Project Management Phases of a SCADA System for Automation of Electrical Distribution Networks

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Abstract

The aim of this paper is, firstly, to recall the basic concepts of SCADA (Supervisory Control And Data Acquisition) systems, to present the project management phases of SCADA for real time implementation, and then to show the need of the automation for Electricity Distribution Companies (EDC) on their distribution networks and the importance of using computer based system towards sustainable development of their services. A proposed computer based power distribution automation system is then discussed. Finally, some projects of SCADA system implementation in electrical companies over the world are briefly presented.

Keywords: *SCADA system, Project Management Phases, Power distribution Networks.*

1. Introduction

In recent years, our modern developed life has deeply depended on different electricity services such as air-conditioner, refrigerator, TV, computer system, etc. These services are possible with the availability of a sustained, reliable and good quality of the electric power supply. Nevertheless the electric power distribution networks are susceptible to interruptions caused by a variety of reasons such as adverse weather conditions, equipment failure, accidents, etc. The Electricity Distribution Companies (EDC) normally identify the faulty section of the network and restore the power supply using their own resources which are mostly based on classical methods and techniques. Today the rapid growth of Information Technology (IT) tools has promoted many EDC to modernize their fault diagnosis as well as troubleshooting systems.

Among new technologies used for this purpose, SCADA systems are considered as the widely appropriate tool used for such processes. SCADA is the acronym for “Supervisory Control and Data Acquisition”. SCADA systems are widely used for supervisory control and data acquisition of diverse kind of processes. Such process can be industrial, infrastructure or facility [1]. The SCADA system usually consists of the following subsystems [2]:

- A Man-Machine Interface (MMI) is the apparatus which presents process data to a human operator, and through this, the human operator, monitors and controls the process.
- A supervisory system, acquiring data on the process and sending commands to the process.
- Remote Terminal Units (RTU) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system.
- Communication infrastructure connecting the supervisory system to the RTU.

In fact, most control actions are performed automatically by RTU or by programmable logic controllers (PLC). Host control functions are usually restricted to basic overriding or supervisory level intervention. For example, a PLC may control the flow of cooling water through part of an industrial process, but the SCADA system may allow operators to change the set points for the flow, and enable alarm conditions, such as loss of flow and high temperature, to be displayed and recorded [3-5]. The feedback control loop passes through the RTU or PLC, while the SCADA system monitors the overall performance of the loop.

The main objective of this work is to show the need of the automation for EDC on their distribution networks and the importance of using computer based system towards sustainable development of their services. This paper is then organized as follows: next section briefly presents a review on SCADA applications. In section 3 we present the different project management phases of SCADA (identification of need; initiation; definition; design;

acquisition and project closeout). In section 4 we discuss the application of SCADA to electric power distribution systems and some projects of SCADA system implementations in electrical companies over the world are then presented. Finally, we conclude in section 5 by some comments.

2. Review on SCADA applications

We present in this part, types of SCADA systems reviewed that include those for electric power generation, electric power transmission, electric power distribution, and process control.

Researcher, Poon H.L. [6], has tried to make a survey of the current development of data acquisition technology. The various practical considerations in applying Data Acquisition Systems are summarized, and some feasible areas of advanced applications are investigated.

Researchers, Ozdemir E. & al. [7], have used a Java-enabled mobile as a client in a sample SCADA application in order to display and supervise the position of a sample prototype crane. The wireless communication between the mobile phone and the SCADA server is performed by means of a base station via general packet radio service GPRS and wireless application protocol WAP. Test results have indicated that the mobile phone based SCADA integration using the GPRS or WAP transfer scheme could enhance the performance of the crane in a day without causing an increase in the response times of SCADA functions.

Researcher, Horng J.H. [8], has presented a SCADA of DC motor with implementation of fuzzy logic controller (FLC) on neural network (NN). He has successfully avoided complex data processing of fuzzy logic in the proposed scheme. After designed a FLC for controlling the motor speed, a NN is trained to learn the input-output relationship of FLC. The tasks of sampling and acquiring the input signals, process of the input data, and output of the voltage are commanded by using LabView. Finally, the experimental results are provided to confirm the performance and effectiveness of the proposed control approach.

