Profibus/Profinet

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***Abstract*—Profinet and Profibus are crucial components in Industrial Control Systems (ICS), playing a vital role in connecting various controllers, sensors, actuators, drives, and ICS software components across different manufacturers and protocols.Ethernet-based fieldbusses such as Profinet and Profibus TCP are becoming increasingly important in meeting the demanding requirements of current industrial applications.However, as the complexity of industrial processes grows, these fieldbusses must address concerns about interoperability, security, and reliability.Overall, this paper provides a comprehensive understanding of the Profibus/Profinet protocols and their usage in industrial applications.**

***Index Terms*—Profibus,Profinet,Communication protocols, Industrial automation.**

I. Introduction

In industrial automation, communication between devices is crucial for efficient and safe operation for seamless exchange of data and commands is fundamental to ensuring smooth operations within industrial settings.Profibus and Profinet are two frequently used communication protocols in this industry. Profibus is a fieldbus protocol that is used in industrial automation to convey data between sensors, actuators, and controllers. Profinet, on the other hand, is an industrial Ethernet-based protocol that supports a wide range of devices and enables for real-time communication. [2]

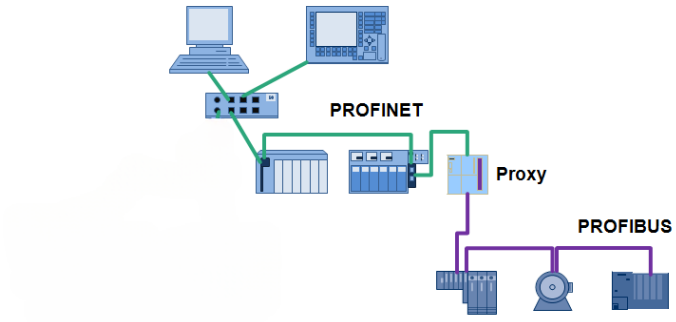

Fig. 1. Integration of fieldbuses such as PROFIBUS/PROFINET

Profibus has been in use for over 25 years and has shown to be a reliable and stable communication protocol for industrial automation applications. [5] It is widely utilized in process and manufacturing automation, as well as factory automation. Profinet, on the other hand, debuted in 2002 and is intended to be speedier and more adaptable than Profibus. It allows for real-time communication, which is essential for applications that require fast and accurate data sharing.

II. Overview of Profibus/Profinet

The field of industrial automation has seen a significant growth in the last few decades, and the need for reliable communication protocols between devices in the field has become crucial. Profibus and Profinet are two of the most widely used communication protocols in industrial automation.

A. Description of Profibus

Profibus (Process Field Bus) is a digital communication protocol designed for process automation applications. Profibus has been widely used since the early 1990s and has evolved into a series of standards that include Profibus DP (Decentralized Peripherals), Profibus PA (Process Automation), and Profibus FMS (Fieldbus Message Specification).

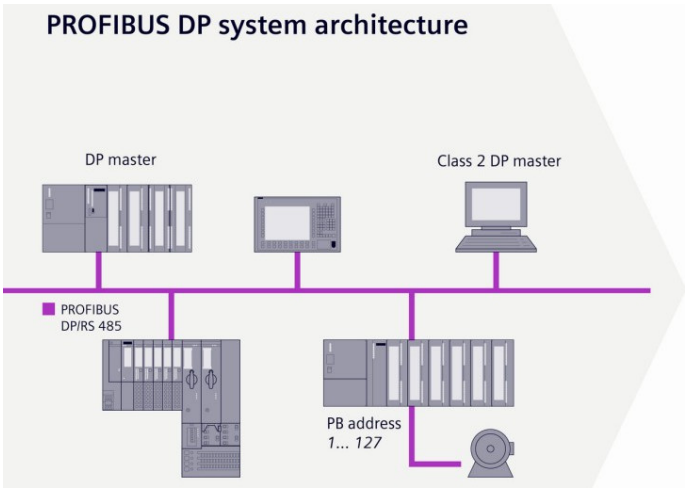

Fig. 2. Profibus System Architecture(Siemens)

1) Physical Layer: Profibus DP uses a physical layer based on RS-485 and can operate at a maximum baud rate of 12 Mbps. Profibus PA, on the other hand, is designed for use in hazardous areas and uses a physical layer based on the intrinsically safe standard IEC 61158-2. The maximum baud rate for Profibus PA is 45.45 kbps. [5]

2) Data Link Layer: Profibus DP and PA both use the same data link layer, which is based on the standard ISO/IEC 8802-2 (also known as the IEEE 802.3 standard for Ethernet). [7] The data link layer provides error checking and correction, as well as data transmission control and arbitration.

