Designing a System to Facilitate the process of Connecting 4.0-Generation Industrial Machines to the internet

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Abstract. Industry 4.0 aims to create more efficient and flexible manufacturing processes that can respond quickly to changes in demand and customer requirements. The integration of digital technologies and physical systems allows data to be collected, analysed, monitored and controlled in real time. This can increase productivity, reduce downtime and improve product quality. In this paper, remote control, monitoring and online data storage of industrial machines based on human-machine interface (HMI) module are facilitated. HMI integrates the control system with the Industrial Internet of Things (IIOT). On the other hand, it can be controlled and monitored anywhere in the world via the Internet using a Virtual Private Network (VPN) to open different navigation private channel and HMI interface. It was clear from the collection of recorded data and the results of practical testing that the designed system facilitated the process of accessing the industrial machine

1 Introduction

The Internet of Things occupies a large part of our daily life in various fields, from industry to biomedical. The industry needs to Link physical devices to the Internet will allow improved control of these devices and the data collected. One of these technologies is the Industrial Internet of Things (IIoT) [1]. The main idea of using the IIoT is to control better the processes taking place in the factory [2,3]. Although IIoT architecture is the same as IoT architecture, its process will be much more robust, with more complex operability circumstances, and more security conditions mainly focused on the production process.

Nevertheless, the application of IIoT comes with significant challenges for manufacturing companies, particularly for “Small and Medium-Size Enterprises” (SMEs) [4-8]. The challenges faced by SMEs in implementing Industry 4.0 are multifaceted and require careful consideration of their specific needs and constraints. The first challenge is that many SMEs still operate with outdated machines that do not have data exchange capabilities [4]. Moreover, the greatest SMEs often have a lack of investment required to replace old machines with advanced ones that are costly [4, 8]. Embedded intelligence in wholly linked devices is a requirement for a “smart factory”. He explains that “smart factories are internally linked by a wireless network which means every device should have its own IP address”. A smart factory leads to optimized manufacturing resulting in a reduction of unnecessary labor and waste of resources [9]. As shown in the schematic diagram of Figure 1, the smart factory consists of four layers. These layers are the "physical resource layer, industrial network layer, cloud layer, and supervisory control terminal layer". They work in a way that physical resources as smart things communicate with each other, using the industrial network. It’s called the Human Machine Interface (HMI), a technology that allows humans to interact with machines, such as computers, robots, and industrial equipment, in a more intuitive and natural way [11,12]. In a computer network, data packets need to be routed from one network to another [13].

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The wireless router with an HMI interface can be used to connect industrial equipment or automation systems to the internet. Then the cloud collects a large amount of data from the physical resource layer and collaborates with people through supervisory control terminals. In this paper describes the process of replacing the DX2300LN-WW wireless router linked to the machine's factory HMI with another the TP-Link-TL -WR845N wireless router. The Delta DX2300LN-WW router provides local remote access to the machine as well as control over data collection on the local area network (LAN) via the VNC Viewer program.

the TP-Link-TL -WR845N Wireless Router. It is one of the most popular routers, as it can be used with the help of Virtual

Private Networks (VPN) to create a private network to connect HMI to the machine system in the factory and for remote access and data transfer anywhere in the world. This paper is organized as follows. Section 2 discusses the design specifications, while Sections 3 and 4 present the results and conclusions, respectively.

