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Scada system and its applications

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Abstract
In the recent world as technology grows, the automation sector is also growing because it controls the process automatically without the need of human person. In this paper, we discuss about the SCADA System which stands for supervisory control and data acquisition. It is a powerful system for industrial automation and supervisory monitoring. This system collects the information from the sensors and the data from a process that is analyzed in real-time by RTU or MTU. This paper also gives information about SCADA generation i.e. monolithic, distributed, networked and web based. SCADA have two types of architecture one is hardware and other is software. SCADA systems are essential to a wide range of industries and are broadly used for the controlling and monitoring of a process like data like flows, currents, voltages, pressures, temperatures, water levels.

Keywords: SCADA, RTU, MTU, HMI, architecture, SCADA generations, applications

Introduction

SCADA is an acronym for SUPERIVISORY CONTROL AND DATA ACQUISITION. As we know that CPU is the brain of the computer and controls all the work done on computer, in the same way SCADA plays the role for industries, perhaps not just for industries. The basic functions of SCADA system is to Monitoring and controlling the instruments, creating a telecommunication between the equipment like instruments and sensors, Store data of all operations for future use. Supervisory Control and Data Acquisition (SCADA) networks have a vital role in Critical Infrastructures (CIs) such as public transports, power generation systems, gas, water and oil industries, so that there are concerns on security issues in these network [2]. Supervisory Control and Data Acquisition is a control system architecture comprising computers, networked data communications and graphical user interfaces (GUI) for high level process supervisory management, while also comprising other peripheral devices like programmable logic controllers (PLC) and discrete proportional integral derivative (PID) controllers to interface with process plant or machinery. SCADA system collects information and data from instruments and sensors at remote site (ground level) and transmit it to central site. The collected data from sensors and instruments is usually received on one or more SCADA host computers that are located at the central site. SCADA system is used on a massive scale in different areas like monitoring variety of processes including wind turbine, refinery, water flow, dams, industrial processes, air pollution, and water pollution from remote areas [1]. The use of SCADA has been considered also for management and operations of project driven process in construction [3].

Scada Components

SCADA is widely computerised system and is generally used to remotely control and monitor the condition of field-based assets from central site. SCADA systems gather pieces of information and data from a process that is analyzed in real-time. It records and logs the data, as well as representing the collected data on various HMIs. The most important elements of SCADA system are master terminal unit (MTU), communications, remote terminal unit (RTU) and HMI. Input to the system normally initiates from the operator via the master terminal unit's keyboard. The MTU monitors information from remote sites and displays information for the operator. The relationship between MTU and RTU is analogous to master and slave. SCADA systems are capable of communicating using a wide variety of media such as fiber optics, dial-up or radio [5].

Master Terminal Unit: At the heart of the system is the master terminal unit (MTU). The master terminal unit initiates all communications, gathers data, stores information, sends information to other systems, and interfaces with operators. The major difference between the MTU and RTU is that the MTU initiates virtually all communications by its programming and people [4]. Almost all communication is initiated by the MTU. The MTU also communicates with other peripheral devices in the facility like monitors, printers or other information systems.

Programmable Logic Controllers: The PLC receives information from the connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters. Depending on the inputs and outputs, a PLC can monitor and record run time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms if a machine malfunction and more.

Remote Terminal Units: A remote terminal unit is a microprocessor controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA system by transmitting data to a master system, and by using messages from master supervisory system to control connected objects [6].

Human-machine interface: The human-machine interface (HMI) is the operator window of the supervisory system. It presents plant information to the operating personnel graphically in the form of mimic diagrams, which are a schematic representation of the plant being controlled, and alarm and event logging pages. The HMI is linked to the SCADA supervisory computer to provide live data to drive the mimic diagrams, alarm displays and trending graphs.