B. Description of Profinet

Profinet is a newer communication protocol that was introduced in 2002 by the Profibus Trade Organization (now known as Profibus and Profinet International). Profinet is designed to provide real-time communication between devices in industrial automation applications and is based on standard Ethernet technology. [9]

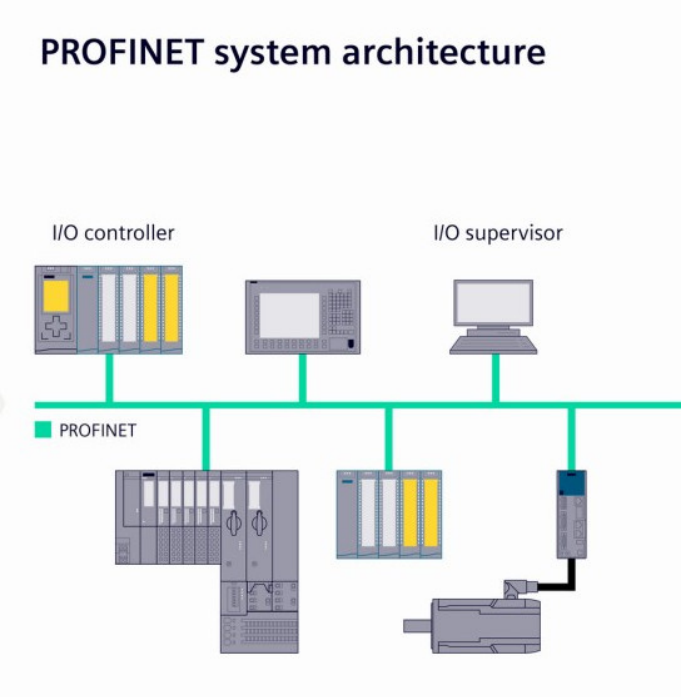

Fig. 3. Profinet System Architecture(Siemens)

1) Physical Layer: Profinet uses a physical layer based on standard Ethernet technology, which makes it compatible with existing Ethernet networks. [1] Profinet supports data rates from 100 Mbps up to 10 Gbps and can operate over copper, fiber, or wireless media.

2) Data Link Layer: Profinet uses the standard IEEE 802.3 Ethernet data link layer, which provides error checking and correction, as well as data transmission control and arbitration. Profinet also uses the Real-Time Ethernet (RTE) protocol to provide deterministic communication with a maximum cycle time of 31.25 µs. [5]

Profibus and Profinet are two widely used communication protocols in industrial automation. Profibus is an older protocol that has been widely used since the early 1990s, while Profinet is a newer protocol based on standard Ethernet technology. Both protocols provide reliable communication between devices in industrial automation applications, and the choice of protocol depends on the specific requirements of the application.

III. Applications

Profibus and Profinet are industrial communication protocols that are commonly used in automation and control systems. One significant application of these protocols is in the manufacturing sector, particularly on an automotive assembly line. Profibus and Profinet are critical in this environment for providing smooth communication between diverse devices and systems, ultimately leading to enhanced efficiency, productivity, and cost savings. [10]

Consider an automotive assembly line, where separate stations are in charge of distinct activities such as welding, painting, and final assembly. Each station is made up of many machines, sensors, and actuators that must all work together to accomplish the intended result. [11] Profibus and Profinet let these devices to interact with one another as well as with the central control system, enabling real-time monitoring and control of the entire process.

