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SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEMS FOR INDUSTRIAL AUTOMATION AND CONTROL SYSTEMS IN INDUSTRY 4.0

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ABSTRACT

In order to respond to the new production models specific to the fourth industrial revolution, a new paradigm of integrated industrial automation and control systems in industry 4.0 management is needed with new web, collaborative and intelligent applications to supervise production processes. The present work represents an analysis of the solutions for the management of production processes resulting from the combination of new technologies and applications conforming to the Industry 4.0 paradigms, in conjunction with SCADA technical solutions for the world of production. The solution that comes with this work is based on the synergy between two concepts, that of cyber-physical SCADA systems and human-centered production, which at first sight may seem antithetical, but which in reality are complementary to each other and actually represent a waysuitable for Industry 4.0. The research method was represented by the systematic analysis of the asynergy of the two concepts found in the specialized web of science literature, as well as corroborated with the real situation in industry 4.0.which is foreshadowed from day to day.

KEYWORDS: SCADA, Entreprise Systems, IT systems

1. Introduction

In Industry 4.0 it is not enough anymore to collect production data in the traditional way used until now. There is a need to step forward with SCADA-based cyber-physical systems that not only collect data, but are able to connect with devices and applications, systems and other real-time software for a continuous exchange of updated and always available information, at all times. The proposal with which the author of this work comes to meet the challenges brought by Industry 4.0, but also its cyber protection, is given by the synergy of two important concepts: the concept of cyber-physical SCADA systems corroborated with human-centered production.

The first concept analyzed here is the *cyberphysical system concept*, which represents according to different approaches in literature *"an orchestration of computers and physical systems. Embedded computers monitor and control physical processes, usually with feedback loops, where physical processes affect computations and vice versa"* (Lee, 2015).

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For Industry 4.0, a physical cyber system is a set of objects that are physically present in the production facility (e.g., machines, tools, products, etc.) and that can be connected to other components of the production process.

This networking, often referred to as the Industrial Internet of Things, is done by creating a virtual copy of the physical object on the computer that captures its characteristics, capabilities, and states.

According to Koulamas & Lazarescu (2020), *"The Industrial Internet of Things (Industrial IoT-IIoT) is the emerging core backbone construct for the various cyber-physical systems constituting one of the principal dimensions of the 4th Industrial Revolution"*.

Based on the collected data, the object is thus able to make decisions independently and communicate directly with the neighboring physical components. In this way, data analysis and decision-making are decentralized, enabling real-time responses.

From the point of view of IT systems, the Internet of Things applied to factory 4.0 revolutionizes the classic pyramidal architecture of production systems where the MES (Manufactory Execution Systems) represents the link between the business level and the production process at the base of the pyramid (Pfeifer, 2021). In the IIoT model, we move from devices connected and applications to a central communications infrastructure (as shown in Figure no. 1).