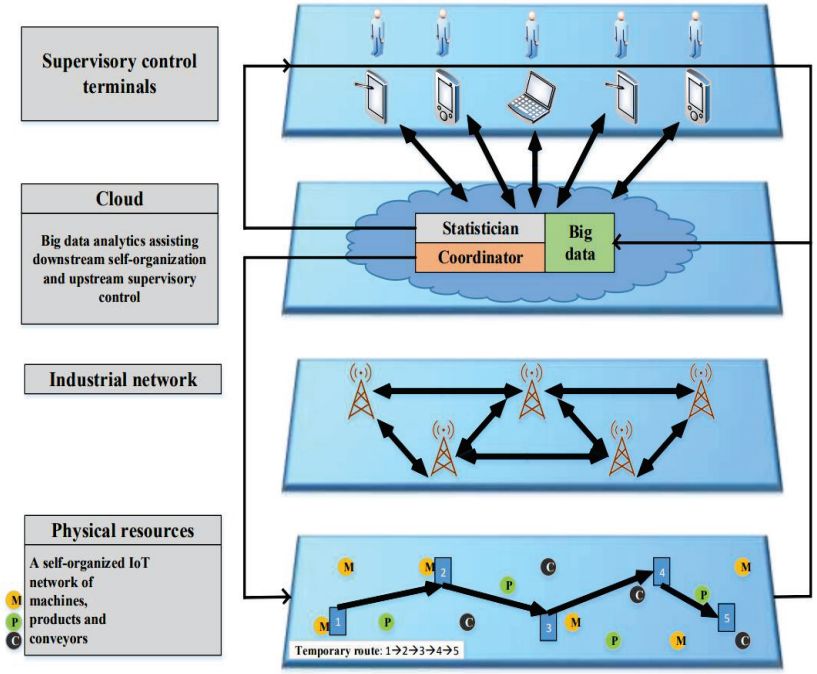

Fig. 1. Framework of the smart factory of Industry 4.0. [10]

2 Design Specification

2.1 Human Machine Interface (HMI)

HMI is very useful to visualize the process in a form that can be easily understood by humans. Some functions of the HMI is monitoring plant conditions and Data trajectories, whether real-time or historical, can also be displayed on internet an HMI. Figure 2 shows DOP-107DV HMI. The DOPSoft 4.00.16 is used to program the HMI because provides a comprehensive range of tools and functions for creating HMI applications, including icons to screen elements, data displays, buttons, and input data. Each graphical form such as buttons and text boxes is associated with tags or registers within a ladder diagram loaded on the machine. This interconnection allows reading and writing data from the machine and displaying it on the HMI. As well as, sending commands, performing calculations, executing control algorithms, and manipulating input/output signals. This design provides ease for the operator to control all parts of the machine to be controlled. Figure 3 gives the Screenshot of the program DOPSoft for HMI designed in this work.

Fig. 2. DOP-107DV Delta HMI

Fig. 3. HMI input and display data

2.2 Radmin VPN

Radmin VPN is used to create a secure communication tunnel between the clients (machine)/user (access control) and the HMI, for remote monitoring and control of the machine from a mobile or laptop anywhere in the world by VPN network. Network traffic to the network client HMI is implemented as follows:

1- Download Radmin VPN from the official website and install it with some settings on both computers.

2- A network is established on the local computer of the factory that is connected to the HMI. The network name (SPEED-PC) and VPN password are generated. Also, for the remote computer, the network name (Basheer 2023) was created with a special password (See Figure 4).

3- The factory local computer VPN gave the IP address of 26.255.120.74 whereas the remote computer had the IP address of 26.155.150.129.

4- Once both devices are connected to the same network, they will be seen listed in the Radmin VPN interface. Computers can now securely connect to each other via VPN.

Fig. 4. Radmin VPN interface

2.3 VNC viewer

The primary purpose of VNC Viewer is to provide remote access and control capabilities locally on the machine, allowing users to interact as if they were physically located near the machine. To connect with a remote HMI using VNC Viewer, the HMI must be properly connected to the network via an Ethernet port. VNC Viewer must be installed on the local computer or on the smartphone, then run it and enter the specific IP Address (192.168.10.108), Port Number (5900), HMI hostname, and password as shown in Figure 5.

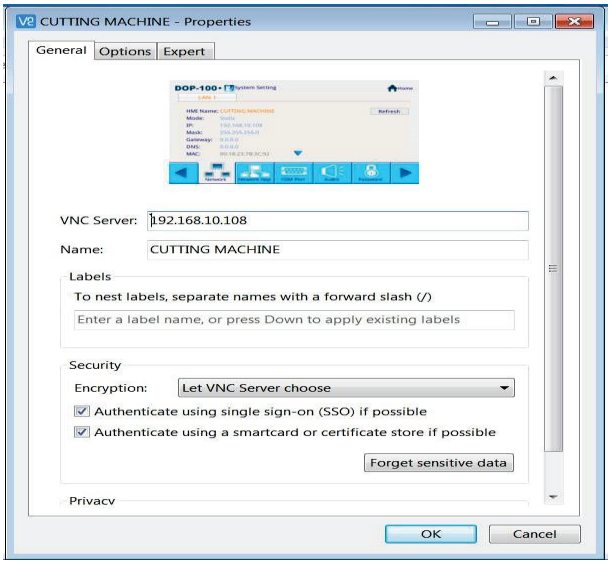

Fig. 5. VNC Viewer access

2.4 Wireless router

In a computer network, data packets need to be routed from one network to another [57]. The wireless router with an HMI interface can be used to connect industrial equipment or automation systems to the internet. Delta provides routers with the model's name "Dx2300ln-WW" that works exclusively with other devices of the same company Delta (PLC and HMI). This router is relatively very expensive as illustrated in Figure 6.

