The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2024

Volume 28, Pages 462-469

ICBASET 2024: International Conference on Basic Sciences, Engineering and Technology

Establishing a Remote Area Network for an Automation System: A Case Study of Yeni Karpuzlu Drinking Water Automation

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Abstract: Yeni Karpuzlu is a town located in the Ipsala district of Edirne province. The drinking water needs of this town are supplied from a deep water well. Water is pumped from the deep well using a submersible pump and sent to a 500-m^3 capacity concrete water tank. Here, the water goes the town's water demand through natural flow. The water is then sent from the tank, which is located 30 meters above ground level, to the town. There is a distance of 800 meters between the well and the tank, and 6000 meters between the tank and the control center located in the town. A local network has been established using outdoor access points for communication between the industrial control devices located at these three points. Data from the instruments are collected at a speed of 300mbps. Additionally, it is sent to the video center via IP cameras for area security. All devices on this network communicate with each other and are controlled. This paper will discuss the operation of the automation system mentioned above. Operations include the pump operation based on tank levels, pressure control using an adjustable valve to maintain network pressure, and monitoring and control operations from the central unit.

Keywords: Automation system, Drinking water automation, Network

Introduction

Industrial automation is a rapidly evolving field that offers numerous benefits to various industries. Automation technologies have been shown to increase productivity, improve product quality, and increase production process efficiency (Atif et al., 2022). The adoption of automation in the manufacturing sector, catalyzed by Industry 4.0, has introduced new technologies that enable the automation of manufacturing processes (Bakar et al., 2021). This shift towards automation is driven by factors such as the need for higher productivity, increased quality, and a shortage of skilled labor (Lin et al., 2023). However, there are also difficulties in implementing industrial automation. The deployment of new complex technologies such as Cyber-Physical Systems (CPS) and the adoption of new manufacturing paradigms such as Computer Integrated Manufacturing (CIM) present challenges that must be addressed for successful automation (Lai et al., 2020). Additionally, the need for greater flexibility and reconfigurability of production facilities is crucial for the effective adoption of industrial robots in manufacturing sectors (Bader & Rahimifard, 2018). Moreover, the Industrial Internet of Things (IIoT) plays an important role in providing automation solutions for industrial processes by connecting sensors, actuators, and robotic devices, thereby enabling the automation of production processes through Factory Automation (Herrera et al., 2020). Integration of IoT with industrial automation technologies such as Raspberry Pi further enhances automation capabilities in industrial environments (Merchant & Ahire, 2017). The advantages of industrial automation are shown in Figure 1. Automated systems for drinking water management have truly transformed the way water quality is monitored and maintained. These systems utilize advanced technologies such as flow cytometry, optical coherence tomography and chlorination to ensure the safety and efficiency of drinking water networks.