Researcher, Aydogmus Z. [9], has presented a SCADA control via PLC for a fluid level control system with fuzzy controller. For this purpose, a liquid level control set and PLC have been assembled together. The required fuzzy program algorithms are written by the author. Sugeno type fuzzy algorithm has been used in this study. A SCADA system has been composed for monitoring of water level in tank and position of the actuator valve. The main objective of this work is to present an implementation setup has been realized with no fuzzy logic controller module/software in this study.

Researcher, Munro K. [10], has developed the idea that SCADA systems are being rapidly integrated with corporate networks but the ramifications of a SCADA breach are far more worrying than disruption to production.

Researchers, Patel M. & al. [11], have presented a SCADA system that allows communication with, and controlling the output of, various I/O devices in the renewable energy systems and components test facility RESLab. This SCADA system differs from traditional SCADA systems in that it supports a continuously changing operating environment depending on the test to be performed. The SCADA System is based on the concept of having one Master I/O Server and multiple client computer systems.

Researchers, Ralstona P.A.S., & al. [12], have provided a broad overview of cyber security and risk assessment for SCADA and DCS, have introduced the main industry organizations and government groups working in this area, and have given a comprehensive review of the literature to date. Presented in broad terms is probability risk analysis which includes methods such as FTA, ETA, and FMEA. The authors have concluded with a general discussion of two recent methods that quantitatively determine the probability of an attack, the impact of the attack, and the reduction in risk associated with a particular countermeasure.

Researchers, Avlonitis S.A. & al. [13], have presented the structure and the installation of a flexible and low cost SCADA system. An ordinary PC with the appropriate interface and software operates the system. The system was installed to an old desalination plant in parallel with the existing old type conventional automation system, which is using relays, timers, etc. The automation system allows remote control and supervision of the plant at reasonable low cost. The design and installation of the automation system, which includes the software and hardware, is simple and easily accessible. The system has reduced the labor cost, and has increased the labor productivity of the operation due to the remote supervision of the process.

3. Project Management Phases of a SCADA system

In this part, we present the different project management phases of SCADA system implementation. In fact, SCADA project can be composed into five phases

(Figure1) [14-16].

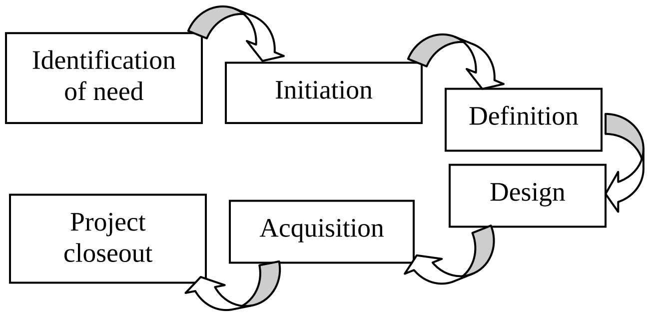

Fig. 1. Different phases of a SCADA project.

The first phase consists on the identification of need. The scope of the project is essentially defined at this point. In fact, the SCADA project will be required for some of the following reasons: to reduce power costs; to reduce staffing; to improve level of service; to avoid environmental incidents; to comply with regulators requirements; to replace an existing aging system, etc.

The second phase, which is the initiation, consists on the validation of the project need; the establishment of concepts and scope; the establishment of the summary Work Breakdown Structure (WBS). At this stage some small amount of funding has been approved to undertake the preliminary investigations, and prepare a preliminary project management plan. It will be necessary to firm up on the scope, identify the main technologies to be used, and gain agreement and approval of the potential users of the system. If the system is being introduced to improve productivity, then it is important that user management understand how they can use the SCADA system to change work practices. Although the work should be concentrating on the functional requirements, it is necessary to keep an eye on the technical capabilities offered by suppliers.

