flotek.g 2017- "Innovative Solutions in Flow Measurement and Control - Oil, Water and Gas" August 28-30, 2017, FCRI, Palakkad, Kerala, India

Demystifying Integration of SCADA and IoT in an Industry

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ABSTRACT

Large-scale industries resort to automation to monitor and control the processes in order to maintain optimum production and quality. Towards this end, it is essential to make automation efficient and economical. Automation helps to reduce manpower as the operational control is automatic and centralized. Modern industries such as aerospace which are matured deploy automated machines for fabrication, assembly, integration and testing. Customized Supervisory Control and Data Acquisition (SCADA) Systems are deployed to monitor and control the processes in these industries. IoT (Internet of Thing) is one of the most disruptive innovations of recent times. IoT supported by tools, techniques and infrastructure has been capable of resolving macro level issues in an automated industry. To derive benefits from both, SCADA and IoT are integrated. This approach facilitates efficient monitoring and control of processes and data archiving to support decision-making. In this paper an attempt is made to examine how the integration of SCADA and IoT is relevant in an industrial environment to offer better products and services.

KEY WORDS

Supervisory Control and Data Acquisition, Internet of Things, Remote Terminal Unit, Master Terminal Unit

1.0 INTRODUCTION

Most of the modern industries are automated with the objectives to efficiently monitor and control processes to optimize production with quality. As a spin off advantage it becomes feasible to reduce the strength of operational staff, control operation centrally and collect data for future use. High-tech manufacturing industries such as aerospace are matured enough and deploy partially or fully automated machines for fabrication, assembly, integration and testing. As part of the automation Supervisory Control and Data Acquisition (SCADA) Systems are customized and deployed in these industries. IoT (Internet of Thing) is one of the most disruptive innovations of recent times. SCADA and IoT are integrated to get optimum solutions. The integration also helps to archive data required for accurate decision-making. This paper gives outlines of SCADA and IoT and examines how the integration is relevant to offer better industrial products and services.

2.0 SCADA SYSTEM

SCADA is a computer-based process control system. The operational objectives of SCADA systems are: (1) Monitor the production system proper, (2) Obtain control over the system and ensure required system performance, (3) Reduce operational staffing levels by centralized operation, (4) limited archiving of data for future use. SCADA systems are customized and deployed in power plants, oil and gas and aerospace industries.
A typical SCADA system consists of 3 sub-systems: (1) Master Terminal Unit (MTU) which is a centralized computer system facilitating supervisors to monitor the process, (2) Remote Terminal Unit (RTU)

which comprises Microcontroller, electronic interfaces, Sensors and control devices and (3) Communication network with wired and wireless connectivity of variety of standards and protocols.
The system collects data from sensors and other devices, analyzes the data and controls the system from a centralized location. Figure (1) shows block diagram of a typical SCADA system with remote terminal unit (RTU) comprising local processor, PLCs and intelligent devices, MTU with supervisory system and human machine interface (HMI). The RTUs collect and send data to the MTU. The MTU processes the data and generates outputs and sends to devices to control processes and to raise alarms on limit exceedance of parameters. The outputs are presented on HMI monitor for manual intervention, if required. SCADA system also stores limited amount of data and events for future use.

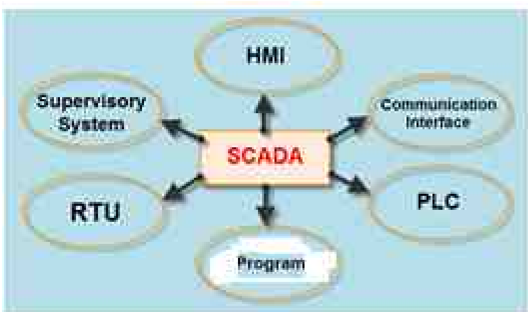

Fig. (1) Typical SCADA System

Figure(2) shows networked architecture with Master, RTU, WAN (Wide Area Network) and communications server to support various types of networks and protocols. A networked system covers larger geographic areas compared to simple system.