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

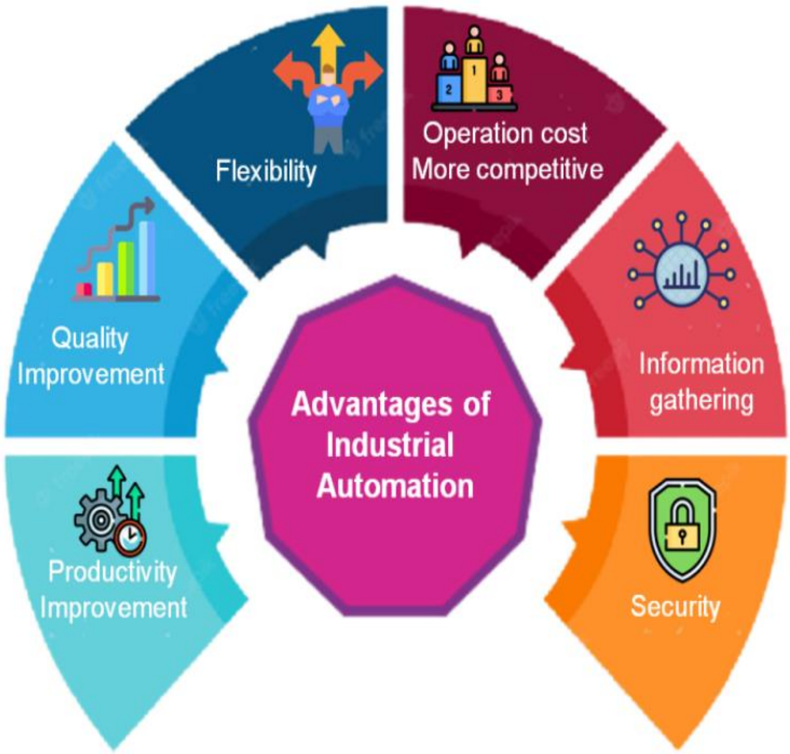

Figure 1. The advantages of industrial automation (Al Shahrani et al., 2022)

In addition to monitoring water quality, collecting water from the source, storing it and presenting it to users is also a separate process. In this study, an automation process of taking water from the well, storing it and presenting it to users will be discussed. An operator will manage the process from the SCADA system(Akı & Gullu, 2016).

SCADA (Supervisory Control and Data Acquisition) systems are crucial in various industrial applications such as water treatment and distribution networks. These systems operate in real-time environments such as water pumping stations, oil refining facilities and railway control centers (Musa et al., 2013). SCADA systems ensure efficient and safe operations by monitoring and controlling critical infrastructure (Shahzad et al., 2014). They are essential for supervisory control, data collection and automation processes, thus improving the reliability and performance of industrial systems (Hammouda et al., 2015).

The architecture and security of SCADA systems are critical to their implementation. SCADA systems provide real-time data about industrial processes, leading to increased efficiency and reduced operating costs (Ara, 2022). They play an important role in communication between devices in strategic industries such as power plants (Arifin et al., 2021). Additionally, SCADA systems aid in sensor fault detection due to their access to data and sensor information (Wang et al., 2020).

SCADA systems are widely used to monitor and control various processes, including controlling temperature control systems in stirred tank heaters (Bayusari et al., 2013). They are also vital for condition monitoring in wind turbines by utilizing SCADA data for performance monitoring (Tautz-Weinert & Watson, 2017). Additionally, SCADA systems are moving towards cloud-based solutions to improve industrial performance in IoT networks (Vilajosana et al., 2019).

In this study, 4 stations located at different distances from each other are configured to be wireless networks with each other. Control and monitoring were carried out with programmable controllers added to the stations. The stations consist of 2 deep water wells, 1 water tank and a control center. PLC was used to control the devices in wells and warehouses outside the center. The system is monitored and controlled from a computer located in the center. In addition, internet connection is available from the center and control of the facility is provided from anywhere. In the following sections, the network structure, characteristics of the stations, and the central control station will be explained.

Method

Yeni Karpuzlu Municipality is a town located in İpsala, Edirne. 3100 people live in the town. The town's drinking water needs are met by groundwater. For water needs, water is drawn with submersible pumps located in wells dug at a depth of 150 meters. The drawn water is sent to a water tank at a height of 30 meters. The tank with a capacity of 500m3 meets the water needs of the town. An automation system has been established to control and monitor this facility. Due to the possible distance between different stations and distances between them, a separate network installation was carried out. In the following sections, the network structure and stations will be discussed.

Remote End Units and Network Structure

There are 4 units for water automation. Three units controlled by PLC are close to each other from the center. There is a distance of 700m between the station where the main well and pump are located and the tank. There is a distance of 300m between the second well and the pump station and the tank. The distances and locations of the pumps and the water tank are shown in Figure 2.

Figure 2. Locations of the pumps and the water tank

Figure 3. Locations of the city center and the water tank

The pumps and the well are located 6km away from the city Centre. Water is pumped into the tank located 35m above the ground by pumps. There is a distance of 6km between the water tank and the city Centre. The center and tank layout are shown in Figure 3. From here, water is sent to the city via natural flow via pipes. Pump status, tank level and other information are sent to the control station at the center via wireless data transfer.