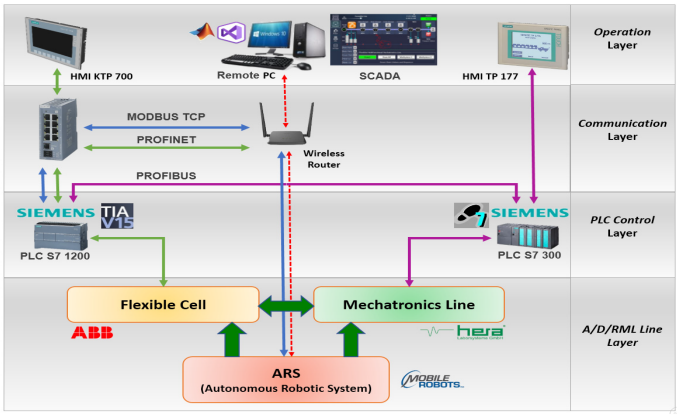

Fig. 4. Structure of a hybrid automotive sytem [11]

A. Manufacturing and Assembly Lines

In the car assembly process, the production line is composed of various stations, each dedicated to a specific task such as engine installation, wheel attachment, or interior assembly.Sensors monitor the process to ensure quality and safety requirements while robots and automated equipment work together at each station to complete their responsibilities. Profibus and Profinet act as a communication link between these devices, allowing them to share data and coordinate their operations. [8] For example, a robot entrusted with installing the engine must be aware of the precise position and orientation of the automobile body, as well as the engine's requirements. Sensors and other devices that communicate with the robot via Profibus or Profinet protocols provide this critical data.

Furthermore, the Profibus and Profinet protocols enable real-time monitoring and control of the production line, with PLCs serving as the system's "brain." These controllers collect data from sensors and other devices, analyze it, and then make decisions based on it. This enables the PLCs to detect any errors or deviations from the planned procedure, such as a misaligned part or a malfunctioning robot, and to take remedial action to ensure the quality and efficiency of the manufacturing line.

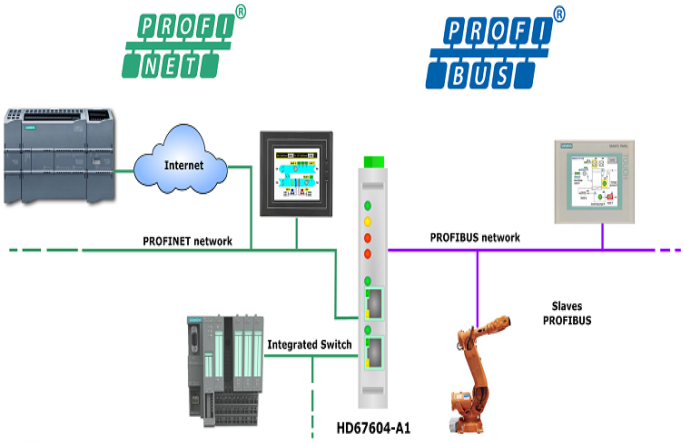

Fig. 5. Example of communications bridge protocol

Profibus/Profinet is a real-time, high-speed communication protocol that allows devices to exchange data quickly and efficiently. It employs a master-slave architecture, in which the master device controls communication and the slave devices respond to the master's demands. This architecture ensures that communication is well-organized and that there are no conflicts or device collisions. The protocol employs a cyclic data exchange method, in which data is transmitted cyclically between devices. This technique ensures that data is shared on a regular basis, allowing devices to synchronize their actions and maintain a consistent output rate.

Furthermore in fig 5, the protocols allow for real-time monitoring and control of the production line, with Programmable Logic Controllers (PLCs) serving as the system's "brain." These controllers collect data from sensors and other devices, analyze it, and then make decisions based on it. This enables the PLCs to detect any errors or deviations from the planned procedure, such as a misaligned part or a malfunctioning robot, and to take remedial action to ensure the quality and efficiency of the manufacturing line.

B. Process Control

Profibus/Profinet communication protocols have several applications in a variety of sectors. In addition to flexible assembly and process control, they are also used in other areas, such as packaging, food and beverage, and automotive production. Profibus/Profinet are used in the packaging sector to control and monitor various machinery such as fillers, cappers, and labelers. The application of these standards in the food and beverage industry ensures that products are produced in a safe and efficient manner. In the bottling business, for example, the protocols can be used to monitor and manage the temperature and pressure during the filling process to guarantee that the beverages are filled at the proper levels.