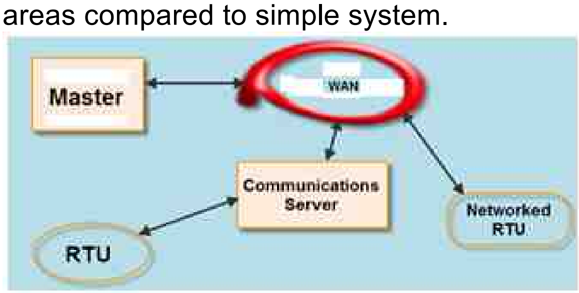

Fig. (2) Networked SCADA System

3.0 EVOLUTION OF SCADA SYSTEMS

Since 1960's SCADA systems are in use in industries. There are four generations of SCADA systems which are evolved based on industrial needs and technological developments.
The first generation stand-alone system is hosted on mainframe computers and has monolithic architecture. The communication with RTUs is over proprietary networks.
The second generation is distributed type with multiple stations communicating amongst them over LAN (Local area Network) with proprietary protocols. Each RTU is assigned particular set of tasks.
The third generation is based on open system architecture. The system functions are distributed and communication is across WAN with Internet Protocol (IP). Due to the geographical spread and usage of WAN, the system is prone to security risks. But proper maintenance and updates reduce its severity.
The fourth generation is the integrated system of SCADA and IoT with the support of technologies such as big data and cloud computing. Diverse range of wired and wireless communication standards and protocols are part of the system. The cost of infrastructure is moderate. The maintenance is easier.
The major factors that influence SCADA architecture are remoteness, data rates, type and infrastructure of communications available at the sites. The security concerns in a diverse SCADA system are to be properly addressed. A summary of four generations of SCADA is given in the Table (1) below.

Table 1 - Generations of SCADA

Sl.No.	Generation	Category	Remarks
1	First	Monolithic	Independent system. Low security risk.
2	Second	Distributed	Multiple systems with LAN. Each system performs a particular task. Reduced cost and size. Moderate security risk.
3	Third	Networked	Systems with WAN, communication- Ethernet, Fiber Optic. Many systems under single supervisor. More security risk.
4	Fourth	integrated system of SCADA and IoT	IoT with support of cloud computing and big data, less cost, easy maintenance. Protocols like TLS (Transport Layer Security) or SSL (Secure Socket Layer) provide security coverage.

4.0 INTERNET OF THINGS

Internet of Things is a system in which things are connected to the Internet. It is one of the most noteworthy innovations of recent times. It supports to establish close link between things in the physical world and its logical representation in information systems. Things are embedded with intelligence to collect and communicate data in real-time over the Internet. Examples of IoT- enabled services are cell phone check-in at hotel / airport and usage of IC chips in animals to locate them. The scope of IoT enlarges by adapting to advancements in technological areas such as connectivity, networks, cloud computing, big-data and cyber security.

IoT provides the following functions:

- Catering for diverse set of adapters and connectivity to devices
- Connecting things including SCADA
- Real time processing of data
- Adopting to Cloud and SaaS (Software as a Service)
- Big-data processing and machine learning

There are four building blocks of IoT Viz., (1) Internet of devices, (2) Internet of objects Viz., Radio frequency identification (RFID), (3) Internet of transducers: Wireless sensor networks (WSN), and (4) Internet of controllers: Supervisory control and data acquisition (SCADA). IoT also enables connectivity with heterogeneous hardware ranging from legacy to state of the art.

As new things compatible with Internet emerge, the application areas of IoT expand along with the need to process big data. The security risks also arise and to surpass it an end-to-end security strategy and measures covering network, application, user and data needs to be put in place.

5.0 INTEGRATED ARCHITECTURE OF SCADA AND IOT

The main functions of SCADA are real-time monitoring and control of processes; while that of IoT are archiving historical data, facilitating predictive analytics and decision-making. An integrated architecture of SCADA and IoT catering for the functions specific to the industry is implemented to improve productivity. In this context, the following are the challenges faced with SCADA in an industry which has grown organically over a period of time:

1) Variety of PLCs and RTUs that support different connectivity protocols.
2) Multiple SCADA systems from different vendors.

3) SCADA systems store only limited amount of data, so historical data not available for predictive analytics.

4) Legacy devices not easy to connect as they lack proper interfaces.

Figure (3) shows an abstract idea of SCADA integrated to an IoT platform. The data from SCADA flows to IoT. So the IoT platform acts as a depository of diverse data sets. Further details of interfaces are depicted in Figure (4) below.

Fig.(3) Block Diagram of SCADA with IOT

In an integrated architecture of SCADA with IoT encompassing a heterogonous mix of proprietary network protocols, security risks do exist. This risk can be surpassed using open network protocols such as TLS/ SSL inherent in the IoT. These protocols will provide comprehensible and manageable security. Table (2) shows the layers of Architecture of SCADA and IoT.