In Figures 2 and 3, 4 stations and their locations relative to each other are shown. Mains electricity is available at each station. Piping has been constructed for water transmission. The operation of the pumps at the stations is controlled by PLC. Water level in the water tank, amount of spent water, water pressure and mains pressure are measured by sensors and processed by PLC. Commands are sent for the pumps to operate according to the water level. The operation of the pumps, the level of the tank, and the water pressure are also monitored from the center. A wireless local network has been established for all this data transfer. Wireless outdoor antennas shown in Figure 4 and Figure 5 were used for wireless data transfer. These devices are also access points. Figure 4 is a long distance antenna with 23 dBi power. All of these antennas can work as AP, Client and repeater. The antenna in Figure 5 has a power of 13dBi.

Figure 4. Access points TP-LINK CPE710

Figure 5. Access points TP-LINK CPE510

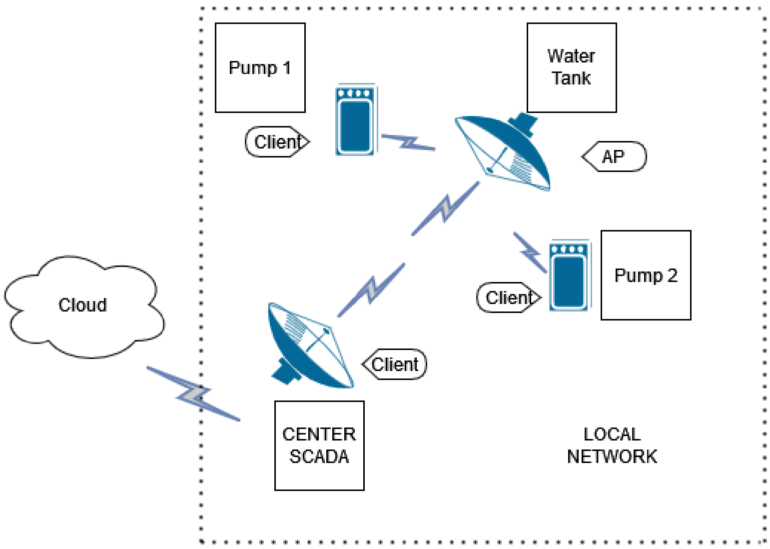

Figure 6. Network architecture of the system

Two high power antennas are connected to the center with water storage. The AP in Figure 5 was used for the communication of the pumps. 4 wireless devices transmitted data at the specified distances for system automation. This established lodge accesses the internet via the network center. A VPN network is also used for system security. The network structure of the automation system is shown in Figure 6.

Water Tank Automation

Pumps transport groundwater to the water tank located 35 meters above the ground. The tank has a water carrying capacity of 500m3. When it is fully filled, 3.5 Bar pressure is created on the pipe on the ground. When the water in the water tank, which is located higher than the city center, is sent to the city center by mountain flow, it creates a pressure between 3-7 bars. This pressure is expected to be around 4 bars. For this reason, the pressure was reduced with a valve at the pipe outlet. The number of liters of water sent to the city is monitored instantly per hour with a flow meter. In addition, 1 pulse was taken for each cubic meter and counted on the flowmeter. In this way, the amount of drained water is also monitored.

The water tank is located at an altitude of 35 meters. The tank, consisting of a concrete structure, has a circular cross-section and a height of 5 meters. The total height is 40 meters. The level is scaled between 0-100 and corresponds to 0-5 meters. A 4-20 mA 0-5 meter analog hydrostatic liquid level sensor was used. Additionally, a floater was used for the upper limit. PLC monitors all sensor and flowmeter data and transfers it to other PLCs and the center. 2 analog sensors were used for pressure. This station has a motorized valve as an outlet. The control of this valve is made according to pressure sensors. Additionally, security cameras have been installed in the station for station security and flow. All stations are connected to this center via clients. There is one access point here. The AP with 23dBi power is positioned 25 meters above the ground to see all stations. Polarization is adjusted to the main center. In this way, it can transfer automation data and camera data to the main center. Transfer speed was measured as 300mbs at a distance of 6km. Water storage automation is shown in figure 7.

