DESIGNING AND IMPLEMENTING SCADA SUBSYSTEM FOR TEXTILE INDUSTRY

Rajesh Kumar, Syed Akif Kamal, Furqan M. Khan
NED University of Engineering and Technology, University Road, Karachi, Pakistan
Email: {newelstein19, aakif_kamal, furqan82}@hotmail.com

1. Introduction

Supervisory Control and Data Acquisition (SCADA) is a computer-based system for gathering and analyzing real-time data and making suitable decisions based on the analysis. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, fluid pressure and level systems, industrial weighing and density systems, energy, oil and gas refining and transportation.

A SCADA system gathers information, such as where a leak on a pipeline has occurred, transfers the information back to a central site, alerting the home station that the leak has occurred, carrying out necessary analysis and control, such as determining if the leak is critical, and displaying the information in a logical and organized fashion. SCADA systems can be relatively simple, such as one that monitors environmental conditions of a small office building, or incredibly complex, such as a system that monitors all the activity in a nuclear power plant or the activity of a municipal water system.

Our final year project is to design a Supervisory and Monitoring System for Looms for M/s Hussein Textile Industry. The design of SCADA systems includes the complete analysis of the problem and its suggested solution based on factors such as market conditions and available resources. In this paper we will try to answer certain issues central to the design of SCADA systems.

1.1. Emergence of SCADA System

With the development of DOS in 1980s, the opportunity for the system integrators and value-added resellers was clear. One could develop a relatively inexpensive Supervisory Control and Data Acquisition System (SCADA) package for the personal computer platform and integrate it with these general-purpose shrink-wrap software packages, and one could have a very cost-effective alternative to DCS (Distributed Control Systems). These packages include Relational Database Management, Spreadsheet packages, Statistical process control capabilities, Expert Systems, Computer-based process simulation, Computer-aided design and drafting, Desktop publishing, Object-oriented display management, Windows-oriented workstations, Information exchange with other plant systems.

During the late 1980s and early 1990s, software and communication standards began to take hold, making interoperability among disparate computing platforms, interconnecting devices and application software a near-term reality. These standards include Open operating standards, such as POSIX or UNIX, Open-System interconnect (OSI) communication model, Client-server cooperative computing model, X-window protocols for workstation communication, Distributed relational database management systems, SQL access to distributed relational databases, Object-oriented programming and platform-independent languages such as JAVA, Computer-aided software engineering.

1.2. Architecture

SCADA systems are organized into five major sub-systems, namely:

- Operational stations
- Controller subsystems
- Data collection subsystems
- Process computing subsystems
Communication networks

The main objective of our final year project is to develop 3, 4 and 5th subsystems and part of 1st subsystem for Weaving Looms.

2. How to choose Equipments

There are several questions that need to be answered before a final decision is made on the actual components of a new Supervisory Control and Data Acquisition system.

2.1. How versatile is it?

For economic reasons, it is usually better to keep as much of the current equipment in the existing system as is realistically possible. The committee set up to design a system must then ask themselves what kind of connectivity a vendor has with the existing equipment. If connectivity is impossible or difficult then the question of customizing comes into play. If a system is customized, will that make future changes, upgrades, and maintenance even more costly? Hussein Industry has a variety of textile machinery ranging in technology from mechanical to electrical to modern computerized machines. We have developed electronic circuitry to enable mechanical and electrical looms to communicate with the network. Air-jet looms are already equipped with sensors, circuitry and basic infrastructure for communication. All of these need to be integrated homogeneously with the system to reap real benefits.

2.2. Is the vendor a recognized company?

For most companies, the smart move is to look at nationally known, proven vendors of Supervisory Control and Data Acquisition equipment. It is important that they have a history of success stories behind them, yet also have local distribution and technical support. Once a vendor is chosen, listen to their experts on recommendations for customizing the system. For some industries without large distribution of plants and equipments, management may decide to give the entire project of developing the SCADA system to a university or engineering college.

