21, rue d'Artois, F-75008 PARIS
http : //www.cigre.org

CIGRE US National Committee
2017 Grid of the Future Symposium

ETED Dominican Republic: Substation Improvement Project in the Dominican Republic

A. LYTZ
SUBNET Solutions, Inc.
Canada

SUMMARY

North America has a mature electric power grid. Grid automation changes are often undertaken as evolutionary modifications or extensions of existing systems, rather than by wholesale replacement. This can impact the approach taken when considering the adoption of new technologies or methodologies.

When introducing an IEC 61850 substation automation system into an established utility, it is often necessary to interconnect it to an existing SCADA system that is using SCADA protocols such as IEEE 1815 (DNP3) or IEC 60870-5-104.

This paper outlines some of the goals, challenges, and successes achieved by ETED (Dominican Transmission Company) when integrating IEC 61850 into an existing system and supporting the remote management of the system. Several modern technologies were retrofitted on existing older hardware such as a local HMI controls, digital alarm annunciators, and SCADA protocol translations.

KEYWORDS

IEC 61850, IEEE 1815 (DNP3), SCADA, HMI, Gateway.

alan.lytz@subnet.com

Introduction

The Dominican Electricity Transmission Company (ETED in Spanish) is a state-owned electricity company whose objective is to operate the National Interconnected Electricity System to provide high voltage electricity transmission services throughout the Dominican Republic. ETED has more than 1,000KM of 138KV lines, managed through about 80 Transmission Substations.

A recent project automated 26 transmission substations by incorporating data concentrators and local HMI systems, in order to integrate the existing relays to each substation concentrator using a variety of protocols, including IEC61850, DNP3, IEC103, SEL Fast Messaging, Modbus and OPC. Each of the data concentrators communicate to ETED´s SCADA Master. Prior to the implementation of this project, nine of the substations had no connection to the SCADA system. While normally unmanned, staff were required to visit these sites to perform local operations manually.

The project also introduced remote engineering management of the substation protection and control devices. Key goals of the project were to integrate new equipment into the existing substation equipment, minimizing expenditure and maximizing retention and utilization of previous automation investment.

ETED re-engineered their substations, replacing obsolete RTU, transducers and other network devices by the state of the art data concentrators, while devices maintain existing protection and control.

In the substations, data concentrators with multi-vendor and multiprotocol capacity were deployed, replacing various obsolete RTUs, transducers and network devices. The data concentrators provide data to ETED's Master SCADA using the IEC104 protocol. A number of compatibility and interoperability issues with various protocols were identified and addressed during the project execution.

The re-engineering system now permits protection and control engineers to access devices and manage the configuration and collect oscillography files. The infrastructure is now ready for a future project for automating device management, oscillography file collection, as well as secure remote access to devices as set out in the NERC-CIP standards for cyber security issues in electrical substations.

This paper describes the challenges that motivated ETED to search for a multi-vendor, multi-protocol solution to achieve their ultimate goals of improved engineering of protection, automation, and control systems that support response, recovery, and cost reduction.

Project Motivation

The challenges that motivated the improvements in the ETED's substations include:

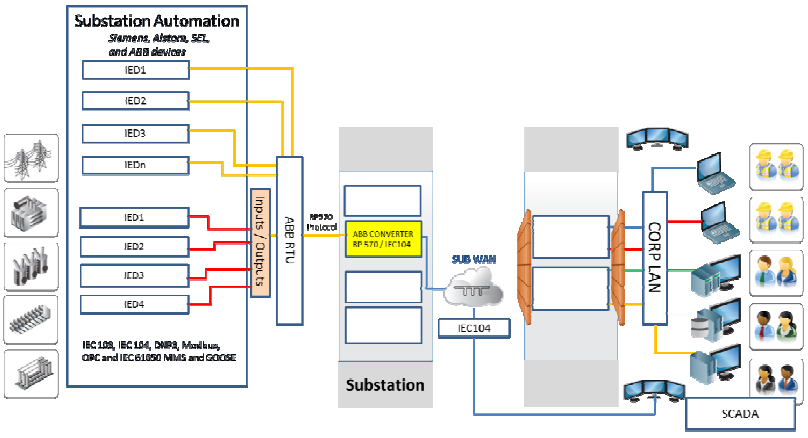
1. Unreliable SCADA data and controls:

   A typical substation included an RTU, transducers and protocol converters (proprietary protocol to IEC104). The I/O signals were connected to the RTU, then it was necessary to use the protocol converter to send the signals to the control center.

   RTUs, auxiliary relays and / or transducers were used to collect signals from protection relays. The acquisition of data was done in a hard-wired manner and the transducers frequently experienced configuration and calibration issues, which generated problems and affected the quality of the signals.