Table 2 - Layers of Architecture

Sl.No.	Name of Layer	Brief Description
1	Physical	Devices & embedded processors
2	Network	Exchange of data
3	Application	Remote control over LAN &WAN
4	Decision making	Process data analysis & reporting
5	Data aggregation	Big data analytics
6	Business processes	Decision-making

6.0 APPLICATION OF INTEGRATED ARCHITECTURE

Many modern industries have implemented integrated architecture of SCADA and IoT to achieve optimum production with quality. SCADA caters for advanced industrial automation and IoT augments with predictive analytics, machine learning and augmented reality (AR) capabilities. Figure (4) shows SCADA, IoT and ERP with an interface MES(Manufacturing Execution System) in the scenario of industrial automation. In a manufacturing industry ERP (Enterprise Resource Planning) and PLM (Product Life-cycle Management) are deployed to boost the production. ERP supports managers while planning, strategizing and decision making. Its main focus is on how to reduce inventory and delivery cycle time, optimize operational costs and improve productivity. PLM helps to effectively manage the entire lifecycle of a product from inception, through engineering design and manufacture, to service and disposal. MES forms the interface between the systems as shown in the Figure (4). MES does evaluation of shop floor parameters based on real-time data.

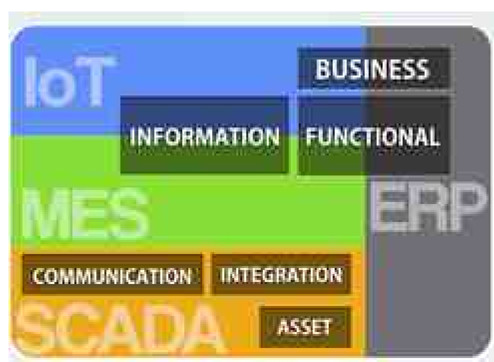

Fig.(4) Industrial Process Automation

The author was associated with implementation of ERP and PLM in an Aerospace industry with distributed manufacturing centers within the country. It has been found possible to improve inventory management, reduce cycle time, monitor cost, respond quickly to customer demands, analyze quality and enhance productivity.

Case Study:

In modern Aerospace industry the innovative approach emerging is positioning of SCADA system to monitor activities and collect real-time data, while IoT to cater for tasks of consolidating data and supporting predictive analysis and machine learning to effect dynamic planning and refining the processes. In commercial airline industry while operating fleets, large volume of data on airplane components to payloads is generated. The tasks of storage of data and associated processing are performed at IoT platform hosted in cloud. Certain challenges encountered in Aerospace industry and corresponding solutions are given in Table (3) below.

Table 3 – Challenges and Solutions

Sl. No.	Challenge	Solution
1	Processing of large volume of data.	IoT platform hosted in cloud used to process data
2	Variety of OEM data, tools and service procedures	OEM neutral single set available through Cloud
3	MRO operations poses difficulty to collaborate	Context sensitive mobility makes MRO operations efficient
4	Traditional mode of delivery of OEM spares/ items not efficient	E-commerce for seamless and efficient transactions

Airbus, one of the largest commercial airplane industries, has manufacturing centers at multiple locations geographically spread. The industry has 11 production sites and 4 assembly lines in four countries: France, Germany, Spain and the United Kingdom and subsidiaries in the USA, Japan and India. This industry has announced integrated SCADA and IoT to establish 'Factory of the Future'. The assembly lines at Airbus are in the process of usage of robot assisted manufacturing. A worker on the shop floor uses a tablet or smart glasses to scan metal skin of airplane and to decide the size of bolt and torque required to tighten it. The information is sent to the IoT platform to generate command to the particular robotic tool which takes up and completes the task. Since the IoT platform connects the workers and the robotic tools, the manufacturing process gets speeded up and the operations become more reliable compared to manual operation. The benefits derived with the integrated SCADA and IoT are: better utilization of assets, more productive manpower, more efficient Processes and improved productivity.

The main issues related to IoT implementation are:

- Data security: transactions of large volumes of data specifically with mobile/wearable devices needs close vigil and corrective measures.
- Robustness of data analysis.
- Additional cost of IoT as an initial investment

7.0 CONCLUSIONS

SCADA system with manual supervision has been an accepted practice in most of the industries. In order to improve production with quality, the Aerospace industries are going ahead with the innovative implementation of integration of SCADA and IoT functionalities. The main issues of integration encountered are due to cyber security for which solutions are getting evolved, and high investment. In spite of its high initial cost Airbus industry has already made inroads by hosting IoT platform in cloud for easier connectivity and resource availability to handle Big Data and predictive analytics. Other industries like chemical/ Petroleum/ Water are setting higher goals with their products and services. The delay to follow the suite is attributable to requirement of development of specific process innovation and initial investment. Once these constraints are overcome the innovative approach of integration of SCADA and IoT will enable growth in these industrial sectors too. The integrated architecture of SCADA and IoT is being evolved and the quantified results of implementation are expected in due course.

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