2.3. Does it meet the requirements?

Of course, a system can have all the buttons and toys any technical person could want, but if it doesn’t meet the needs that the evaluation committee has formulated, it isn’t worth having. Each department on the committee will be more concerned with one function over another. It is important that they rate, on a scale of one to 10, the importance of each feature or need so that an acceptable compromise can be reached. This issue pertains to the quality of domain analysis carried out which is the defining feature of any computer system. The ultimate goal is to satisfy the end-user, not to create state-of-the-art widgets and connections.

3. The master station

The master station gathers field data directly from the remote stations, or sub-master, and provides monitoring and control over the entire system through its operator interface. There are several master station types available including:

A. VAX, LINUX or UNIX-based computer.

Used in extremely large applications that may also require sub-master stations to gather data, support local operator interface, support logging of alarms and events, communicate with remote stations, and interface with a larger master station.

B. Personal computer.

It is used in small-to-medium-sized applications. There are many vendors of Supervisory Control and Data Acquisition software for the PC that allows acquisition of data, graphical interface, historical data storage, and alarming. They are user-friendly and provide the ease of customization.

C. Programmable controller.

In order to determine whether a PLC should be used in your application, ask whether the master station needs to control local input/output, whether the application requires master station redundancy, and how many remote stations your application requires?

4. Remote terminal units
An RTU is a microcontroller-based unit, specifically designed for real-time processing of input and output of data. Remote terminal units also log alarms, report status to the master station, and carry out the commands from the master station. In order to choose the appropriate device for your application, ask the following questions:

A. What protocol does your application require?
B. Does it use analog input/output?
C. How many input/output points does it require?
D. Do you need the remote station to collect data without being told to by the master station?
E. Do you need online programming, faster ladder logic speeds, and a built-in clock/calendar?
F. Do you want the remote station to interrupt the master about certain events?

Since some RTUs attached to existing looms employ Modbus protocol, therefore the RTUs we designed for mechanical looms followed the same protocol. The RTU keep gathering and storing the production data in its RAM. At pre-selected intervals the master polls the RTU for data. Periodically, RTU flushes the old data out. Although the RTU is capable of noticing machine stops and other failures, it doesn’t interrupt the master about these events. The information is relayed only when polled. The reason for this design is discussed in the next section.

5. Data communication equipment and the Line Discipline

Whatever communication network you have chosen will determine the appropriate data communication equipment you will need. The equipment is simply the link between a transmission medium and the data terminal equipment, or it can be viewed as the data transport mechanism between the host computer system and the remote terminal unit. Data communication equipment can include telephone and radio modems, microwave, Ethernet cards, or satellite transmission equipment. No matter which communication method is chosen, Supervisory Control and Data Acquisition systems usually use a communication format called master-slave. This means that all conversations are initiated by the master station. The remote terminal unit, or slave, replies only when it receives a message. The master controls all conversations. Hence the Poll/Select line discipline is feasible.

5.1. Ethernet

Due to its availability, and high communication rates, Ethernet is becoming a prime network control candidate. Almost all modern computers and industrial equipment come equipped with Ethernet interface. Combined with the current standards for Ethernet, a synergistic effect is developed on the number of trained personnel to setup and work with Ethernet devices.

Another important advantage of Ethernet is access to the Internet which makes it possible to implement remote data logging and diagnostics. If desired, the data can be made available through Internet by deploying application servers on the PCs without any change to the PC-RTU communication interface.

Ethernet was not created to guarantee the delivery of time-critical information. The major limitation is the non-deterministic nature of communication. Ethernet uses the carrier sense multiple access with collision detection (CSMA/CD) to resolve contention in case of simultaneous data transmission. If two nodes transmit messages simultaneously, the messages collide and are destroyed (data is lost). The two transmitting nodes listen to the network to detect a message collision. If a collision is detected, the transmitting nodes wait a random length of time to retry transmission. If sixteen collisions are detected, the node stops transmitting and reports an error. Thus it presents disadvantages when used as a control network though it may work well just for monitoring purposes.

From our analysis we have recommended M/s Hussein Industry that a PC should accumulate data from each weaving room through serial communication. PCs in all rooms can easily be connected through Ethernet.