   The sending of commands was unreliable and most of the commands sent were not satisfactory because they passed through many faulty elements.

ETED Dominican Republic Utility – Typical Substation



2. 26 substations lacked data concentrators:

   ETED initially selected a data concentrator product, but after 3 months of testing, this hub was not able to integrate data from a particular model of protection IED widely deployed by ETED using the IEC103 Protocol. The device also had compatibility issues with some IEC61850 MMS commands.

3. Problems with the IEC103 protocol:

   One of the peculiarities of the IEC103 protection protocol is that it defines specific meanings for many protection signals, but many device vendors instead provide private data mappings that differ from those defined in the standard. The IEDs used by ETED had a profile for analog measurement reporting that differed from that described in the standard. The initially-selected data concentrator could not support this alternate profile and the concentrator vendor's recommendation was to replace these IEDs with a different product using the concentrator vendor's proprietary protocol. This was not feasible for ETED due to the high cost that would be incurred in the replacement of these relays.

4. There were nine isolated Substations:

   Nine Substations had no connections to the ETED SCADA Master. These were unattended substations that required the control center to roll a truck to perform switching locally. This increased the risk of failures, errors in switching, long outage restoration times, and high cost of operation.

5. Outdated alarm annunciator panels in all substations:

   The announcers were obsolete, many were not operational, and there were no spare parts as the product was discontinued by its vendor.

6. Constant troubleshooting:

   Most of the daily activities of the Engineers were dedicated to the resolution of failures. The high number of hours of troubleshooting did not allow the personnel to dedicate themselves to other activities and / or projects.

7. No local HMI for monitoring and operation:

   There was no local visibility or HMI operability of the substations, which made the execution of switching moves difficult and prone to error. Engineers used paper drawings and mark sheets to track current switching positions.
8. Diversity of relays and protocols in substations:

   The substations included protection relays and other devices from a number of vendors; with a variety of protocols such as: IEC103, IEC104, DNP3, Modbus, OPC and IEC 61850 MMS and GOOSE. However, the existing RTU was unable to integrate all the devices and translate different protocols into IEC104 to transmit the information to the Control Center.
9. No secure remote access to protection & control devices:

   There is no secure remote access to protection and control devices for fault file retrieval or configuration management. The management of the configurations must be done locally. If some adjustment are needed the engineer must travel to the substation and make the changes connected locally to the devices.

10. Slow fault location analysis:

    ETED does not have a system for automatic fault analysis and location. To obtain oscillographs, the personnel must go to the substation, connect to the relays and download the oscillograph files manually for later analysis and location of the fault.

11. Issues with document management:

    There is no system that centralizes all the documentation of the substation, such as:
    - Device manuals
    - Connection diagrams
    - Blueprints
    - Architectures
    - Etc.

Technical Challenges
The challenges of the project improvements in substations can be summarized as follows:

1. Ensuring that changes in substations SCADA architecture are achieved system wide in a simple way and without the need to replace existing relays.

2. Interoperability of multiple protection, control, and measurement devices of various manufacturers using IEC 61850 (MMS), DNP3, IEC103 and Modbus with a new Data Concentrator / Gateway and in turn with the ETED control center using the IEC104 protocol.

3. Supporting the specific IEC103 protocol profile deployed in IEDs in the multi-vendor ETED system.

Project Execution

The following activities were part of the improvements in the ETED'S substations:

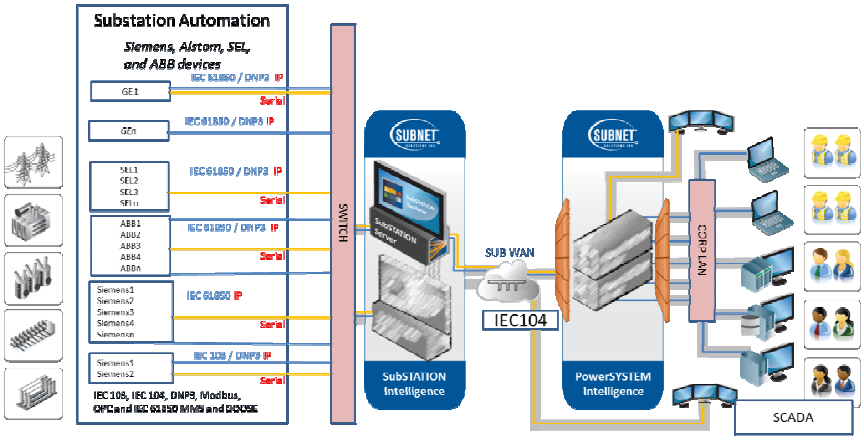
1. Replacement of RTUs, transducers, protocol converters and data concentrators.

   The existing RTUs, transducers and protocol convertors (proprietary to IEC104) were replaced with a gateway product capable of supporting all the IEDs and protocols used in ETED substations.