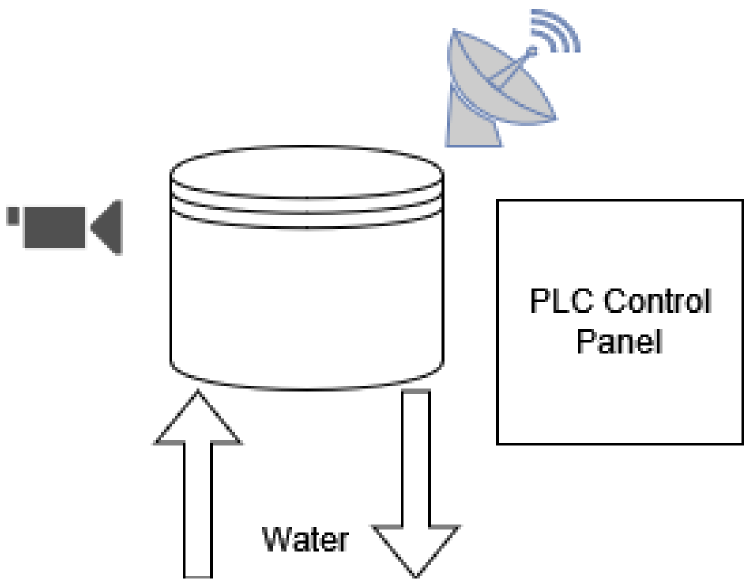

Figure 7. The water tank automation

Water Well - Pump Automation

Drinking water is sent to the water tank by a submersible pump from the well located at a depth of 150 meters. The pump is operated when needed, depending on the water level. The operation of the pump is done by a driver. Operations such as frequency control and overcurrent control are also performed and monitored with the driver. The operating modes are according to the level, according to the float and manually. In addition, pump operation can be done via the panel with a selector switch, independent of the PLC and automation system. Chlorination is also carried out at this station. The chlorine pump control is somehow operated at the appropriate dose according to the water level. An IP security camera is positioned for station security. Automation data and camera image are transferred wirelessly. Well automation is shown in figure 8. GLC-496T PLCs were used for the stations in the facility. A 7” HMI touch panel was used for the wells.

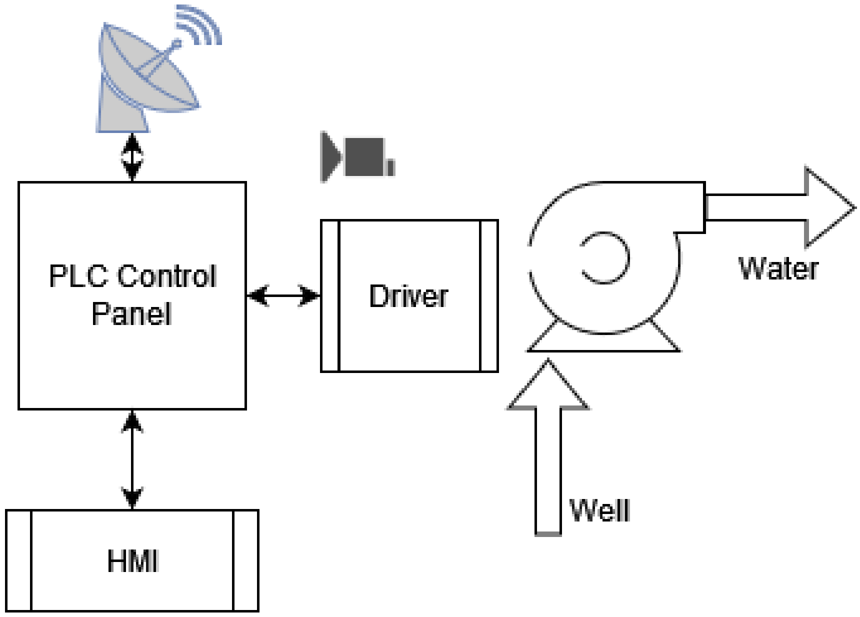

Figure 8. The pump automation

SCADA - Central Monitoring and Control

SCADA design has been made for central control of the facility. On this screen, data received from 3 PLCs were processed and visually reflected on the screen. Water level, pressures and water flow are monitored instantly. Additionally, operating modes are also controlled here. Automatic and manual control selection can be easily made by the operator. In addition, camera images at the stations are transferred to the center and monitored. All data is transferred wirelessly. At the farthest distance, the data rate to this unit is measured at 300mbp.