Architecture of Scada System

The hardware SCADA architecture uses the programmable logic controllers (PLCs) and remote terminal units (RTUs). The software SCADA architecture includes Human Machine Interface (HMI), a central database (Historian) and other user software [7]. PLCs and RTUs are microcomputers that communicate with an array of objects such as factory machines, HMIs, sensors, and end devices, and then route the information from those objects to computers with SCADA software. The SCADA software processes, distributes, and displays the data, helping operators and other employees analyse the data and make important decisions. The SCADA system's ability to notify the operator of an issue helps him to resolve it and prevent further loss of product. Most control actions are performed by RTUs or PLCs. The RTUs consist of programmable logic converter which can be set to specific requirement.

Hardware Architecture: SCADA hardware system can be classified into two main parts Clint layer and Data server layer. The Clint layer is the one which caters for the man and machine interaction. The data server layer is the one which handles most of the process data activities. The PLCs are connected to the data servers either directly or via networks or buses. The SCADA system utilizes a WAN and LAN networks, which consists of internet protocols used for communication between the master station and devices. The physical equipment's like sensors connected to the PLCs or RTUs. The RTUs convert the sensor signals to digital data and sends digital data to master. According to the master feedback received by the RTU, it applies the electrical signal to relays. Most of the monitoring and control operations are performed by RTUs or PLCs.

Software Architecture: Most of the servers are used for multitasking and real time database. The servers are responsible for data gathering and handling. The SCADA system consists of a software program to provide trending, diagnostic data, and manage information such as scheduled maintenance procedure, logistic information, detailed schematics for a particular sensor or machine and expert system troubleshooting guides. This means the operator can see a schematic representation of the plant being controlled.

Types of Scada Systems

There are different types of SCADA systems that can be considered as SCADA architectures of four different generations:

Monolithic or Early SCADA Systems: In the Early SCADA system, the computing was done by large minicomputers. The Common network services did not exist at the time SCADA was developed. Thus, these SCADA systems were independent systems with no connectivity to other systems. The communication protocols used were strictly proprietary at that time. The functions of the monolithic SCADA systems in the early first generation were limited to monitoring sensors in the system and flagging any operations in case of surpassing programmed alarm levels. The first-generation SCADA system redundancy was achieved using a back-up mainframe system connected to all the Remote Terminal Unit sites and was used in the event of failure of the primary mainframe system [11]. Some of the first generation SCADA systems were developed as "turn key" operations that can ran on the minicomputers such as the PDP-11 series. In this architecture, RTUs communicate to MTU using Wide Area Networks (WAN) as shown in Figure given below [12].

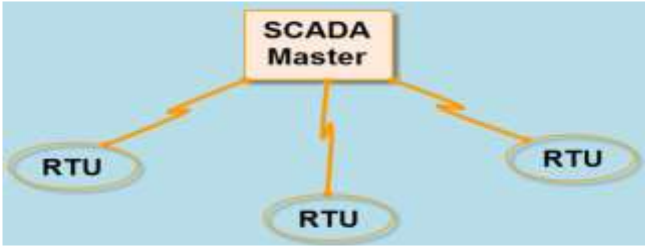

Fig 1: Network architecture of Monolithic or Early SCADA Systems [8]

Distributed SCADA Systems: The second generation of the SCADA system is known as Distributed SCADA System because the sharing of control functions is distributed across the multiple systems connected to each other using Local Area Network (LAN) [8]. The each station was used to share the real time information between them and command processing for performing control tasks to trip the alarm levels of possible problems, thus reducing the cost as compared to the previous generation of SCADA system. The network protocols are still not standardized in the distributed SCADA system. The network architecture of the distributed SCADA System is shown below in the figure. The security of the

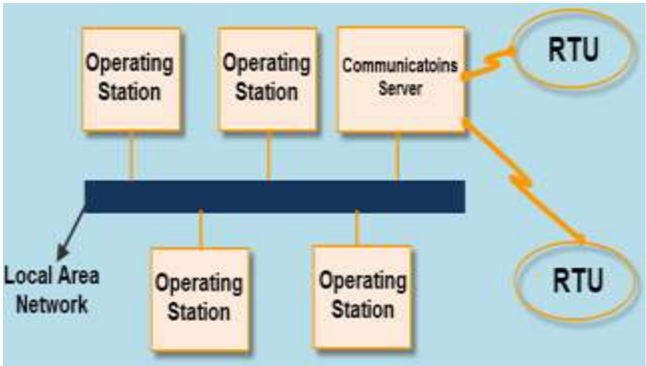

Fig 2: Network architecture of Distributed SCADA Systems [8]

SCADA installation was determined by a very few people beyond the developers, as the protocols were proprietary. But generally, the security of the SCADA installation was ignored.