For example, Maintaining proper temperature and pressure during the filling process is critical in the bottling industry for ensuring product quality and uniformity. Various protocols and automated systems are used to continuously monitor and control these parameters in order to achieve this. This helps to reduce waste and increase efficiency while also ensuring that the beverages are filled to the proper quantities. [12]

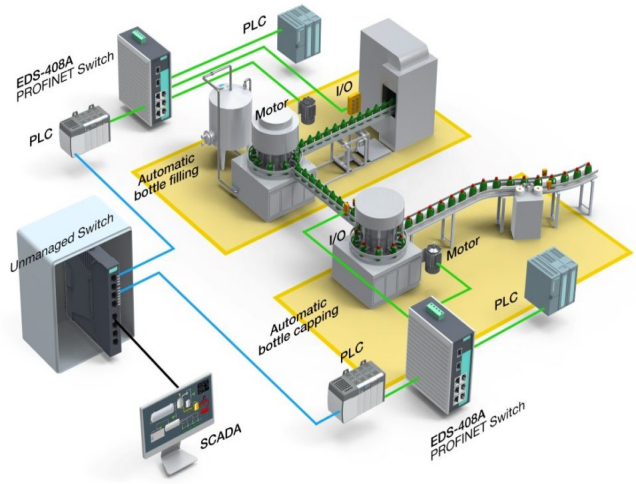

Fig. 6. Example of bottling facilities using profinet&profibus [12]

One such protocol makes use of sensors and control systems strategically placed throughout the manufacturing line. These sensors capture temperature and pressure data in real time, which is then processed by the control system. If the system detects any deviations from the required values, it can automatically modify the relevant equipment to put the parameters back within the allowed range. This closed-loop feedback system ensures that the filling process is stable and consistent, resulting in a high-quality product that meets both the manufacturer's and the consumer's expectations.

C. Transportation Systems

Profibus and Profinet are also widely used in transportation systems, including rail and automobile applications. These communication protocols provide quick and dependable connections for controlling and monitoring a variety of components such as sensors, actuators, and motors. Profibus and Profinet can be used in the railway industry to monitor and regulate train speed, track switches, and signaling systems, improving safety and efficiency. [8] Similarly, in the car industry, same protocols can be used for engine and transmission control, anti-lock brake systems, and suspension control.

Profinet switches, for example, are used in the automotive industry for diagnostic purposes, reducing downtime and maintenance costs. These switches allow data to be communicated between various equipment within a vehicle, such as sensors and control units, hence expediting diagnostic operations. They also provide real-time data monitoring, allowing for more effective maintenance and troubleshooting. Operators may effectively monitor and operate these systems in real-time

by merging Profibus and Profinet into transportation systems, resulting in greater safety and efficiency.

IV. Communication Requirements

Effective communication is critical in industrial automation systems, and the communication requirements must be carefully considered. Bandwidth and latency are two essential communication characteristics to consider.

1) Bandwidth: Bandwidth refers to a communication channel's ability to send data within a given time frame. The needed bandwidth in industrial automation applications is determined by the amount of data that must be sent between devices as well as the connection frequency. [5] A high-speed production line, for example, may entail rapid data transfer between equipment, necessitating a greater bandwidth.

Profibus and Profinet both have significant bandwidth capacities. Profibus DP can handle up to 12 Mbit/s and Profinet up to 100 Mbit/s. These fast speeds enable real-time communication between devices in industrial automation applications. [2] Profibus and Profinet, in addition to high data transfer rates, allow different data transfer modes, such as cyclical, acyclic, and time-critical communication, which can help improve bandwidth consumption.

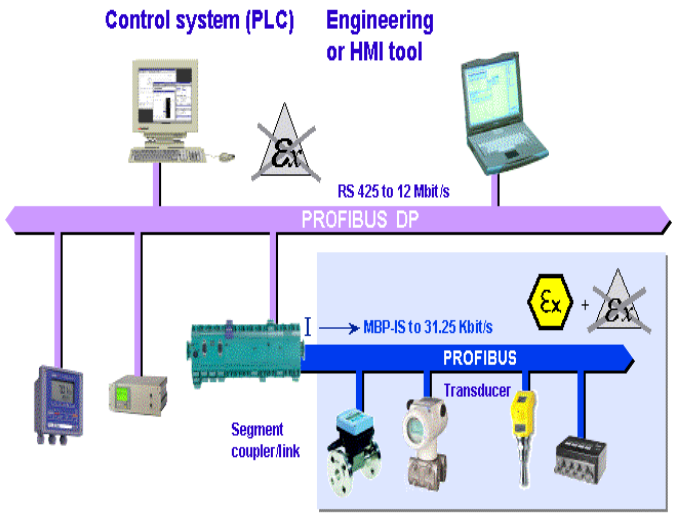

Fig. 7. Transmission technology.(Siemens)

2) Latency: Latency is the amount of time it takes data to transit from one device to another. In industrial automation applications, low latency is critical for ensuring real-time control and responsiveness. For example, in a robotic assembly line, the latency between the control system and the robot must be kept to a minimum to ensure rapid responses to changes in the manufacturing process. [9]

Profibus DP has latency times of less than one millisecond, whereas Profinet has latency times of less than one second. Because of their low latency, both protocols are appropriate for real-time control and monitoring in industrial automation applications. Profibus and Profinet, in addition to reduced latency, provide capabilities like as time synchronization, message prioritizing, and redundancy, which can help ensure that crucial control and monitoring messages are delivered promptly and reliably.