6. Check protocol

In order for the host, or master, and the remote terminal units to communicate with each other there must be a common method of encoding and decoding the messages between them. This is referred to as the protocol. In order to choose the one best suited to your application, consider the following:

A. Avoid proprietary protocols. A closed protocol leaves the end-user with fewer options for integrating equipment from various vendors.

B. Select equipment that supports well-behaved, open protocols that are well-documented and supported by many vendors, such as Modbus.

C. Do you need to connect to existing equipment?

Many Supervisory Control and Data Acquisition systems require the Modbus protocol, yet designers may, for various reasons, choose to install Allen-Bradley units which do not support Modbus. That is where third-party protocol suppliers may have the answer to this common problem. There are a number of third-party protocol suppliers available that allow existing protocols to communicate with equipment made by different manufacturers.

D. Use existing protocol. In certain cases, the output of the sensor, data acquisition system, or the terminal is already encoded in a well-behaved, open protocol. In these cases, you may choose to go with it.
Keeping all these best practices in perspective and the already existing looms employing Modbus protocol, it has been suggested to continue to develop circuits conforming to Modbus protocol. Even if the management decides to move from serial to Ethernet communication, Modbus still remains the choice protocol with its different variation such as RTU, ASCII and TCP.

7. Data distribution and Security

It is also important to evaluate the mechanisms available for data distribution in a Supervisory Control and Data Acquisition system:

A. Who needs access to the information?
B. How often?
C. What network interfaces are possible with the system?
D. Can the system function as a TCP/IP server to deliver archived data to other users as well as a client to deliver data to a server?
E. How time-sensitive the information is?

Most SCADA systems were originally built before and often separate from other corporate networks. As a result, IT managers typically operate on the assumption that these systems cannot be accessed through corporate networks or from remote access points. Unfortunately, this belief is usually fallacious. In reality, SCADA networks and corporate IT systems are often bridged as a result of two key changes in information management practices. [7] discusses some other misconceptions about SCADA systems threats. The integration of process and business network can cause multitude of security problems. The major issue is that problems on the business network can be passed on to the process network through the business/process interface, and this can seriously impact production. There are some hilarious examples of accidental and deliberate problems in interfacing business and process. [4] and [5] present some case studies and solutions to avoid such problems and consequently enhance security on such systems. The requirement for high security becomes significant if either process or business network is connected to Internet. As more mills attach to either the Internet or the corporate wide area network (WAN), the chances of being hacked are growing.

8. Budget scope

We feel very grateful to the management of Hussein Textile Industry for entrusting such an important task to us. Being engineers, we have tried our best to use our knowledge to make good engineering decisions keeping in view cost/benefit ratio. After the successful site testing of our prototypes, the management will be fully enlightened on the cost analysis of complete project.

9. Measuring progress

During the project implementation, it will be important to set measurable milestones for the company and the suppliers involved. These should be easy to evaluate through direct observation of the system in its various stages and should be written into the contract of all suppliers. These should include:

1. Software design: all parties should have a good understanding of the project-critical requirements needed.
2. Factory acceptance before system shipment.
3. Site acceptance to ensure the system is ready for commercial operation.
4. Final system acceptance.

Once the new Supervisory Control and Data Acquisition system is up and running, it is important that a post-installation analysis be completed to identify project mistakes and the factors which contributed to the project's success. With the new technological advances becoming available each year, this analysis may be beneficial if and when another revision becomes necessary in the future. Currently some modules of our system are in factory acceptance phase while others are under development. This being our final year project, we are not only constrained by the client deadline but also our academic deadline.

Summary and Future Work

Domain analysis in perspective of SCADA systems is the central theme of our project. As the project progressed, issues concerning the design keep coming up. We have tried to document these engineering decisions in this paper. The implementation of the project is still underway and some new challenges may crop up in the meantime.

References:

[5] Ian Weise, "THE INTEGRATION OF SCADA AND CORPORATE IT"
[7] UNDERSTANDING SCADA SYSTEM SECURITY VULNERABILITIES.