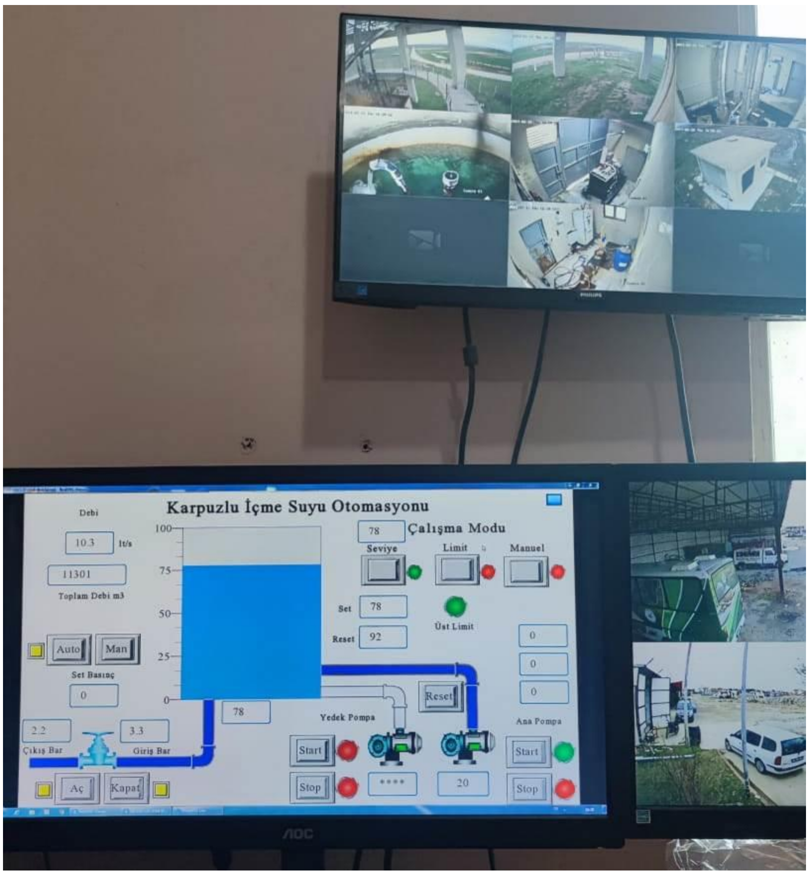

Figure 9. SCADA and camera view

Conclusion

In this study, an automation was established for the drinking water of a town. PLC and wireless network devices were positioned in 3 stations located in different locations, allowing the stations to communicate with each other. For remote control, another antenna was added to the control room located in the city center, allowing remote control by the operator. With the internet connection from this center, authorized personnel are allowed to monitor and control the facility from anywhere they want. 2 pumps are controlled in the facility. The level of the water tank, pressure and flow rates are monitored instantly. Both the water and the security of the facility are monitored with cameras. The operator displays the status of the equipment in the facility (operating, error, waiting) and the values of the sensors. Remote control function can be performed in different modes. Seamless data transfer between locations is ensured with the installed outdoor access points. In addition to transferring automation data, images of IP security cameras were also transferred.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

Acknowledgements or Notes

This article was presented as an oral presentation at the International Conference on Basic Sciences, Engineering and Technology (www.icbaset.net) held in Alanya/Turkey on May 02-05, 2024.

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To cite this article:

Gullu, A., & Aki, M.O. (2024). Establishing a remote area network for an automation system: A case study of Yeni Karpuzlu drinking water automation. *The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 28,* 462-469.