The third phase consists on the definition of the project. The work at this stage should still be concentrating on the functional requirements. At this stage the project is starting to get serious. A project team is in place, and organizational and reporting processes are established. The scope is being finalized (sites, functions, etc.). It is important to firmly identify the benefits of the system, to develop benefit realization plans and develop plans to manage risks.

The fourth phase consists on the design of the SCADA project. This phase normally involves preparing the specification, and developing tender evaluation plans. It is probable that a prequalification phase could proceed at this time to overlap the tender preparation, and the prequalification phases. The modern approach is to use design and construct contracts, and pay for performance.
The fifth phase consists on the acquisition. In this phase the SCADA project will go through a number of steps: design configuration of SCADA master software; development of custom software; assembly of RTU's in factory, and testing; field installation of instrumentation, communications, and RTU's; commissioning; site acceptance testing; customer training. Subsequent to this, the system normally has a defects liability period, and beyond that maintenance must be contracted for.

The last phase, which is the project closeout, consists on the establishment of the project final report; the closeout of any outstanding defects and nonconformities; the final completion and the post implementation review (PIR) as required.

4. Application of SCADA to electric power distribution systems

A reliable power distribution system is an essential component for the economic growth and development of a country. Therefore, a modern electric power network system must be capable of performing 365 days a year and 24 hours a day with a high quality of uninterrupted power supply, even during the peak hours, to improve the performance of services to the customers. In view of the extensive size of the distribution networks, this can be achieved only by proper computer-based monitoring and control system as well as by efficient distribution and metering.

The "Monitoring and Control System" is the main part of a distribution automation network. This system was defined by IEEE as "A system that enables an electric company to remotely monitor, coordinate and operate distribution components in a real-time mode from remote location". The location from where control decisions are initiated is generally called Distribution Control Center (DCC). Within this center, different kinds of application software are used, which cooperate among themselves to achieve the control task [17-19].

Many other types of equipments will also be used to support such automation of a power network. They include Automatic Meter Reading (AMR), Data Concentrator Unit (DCA), Remote Terminal Unit (RTU), Supervisory Control and Data Acquisition (SCADA), Communication equipments, etc.

In this discussion we would mainly focus on the customer service quality. Customer service requirements point to one key element: Information, i.e., the right amount of information to the right person or computer within the right amount of time. The flow of information requires data communication over extended networks of systems and users. In fact, utilities are becoming among the largest users of data and are the largest users of real-time information [20-21].

Hence, the implementation of power network automation system will provide better services to EDC customers and improve the power quality and reliability of the electric supply services, which would satisfy the following goals:

- Respond to customer service interruptions more quickly.
- More efficiency of the power system by maintaining acceptable power factors and reduced losses.
- More control and limit of peak power demand.
- Ability of EDC engineering staff to monitor and control the power system during normal and abnormal conditions by providing more reliable and appropriate real time data.
- Ability of EDC engineering staff to perform the power system analysis and planning by providing increased access to past and current operations data and associated software tools.
- Ability of EDC engineering staff to manage the power system assets and system operations by providing increased access to better performance data and historical statistics.

A simple architecture of a power network automation system is given in figure 2.

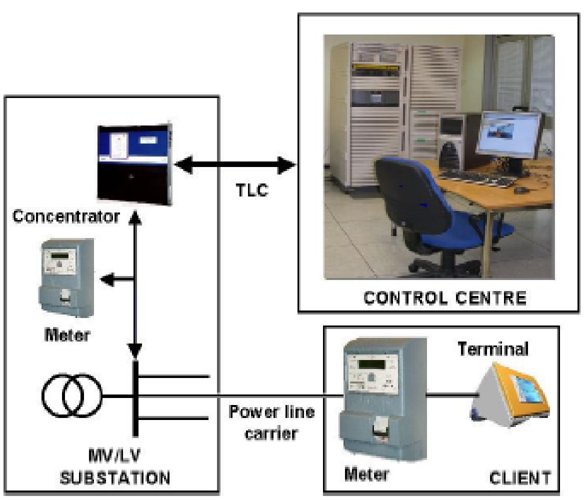

Fig. 2. General architecture of the power network automation system.