Networked SCADA Systems: In the third generation, any complex SCADA system can be reduced to its simplest components form by connected it through communication protocols. In this type of SCADA systems, the network may be geographically distributed and communicate using Wide Area Network (WAN) Systems over data lines or phone. This type of SCADA systems uses Ethernet or Fiber Optic Connections for transmitting data between the nodes frequently. The Programmable Logic Controllers (PLC) is used for monitoring and adjusting the routine flagging operators only in case of major decisions requirement. The architecture of the third generation is shown in the figure below. The several distributed architecture SCADAs were running in parallel along with a single supervisor and historian in the network architecture [3].

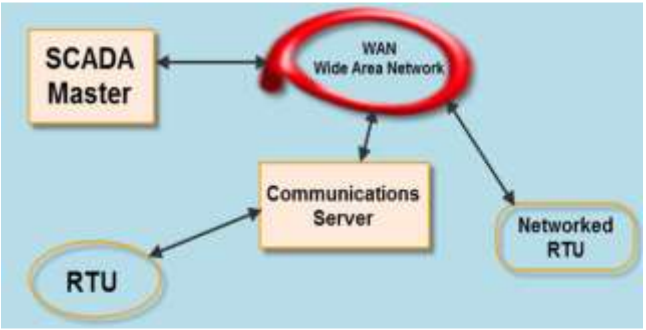

Fig 3: Network architecture of Networked SCADA Systems [8]

Internet of Things: Due to the growth of internet in recent decades led SCADA systems to implement web technologies allowing users to view data, exchange information and control processes from anywhere in the world. In fourth generation, the infrastructure cost and deployment cost of the SCADA systems is reduced by adopting the integration of internet of things technology with the commercially available cloud computing. The maintenance and integration is also very easy for the fourth generation compared to the earlier SCADA systems. It is a network of devices with a significant focus on transfer, control of critical information, getting insights from large data. Therefore, to inculcate IIoT in SCADA, several devices, protocols need to be integrated into the existing system [12]. The architecture of the fourth generation is shown in figure below. These SCADA systems are able to report state in real time