Fig. 6. Delta brand wireless router

In order to overcome this monopoly and reduce the cost, the Delta Wireless device was replaced by the TP-Link-TL-WR845n wireless router shown in Figure 7. It is one of the most popular routers. This contribution in this paper was achieved with the help of VPN and port forwarding as illustrated previously.

Fig. 7. TP-Link-TL-WR845n wireless router

2.5 Port forwarding

To enable easy access to the HMI and control of the device from anywhere in the world for free along with a VPN, a method of port forwarding was used. This allows remote devices on the Internet to be able to access the local computer in the factory's private network. A process that forwards network traffic to the HMI network host was performed as follows:

- Command Prompt (CMD) uses the "netsh command" to start the port forwarding process, as shown in Figure 8.
- The port number and IP address of both source and destination hosts were entered when typing in the "Command Prompt window" the following:

"netsh interface portproxy add v4tov4 listenaddress = 26.225.120.74 listening port = 5900 communication address = 192.168.10.108 communication port = 5900"

- Port forwarding is triggered after you press enter to run the "netsh command".

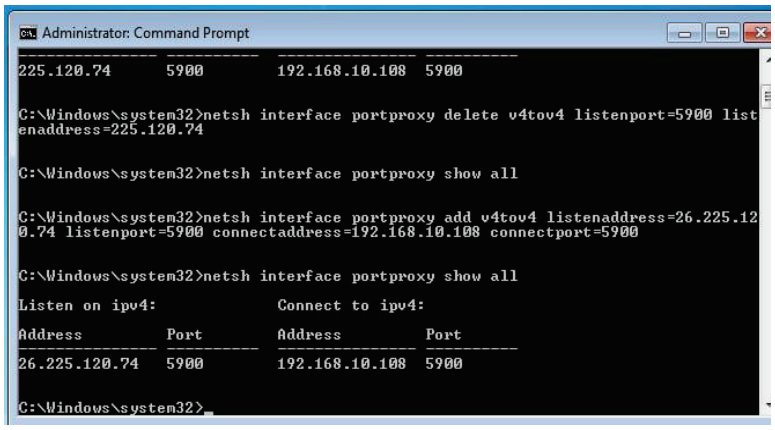

Fig. 8. Port forwarding for command

The electronic server is installed and configured on the local computer that connects to the local network for the purposes of collecting and storing data for analysis as shown in Figure 9.

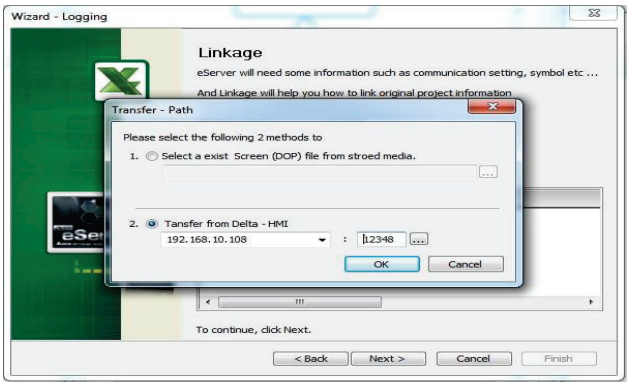

Fig. 9. eServer software Path

The IP address for the HMI is set to 192.168.10.108 and activating VNC and giving it port number 5900 and activating eServer by giving it port number 12348, as shown in Figure 10.