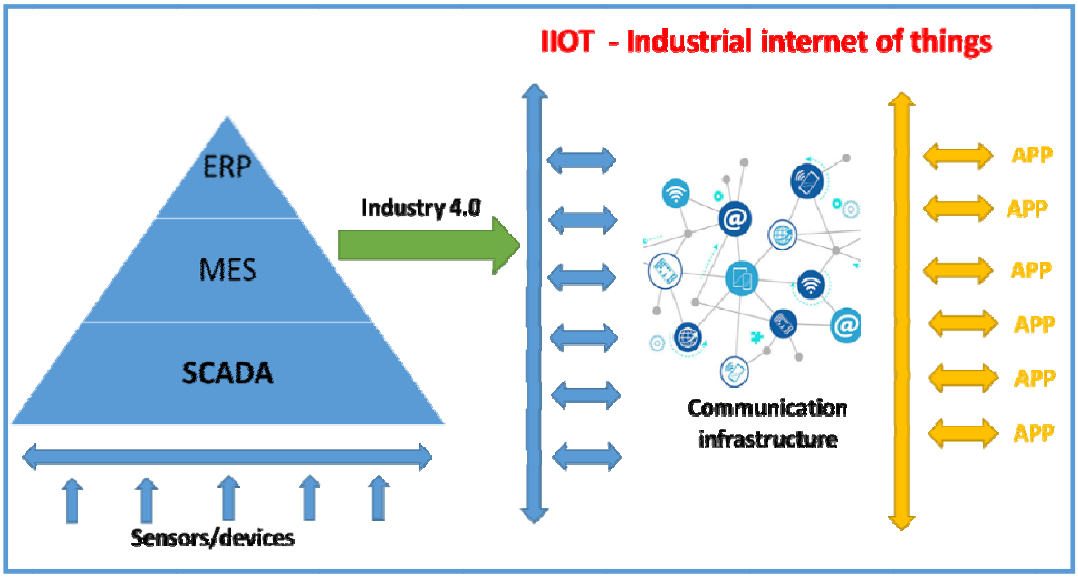


Figure no. 1: *Transition from standard architeture to IIOT*
(Source: Authors)

The second concept analysed here is that of people-centred manufacturing. According to recent studies, the new paradigm of Industry 4.0 will lead to a shift from a task-oriented to a people-oriented organisational model (Dobrowolska & Knop, 2020).

In a people-centered manufacturing system, the planning and execution phases of a task coincide because the human factor has full control over the process and technology. It also encourages the development and use of personal skills and the creation of a positive, collaborative, and socially interactive work environment. Since, according to this model, the human factor plays a key role in optimizing production performance, it is essential to provide work tools and technologies that facilitate collaboration and interaction between people and focus on the human dimension.

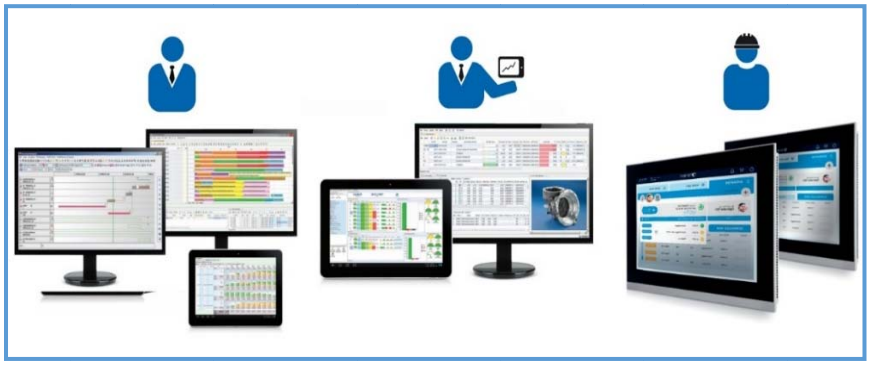


Figure no. 2: *Human-centered manufacturing process*
(Source: Authors)

To connect the two concepts presented above, we need communication in industrial automation. Ethernet dominates industrial automation communications, but users still need to choose the best industrial protocols for the different architectural layers.

2. Materials and Methods

Industrial automation systems are composed of many devices and components networked together. Devices in the field – such as sensors, actuators and intelligent systems – are connected to the controllers. These programmable controllers (PLCs) and programmable automation controllers (PACs) monitor and control field devices, communicate with each other, and are connected to higher-level human-machine interface (HMI), control, supervisory and data acquisition (SCADA) systems), historicization, analysis and others (Figure no. 3).

The proposed SCADA systems for industrial automation and control systems in industry 4.0 consist of many interconnected devices and components.

On the first layer, plant/factory level we have devices in the field, as sensors, actuators and intelligent systems wich are connected to controllers. The programmable logic controllers (PLCs) and programmable automation controllers (PACs) monitor and control field devices, communicate with each other, and are connected to the next level to human-machine interfaces (HMIs), and than supervisory control and data acquisition (SCADA), historization, analytics, and other systems (Figure no. 3).