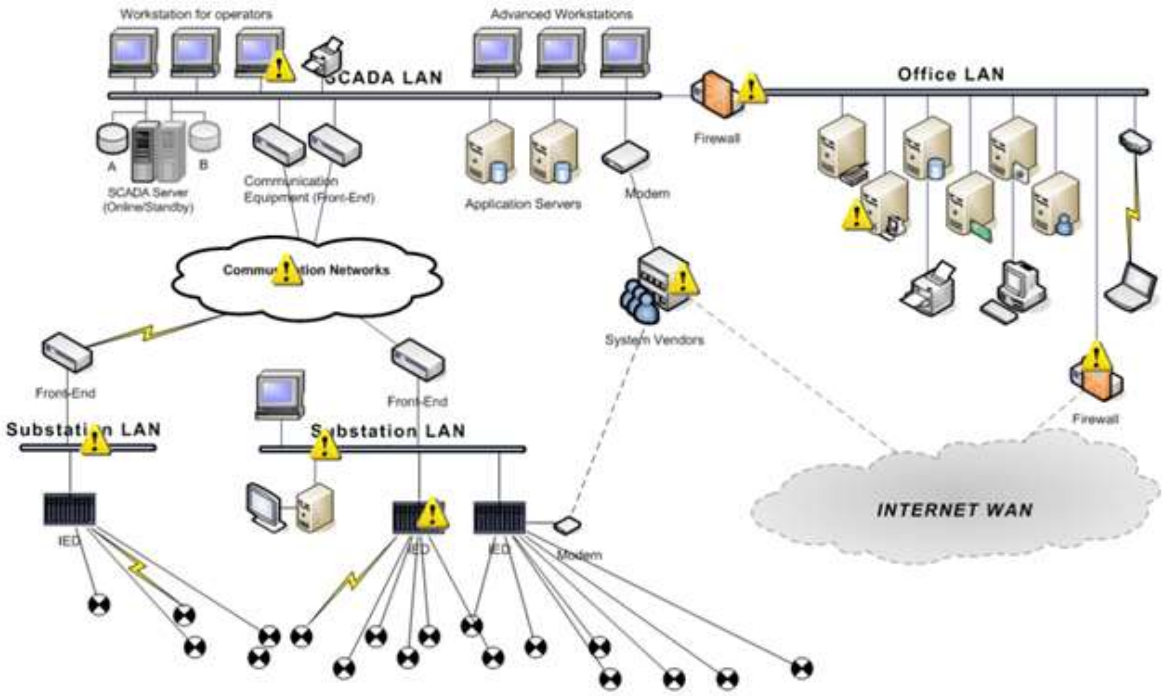

Fig 4: Network architecture of Internet of Things [8]

By using the horizontal scale from the cloud computing facility; thus, more complex control algorithms can be implemented which are practically sufficient to implement on traditional PLCs. Industries 4.0 are an example of the fourth generation SCADA system in which distributed cognitive computing, CPS, IoT, and cloud computing is used for controlling the action [13].

Applications

Both large and small systems can be built using the SCADA concept. These systems can range from just tens to thousands of control loops depending on the application. SCADA systems are used for monitoring a variety of data like flows, currents, voltages, pressures, temperatures, water levels, and etc., in various industries.

SCADA in Manufacturing Industries [8]: In manufacturing industries the regular processes like running the production systems to meet the productivity targets, checking the number of units produced and counting the completed stages of operations along with temperatures at various stages of the manufacturing process, and so on, are taken care by using the SCADA application.

SCADA used in Waste Water Treatment and Distribution Plants [15]: Wastewater treatment plants are of different types such as surface-water treatment and a well water treatment system in which many control systems and automation processes are involved in water treatment and distribution systems. SCADA systems are used for controlling the automatic operations of the equipment used like backwashing the filters based on the hours of working or amount of water flow through the filters. In distribution plants the water tank levels, pressure of system, temperature of plant, sedimentation, filtration, chemical treatment and other parameters or processes are controlled using the SCADA applications such as PLCs, PC based workstations which are connected each other using Local Area Network (LAN) such as Ethernet.

Telecom and IT based systems [9]: Management of different RF based systems, communication mediums and large communication systems including data logging through antennas can be easily done through the SCADA.

MATLAB: The SCADA system is used along with the MATLAB software for controlling purpses. SCADA-MATLAB platform which connects usual SCADA supervisory system to MATLAB software to handle complex control algorithms. Their result demonstrated the reliability and effectiveness of SCADA-MATLAB platform in real-life typical situations, including gate malfunctioning and extreme water off-take conditions [14].

Thermal Power Plants: It allows an operator to make a set point changes on remote controllers, to open/close valves/switches, to monitor alarms and to gather instrument information from a local process to a widely distributed process, such as oil/gas fields, pipeline systems, or hydroelectric generating systems. In the context of SCADA, it refers to the response of the control system to changes in the process and makes them similar to real-time control system in the virtual environment [10].

Conclusion

SCADA system is a centralized system which monitors and controls entire area process with the help of software and hardware components. It is a supervisory system which gathers data from the remote location with the help of sensors and sends the commands for controlling the process to PLC or HMI. SCADA systems can be constructively implemented in various sectors which will reduce human effort and improve accuracy of system monitoring. At present generation, SCADA systems came into existence that allowed us to control and monitor real-time data anywhere in the world. SCADA systems are essential to a wide range of industries and are broadly used for the controlling and monitoring of a process such as wind turbine, refinery, water flow, dams, industrial processes, air pollution, and water pollution.

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