and opened using standard office applications.

Many large enterprises are interested in where all of their power is actually being used. One of this substation's features is revenue accuracy meters on each of the feeders. With appropriate safeguards this feature provides the ability to distribute power costs proportionately among the users. The SCADA system displays the accumulated power usage by feeder on a "billing" screen, which includes the ability to manually reset these accumulated power values in the meters.

Business Benefits

In a very real sense, Northwest Airlines is not affected by the operation of the substation as long as the terminal has the power it needs. However, the number of personnel needed for reliable operations directly affects the company operating their power system. As with any business relationship, this will trickle back up to NWA in the cost of the operations contract.

Therefore, all parties involved benefit from reduced personnel expenses through enabling the Central Generating Facility personnel to remotely monitor and control the substation. Other benefits include better visibility over the substation operation, accurate data on power usage, and quicker troubleshooting through remote monitoring. All of these contribute to fewer substation problems and less downtime, helping Wayne County's Detroit Metropolitan Airport and Northwest Airlines reliably get planes to their destinations on time.

Biography

Jim Michaelis grew up in northern California. He is a member of IEEE (S' 1979, M' 1984) and

ISA (SR' 1994). Jim earned his BSEE from the University of Nevada - Reno in 1984. In 1990 he passed the Professional Engineers exam for Electrical Engineering in California while working as a Control Engineer for Reliance Electric Industrial Company. Jim joined Programmable Control Services, Inc. (PCS) in 1994 as a Control Engineer with a Drive Systems specialty. PCS is a Spokane, Washington based control system integration firm specializing in the metals industry and power system automation using PLCs.

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