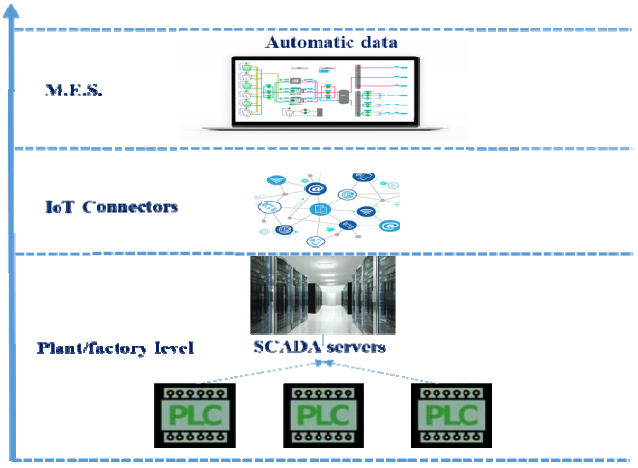


Figure no. 3: *Industrial automation systems – proposed model*
(Source: Authors)

The architecture of industrial automation and control systems can be composed of several layers of devices and networks. Industrial network hierarchies are defined by many characteristics and do not always have a precise definition because some network layers can be virtualized or compressed in the same physical network. A representation of the relevant levels that need to be networked within an Industry 4.0 factory (Figure no. 4) is illustrated below:

– Level 5: Entreprise Systems.
– Level 4: MES.
– Level 3: SCADA – supervisory, control and data acquisitions.
– Level 2: Automation control via local PLCs and PACs.
– Level 1: Sensors, devices and field networks.

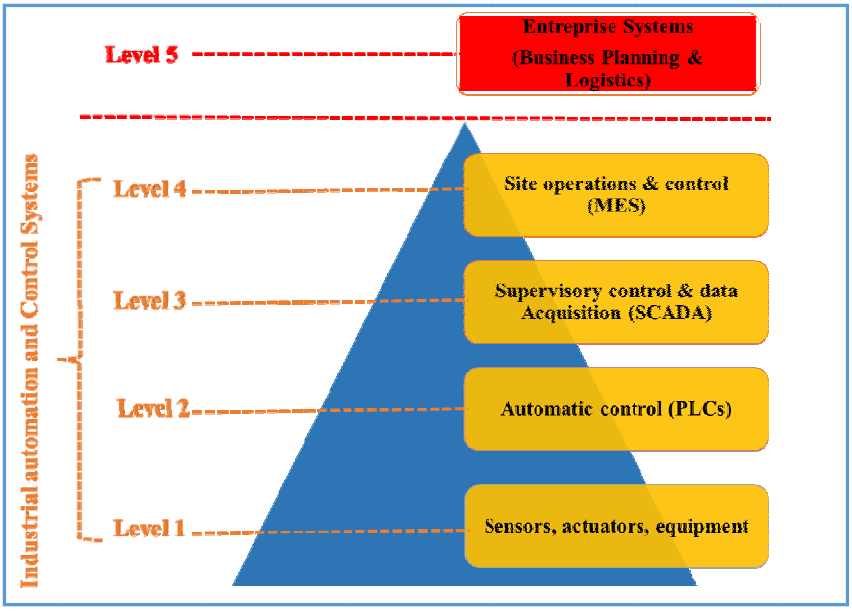


Figure no. 4: *Industry 4.0 factory levels – proposed model*
(Source: Authors)

Controllers can be connected to field devices at levels 0 and 1 via wired I/O, fieldbus networks, and industrial Ethernet. These connections are local to a site and typically consist of small packets of data that must be transmitted quickly because the physical devices must be monitored directly in real time. Different requirements apply to communications across and between controllers. Industrial networks connecting levels 1 and above are sometimes referred to as plant-wide networks. Compared to lower-level communications, plant-level data packets may have less stringent timing requirements. Plant-level networks connect very different systems than lower, more dedicated levels. This results in new requirements for modern network communications at the level of the industrial plant:

– Safety: Equipped with built-in safety features.
– Contextualization and object orientation: Ability to define and organize transported data.
– Platform independence: Allow distributed applications to communicate unimpeded.