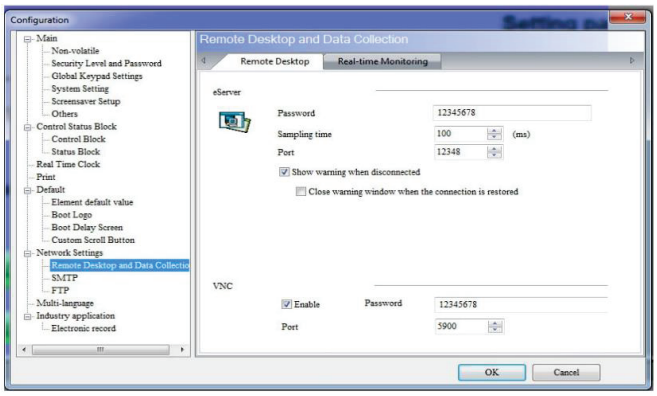

Fig. 10. VNC and server activation settings

3 Results and Discussion

The effectiveness of remote access to the designed network is tested in the smart factory. The HMI is accessed for online monitoring and control using a laptop or phone running a VNC viewer. As shown in Figure 11, it uses a virtual private network (VPN) to create secure communication tunnels using Radmin VPN between the plant network and the remotely monitored machine. Create a network between the factory and the remote controller using a computer, and both parties obtain an IP address. Once both devices are connected to the same network, they will be listed in the Radmin VPN interface. Since the factory local PC is connected to the HMI wirelessly through the use of the TP-Link-TL-WR845n wireless router, a port forwarding method has been used. This allows for easy access to the HMI without the need for periodic setup of the connection process.

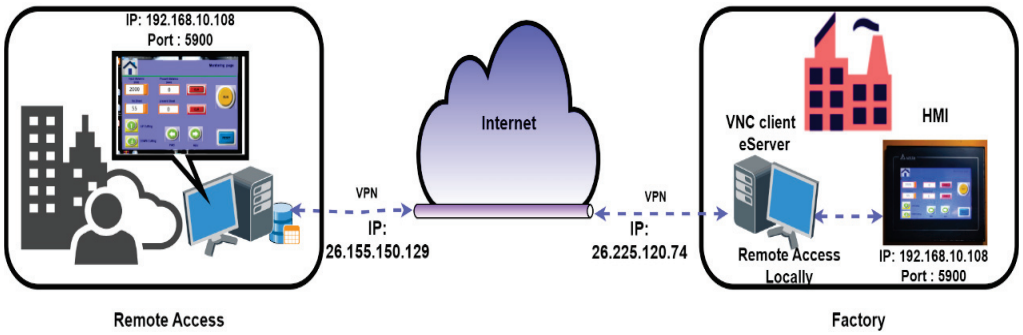

Fig. 11. Network Topology

This allows the device to be monitored and operated remotely from a mobile device or laptop, as if the user were directly in front of the HMI screen. As shown in Figure 12.

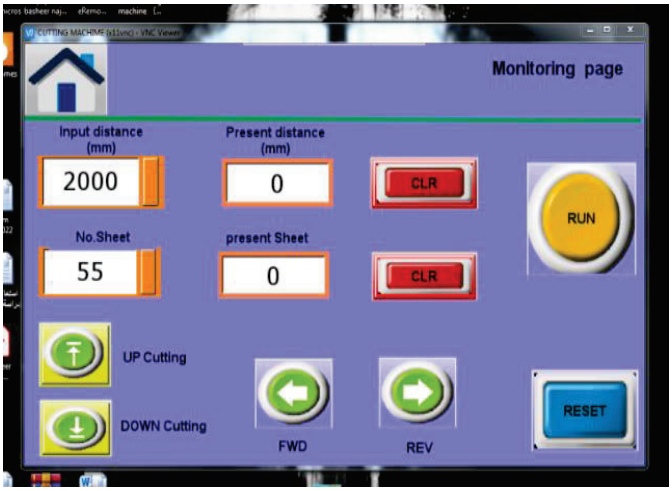

Fig. 12. HMI snapshot from the remote computer

The results of saving HMI data on the local and remote computer are shown by eServer and presented in an Excel file, where this data represents production information as shown in Figure 13.

Number of plate steel	Length of plate steel in (mm)	Date
400	2400	02/18/2023
400	2400	02/18/2023
400	2400	02/18/2023
10	2000	02/18/2023
10	2000	02/18/2023
10	2000	02/18/2023

Fig. 13. Screenshot of part file Excel.

4 Conclusions

In this research, an innovative smart network was designed for remote control and monitoring in industrial processes, where an alternative method was used for industrial devices represented by the wireless router (Dx2300ln-WW) in order to reduce the cost in the system of connecting machines to the Internet. The HMI of the industrial machine was connected to a virtual private network (VPN) using the Radmin VPN program to create secure communication tunnels between the factory network and the remote monitored device, which in turn works to connect the smart HMI with the remote monitor. The TP-Link-TL-WR845n wireless router was used within network requirements, as the local computer in the factory is linked to the HMI wirelessly through it. The proposed system has proven its effective ability to transfer data and remotely monitor fourth-generation industrial machines at a very low cost and is more secure and private.

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