V. Pros and Cons of Profibus/Profinet

In the industrial automation industry, Profibus and Profinet have become widely used communication protocols. They have major benefits including as scalability and real-time performance, making them suited for a wide range of applications. However, they have some drawbacks, such as complexity and limited range, that should be considered when choosing a communication protocol for an industrial automation system. [5] Furthermore, compatibility issues between devices from different manufacturers may arise, complicating the integration process. Despite these challenges, the advantages of using Profibus and Profinet in industrial automation applications outweigh the disadvantages, making them a popular choice among engineers and system integrators.Here are some pro and cons:

A. Advantages

1) Scalability: Scalability is a significant advantage of Profibus/Profinet. They can support both small and big systems, making them suitable for a wide range of applications. These protocols can operate in a variety of network topologies and support many configurations. [3] As a result, businesses can grow their systems without major redesigns, resulting in more adaptable and cost-effective solutions.

2) Real-time performance: For real-time control and monitoring in industrial automation applications, Profibus/Profinet are renowned for their superior real-time performance. They provide fast data transfer rates, which are vital in time-sensitive applications including factory assembly lines, robotic control, and process control.

B. Disadvantages

1) Complexity: The complexity of Profibus/Profinet is one of their drawbacks. Designing, implementing, and maintaining these protocols necessitates specialized knowledge. In order to handle the installation and maintenance of the network, businesses may need to spend in staff training or hire professionals. [10] Furthermore, there are numerous variations of these protocols, making it difficult to select the appropriate protocol for specific applications.

2) Limited range: Another drawback of Profibus/Profinet is their restricted range. These methods are most effective in short-range applications within a plant or building. Other protocols, such as Ethernet or wireless, may be more appropriate if an application demands communication across vast distances. Furthermore, repeaters and bridges can be used to extend the range of Profibus/Profinet, but this adds complexity and cost to the network. [1]

In summary, ProfibusProfinet is ideal for industrial automation applications that require reliable and fast communication between devices. Its scalability and real-time performance make it ideal for complex and demanding industrial processes.

However, implementing and maintaining these protocols can be complex and requires skilled personnel and appropriate equipment [6].Finally, Profibus/Profinet are ideal for industrial automation applications that demand dependable and fast communication between devices. They are a fantastic solution for complicated and demanding industrial processes because to their scalability and real-time performance. However, implementing and maintaining these protocols can be difficult, requiring skilled personnel and specialized equipment.Furthermore, the limited range of Profibus/Profinet may pose difficulties in large-scale industrial operations. In order to decide whether to apply these protocols, businesses must thoroughly assess their communication needs and weigh the benefits and drawbacks of each. [10] Overall, Profibus/Profinet are good communication protocols that provide considerable benefits for industrial automation applications.

VI. Conclusion

A. Summary of the paper

The objective of this paper is to provide an overview of the use of Profibus and Profinet communication protocols in industrial automation applications, with a focus on their application in flexible assembly, disassembly, and repair tasks in a mechatronic line that uses an Autonomous Robotic System. The paper underlined the importance of effective communication in industrial automation, naming bandwidth and latency as two essential communication characteristics to consider. The article also discussed the benefits and drawbacks of using Profibus and Profinet, such as their scalability and real-time performance, as well as their complexity and limited range.

B. Future Work

While Profibus and Profinet are widely used in industrial automation applications, there is still room for future research and development. Integration of these protocols with other developing technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) is one area of focus. Researchers could look at how merging these technologies could increase the performance and efficiency of industrial automation systems. Future work will also include the creation of more advanced diagnostic tools and methodologies for monitoring and managing Profibus/Profinet networks. Having efficient diagnostic tools is crucial to rapidly and effectively identifying and fixing problems as these networks become more complex.

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