To communicate between levels, we propose in this work to use Time sensitive Networking (TSN) which is a complete development of the ethernet standard in the Quality of Service (QoS) areas, including bandwidth reservation, and synchronization.

Acording to Hyeong et al, (2022), *"Time-sensitive networking (TSN) is one of the deterministic ethernet technologies. Some of the sub-standards of the IEEE 802.1 ethernet standard established by the IEEE TSN task group support time synchronization, stream reservation, seamless redundancy, frame preemption, and scheduled traffic. In particular, scheduled traffic based on time synchronization can minimize the delay in a transmission queue for time-critical traffic, and guarantee bounded latency and real-time response even in a congested network"*.

3. Results – SCADA and Industrialization 4.0

As Godoy & Pérez (2022), stated, SCADA is not a specific technology; it is a type of application. Supervisory, Control and Data Acquisition Systems (translation of the acronym SCADA from English) are a fundamental element for Industry 4.0 and for modern industrial automation. In fact, it is not enough to install state-of-the-art PLCs on industrial machines or to have a suitable HMI to be able to say that we are a 4.0 company, we also need a system that is able to supervise all production, connected machines with each other and manage the entire automation system based on the collected data: a SCADA, in fact. In previous articles published in the research carried out in the project SAFEPic 19, SCADA Center of Excellence, we have already talked about what a SCADA consists of, but we never talk enough about the flexibility of these systems and their increasing importance for industries around the world. Without a system that allows the sharing and accessibility of all collected data, we could not even talk about Industry 4.0 and it would be almost impossible to monitor large installations such as water purification or waste disposal facilities. Moreover, in similar installations, it is absolutely necessary to have a system that warns us of the triggering of alarms or exceeded values thanks to the sensors installed on the different machines and interconnected with the rest of the industrial plant.

A surveillance system, however, is not limited to controlling the occurrence of alarms on a production line, an effective SCADA is also very useful for predicting and managing the progress of the production cycle and what will actually be produced based on the availability of materials required premiums materials. With a program able to tell us how much our machines will actually be able to produce and, consequently, how long they will have to work, we can better organize work shifts and more efficiently schedule the work cycles of production lines, while driving to energy savings and better production times, with benefits also reflected in worker well-being. A SCADA behaves exactly like an orchestra conductor, except that instead of musical instruments there are machines and instead of sheet music there are production recipes. Before we talked about the importance of SCADA systems to streamline an industrial line and to collect and share production data, but if we wanted to send data to production through the management of our company, would it be possible without a SCADA system? Unfortunately it would not. If we were to share commands to produce a certain item directly from the management system to the machine, the installed PLCs would not understand any of the information we sent. SCADA comes into play precisely to overcome this problem. This highly useful data acquisition and surveillance system acts as an interpreter between the company's management system and industrial machine PLCs, translating management software instructions into recipe parameters that are loaded to start a production run. Instead, SCADA systems collect production data and, before sharing it with the company's EMRs, translate it into understandable

information for the software installed on the computers used in offices.

Advantages of SCADA software:

The use of SCADA software provides many benefits to businesses; especially, it helps companies to get maximum benefits. A summary of these are included within Figure no. 5:



Figure no. 5: *Advantages of SCADA software*
(Source: Authors)

4. Conclusions

It is almost impossible for anyone to assess the changing automation needs of different SCADA users, especially as they grow and grow along the maturity curve of an automation system and the connection capabilities of plant assets evolve as well. Therefore, for those who have to choose SCADA software it is of fundamental importance not only to evaluate what the available technology can immediately offer their company, but also to find a partner in the automation sector that knows the emerging potential. Technology is able to answer several questions:

– What are the company's short/long term goals? Is the proposed automation consistent with these goals?

– What functionality will really help the company in the long run?

– How will technology eliminate or reduce inefficiencies and costs?

– SCADA automation systems have become crucial to protect engineering investment and to add new capabilities to the system, simply and efficiently.

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