The new gateway integrates devices from different manufacturers using different protocols, then converts all data to the IEC 104 protocol to make the information available in the ETED control center.

The gateway also supports IEC61850 MMS commands in an interoperable manner, permitting control of IEC 61850 devices both from the substation itself and from the ETED control center.

ETED Dominican Republic Utility – After



2. Modification of the profile of the IEC103 protocol:

   The gateway configuration capability included support for private IEC103 message formats. This permitted retention of all existing relays using the IEC103 protocol. No replacement was performed, and no firmware updates were required.

3. Digital alarm annunciator panels:

   Obsolete annunciator panels, which no longer had functionality, were replaced by functionally-equivalent digital annunciator displays in the new local HMI.

4. New customizable HMI for monitoring and operation:

   Local HMIs were implemented within the gateway without the need to install additional equipment. With this, the operators have customizable local visibility in the substations, which improves the reliability in the execution of switching and improves the restoration response time.

5. Interoperability of protocols in the substations solved:

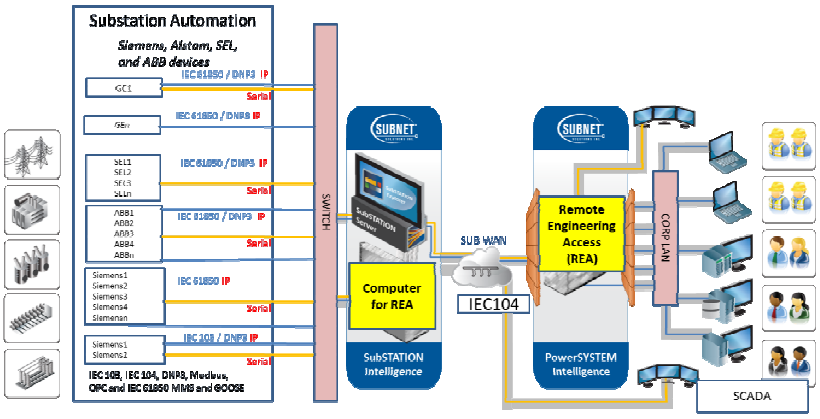
   The gateway supports the wide diversity of protocols used within the substation and between the substation and SCADA master. The gateway acquires, processes, and sends information to the SCADA master, as well as executes the commands coming from the SCADA master or from the local HMI. For the operator and for the SCADA, command operations are performed consistently, irrespective of the protocol used and/or the relay manufacturer. The gateway is responsible for making all conversions and relevant data and command mapping.

6. Remote access to protection and control devices solved:

   For remote access to the devices, ETED installed a ruggedized computer in each substation. In this way, the protection personnel have remote access to the devices of each substation without having to go to the facilities. Any information that is required of each equipment of the Substation can be verified, records of events and faults can be extracted, and the settings can be applied and verified automatically. However, several challenges are still posed with this scheme such as:

   - Locating and extracting faults automatically
   - This scheme is vulnerable as it does not implement the Cyber security schemes for substations established in the NERC-CIP standards.
   - Continued problems in document management

ETED Dominican Republic Utility – After



Conclusion

The project improvements in the 26 ETED substations managed to increase the reliability of the system, with the inclusion of the new gateway, multiple points of failure were eliminated. The gateway integrated devices from different manufacturers and with different protocols.
The control center experienced a significant improvement in the remote operation and management of the substations. The new gateway included additional internal supervision of system operation, giving rise to improved fault diagnosis and local storage of data.
Status and measurement information is received reliably, there is no loss of data, sending commands via IEC61850 MMS, IEC103, DNP3 and Modbus are executed successfully, both from the substation itself and from the ETEDS's control center through the IEC104 protocol.
With the modification of the profile of the IEC103 protocol, it was possible to integrate the existing relays without the need to replace them. Substantial capital investment was saved and O&M costs reduced using a multi-vendor solution.
It was also demonstrated that it is possible to achieve the co-existence of advanced technology such as the IEC 61850 protocol (MMS) and traditional protocols such as IEC103, IEC104, DNP3 and Modbus.
With the implementation of the local substation HMI, operators now have local visibility in the substations, which has improved the reliability in the execution of switching and helps to reduce the restoration response of outages. In addition, replacing the alarms with customizable digital displays mitigates the problem of future obsolescence presented in the substations.

In the future, the gateway provides a platform to integrate the new devices without needing to modify the substation automation solution architecture, allowing ETED to select the most appropriate and most economical devices.

Remote Engineering access to all devices is now possible, with the added ability of engineers to extract oscillography files as well as the possibility of managing the configuration remotely.

By the end of 2017, ETED will fully implement the new architecture of the protection and control devices for the implementation of remote device management system, permitting automation of many tasks, optimizing response times to failures.