This figure outlines components and their locations in the chain going from the central computers, down to the electricity meters and optional terminal units which can be used by the customer to view the real time status of the network.

The control center represents the main part of a distribution automation network. It can be based on an open hardware architecture, which can be easily scalable and flexible for future additions, using a number of commercial equipments, such as:

- a duplicated management server housing the application software and the alarms handler;
- a duplicated data collection server;
- one gateway server interfacing the control centre to the external commercial management system and another interfacing the remote-control system;
- a firewall with an unlimited client number;
- one router;
- three operator workstations;
- one high storage media.

The terminal units at the customer location will be used for many tasks. They will display the consumption, service and billing information including hourly load curves. The customer can also remotely close the circuit breaker of an outdoor meter equipped with the motor option. Also, the terminal units will communicate with the control centre to receive messages, alert the client in time to reduce the load when it exceeds a given limit and prevent tripping of the meter breaker and finally support prepayment.

In order to exchange data, the different system components need equipments installed in the MV/LV substations, which manage the data transmission to and from the meters, by a Power Line Carrier (PLC) over the low voltage lines and provide the connection to a control centre, using a dedicated protocol, over public or private communication networks. As the amount of data to be exchanged is huge, it asks for the use of computer and other smart equipments to manage the power network in real time. One of the smart equipments used is the Automatic Meter Reading (AMR). The AMR has replaced the old conventional energy meter (disk type) because of its better performance to process a huge amount of data in real time.

The communication systems will include various equipments with microprocessor controllers such as SCADA, RTU, Data Concentrator (Logger) and fast computers to supervise and control the network [22-23].

The different equipments, including SCADA system, have been successfully installed in many EDCs over the world [24-27].

SCADA systems come in a myriad of types, sizes, and applications [28]. There are many SCADA system manufacturers and most provide a multitude of SCADA systems (Table).

Table: Major manufacturers and current SCADA systems.

Manufacturer	***Current SCADA***
ABB	Process Portal A/Operate IT, Ranger
ACS	Prism
Alstom	ESCA
C3-Ilex	EO SCADA
Citect	CitectSCADA
Foxboro	Invensys I/A series
GE Fanuc Automation	iFix 32
GE Network Solutions	XA21, Swift
Motorola	MOSCAD
QEI, Inc	TDMS-2000

Most developed countries, applied SCADA projects for their electrical distribution systems. Implemented SCADA systems, in these countries satisfied latest technology requirements like expandability and flexibility, conformity to international standards, high reliability, high functionality and high performance and high-level human interface.

In Japan, for example, the implementation of a SCADA system for automatic power distribution [29] has remarkably decreased both interruption frequency and interruption time by line faults.

In Taiwan, many distribution system dispatchers have installed SCADA systems for more management and rapid operation control. The automation of the system and the interactive display of geographic views have been identified as a necessary functionality for a complete distribution system SCADA [30].

In other side, developing countries started giving importance of implementing SCADA systems for automating some of their industrial processes including the electrical distribution networks.

In Tunisia, for example, we developed many applications for the analysis [31-33] and the supervision [34-35] of thermal power plants using SCADA systems.
In [36] we show the need of automation for the Saudi Electrical Company on its distribution network and how to explore the importance of computer based system towards more sustainable services.

Moreover, in 2001, two Swedish donor agencies have funded SCADA systems for controlling power networks in nine developing countries (Botswana, Pakistan, Ecuador, Vietnam, Jordan, Zambia, Kenya, Zimbabwe and Lesotho) [37].

5. Conclusion

In this paper, we presented the project management phases of SCADA projects and then a computer based power distribution automation system is discussed.

Moreover, we proved the importance on using computer based system for sustainable development in the automation of the power distribution network to improve the customers' service and the reliability of the network.

Also the paper outlines the general concepts and required equipments for the automation of such power networks. Some projects of SCADA system implementation in electrical companies over the world have been presented.

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