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POSSIBILITES OF COMMUNICATION ENHANCEMENT FOR EXPERIMENTAL PRODUCTION SYSTEM

Urgency of the research. *Modern trends in the industrial communication focus on implementation of new communication protocols, wireless data transfer at reduced costs. Communication part of every automation system is crucial and reliability of these systems is very important.*

Target setting. *When designing automation systems and solving connection of different devices, developers have to solve the various aspects as addressing, data rates, data security, etc. The modern Ethernet based communication protocols and data transfer technologies provide significant cost and work reduction.*

Actual scientific researches and issues analysis. *To prepare this paper, different publicly available datasheets and experimental solutions were analyzed as well as conclusions of our previous experiments were used to create the knowledge base about this research topic.*

Uninvestigated parts of general matters defining. *Since there are many different communication solutions, wired and wireless too, and every manufacturer of industrial devices provides its own best solution for communication there is large amount of solutions. This paper is insufficient to describe them all.*

The research objective. *In this article, different communication and connection technologies were analyzed for future implementation to an existing experimental production system at the Department of Automation, Control and Human-Machine Interactions.*

The statement of basic materials. *To integrate an existing model of industrial production system to the concept of the Industry 4.0 it is necessary to implement the newest communication technologies. Using Ethernet-based communication protocol, such as Profinet with combination of IO-Link provides good basis to solve this issue.*

Conclusions. *The proposed paper provides possibilities of extending the communication interface for the FMS-500 experimental system. This system is currently based on programmable controllers S7-300 and the PROFIBUS communication interface. The planned rebuilding of the assembly system involves the exchange of programmable controllers, the expansion of communication protocols and the integration of new functionalities.*

Keywords: *automation; control; communication.*
Fig.: 5. References: 10.

Introduction. The development and advancements of automation tools and IT technologies require the application of contemporary software and hardware solutions both in practice and in teaching. In order to meet the increasing demands of the labor market in automation, practical skills and knowledge together with modern means and tools are essential.

A theoretical analysis of the problem is not sufficient for a better understanding of the communication interfaces, it is necessary to gain and check the knowledge using practical tasks. The FMS-500 experimental workspace at the department of Automation, Control and Human Machine Interactions was designed to provide a practical demonstration of work with industrial line, but it is necessary to update current status by adding a new communications applications. This update involves reconfiguration of an existing automated production line, replacing controllers, exchanging technical resources, and adding new components to the system.

This is a large project that consists of several subtasks. They are focused on identification of new hardware, designing new workplaces and related components, communication addressing between individual system components, and communication with system itself over a remote communication interface.

This paper focuses on the communication interfaces used in the existing system and the possibilities of replacing them with new, innovative technologies to be used in the Industry 4.0 platform [1-3].

Experimental production system. Flexible assembly system FMS-500 was developed by Festo to bring industry technology to students and educators. It serves as a demonstration tool for creating automated systems that consist of sensors, controllers, actuators and communication interfaces.

In its present form, the whole system uses PROFIBUS communication technology. It creates a link between the individual controllers of the system stations, the Siemens S7-300 PLC, and personal computer which serves as the monitoring station of the on-going process.

The structure of the FMS-500 system is shown in Fig. 1, but our workplace does not contain all possible system modules. Our line consist of stations for: distribution, testing, submission and sorting [2; 3].

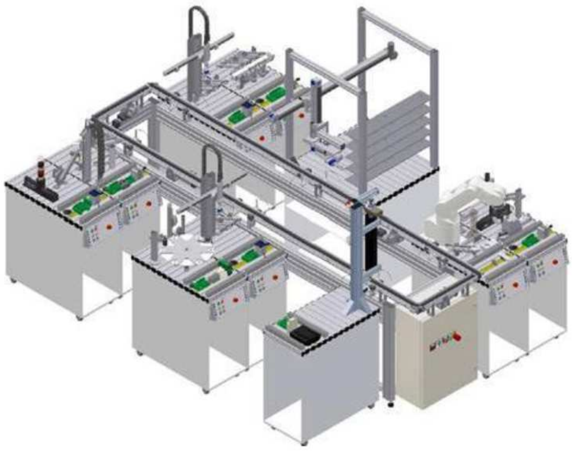

Fig. 1. Experimental production system – FMS-500

Communication systems can be divided into 3 layers:

1. The layer of sensors and actuators provide real-time communication. These networks are the lowest level of control, and data and power are transmitted on a common transmission medium. Such networks are: AS-Interface, Interbus, HART, etc.
2. Layer of bus devices is used to communicate programmable machines. It is used to connect I/O devices, real-time control devices. It uses longer frames for communication to configure the actuators and sensors. Here we can include networks like: DeviceNet, Interbus, CAN, and so on.
3. The layer of industrial communications collectors is at the highest level in the industrial network hierarchy. Typically, these are dual-band networks. They allow manage service events, transfers of object-oriented data and variables. These include networks such as: Profibus, P-Net, WorldFIP, etc. [4,5]

PROFIBUS. PROFIBUS is the name of the standard for PROFIBUS and PROFINET bus. It is an open operating bus regulated by IEC 61158. By means of one bus cable, PROFIBUS connects the controller and the control system with decentralized operating devices (actuators, sensors) and also enables the exchange of data with higher communication systems. PROFIBUS is built as a modular communication channel, which also includes the communication protocol itself. With modularity, it is possible to specialize communication to various tasks such as motion control (PROFIdrive) or integration of HART devices, and so on. This creates different PROFIBUS profiles such as: PROFIBUS PA, PROFIBUS DP, PROFIdrive, PROFIsafe and more.

For a simple and low-cost communication solution, RS-485 communication is recommended. Transmission speeds range from 9.6 to 15,000 Kbit/s, depending on the media used, and the number of nodes in that segment is limited to 32 and 126 across the network. Uses circuit topology, tree, and circle [4].

PROFINET. We have decided to replace the existing communication channel and the network with PROFINET communication. PROFINET is an industry-standard with physical layer Ethernet that ensures long-term compatibility with other manufacturer's products. PROFINET uses the same Ethernet as IT solutions, and is adapted to industrial conditions.

Integrated Ethernet communication, meets the broad requirements for data transfer. Communication takes place through the same cable in every application, from simple control to drive applications.

Using the flexible structure, the network can adapt to the physical structure of traffic, thus can eliminate costly, special communication solutions. The advantage of Ethernet is also the ability to combine wired and wireless solutions. As a result, Wifi and Bluetooth communication are seamlessly integrable into networks with real-time access to data. In Figure 2 an example of a Profinet network is shown that combines fixed and wireless communications [4; 5].

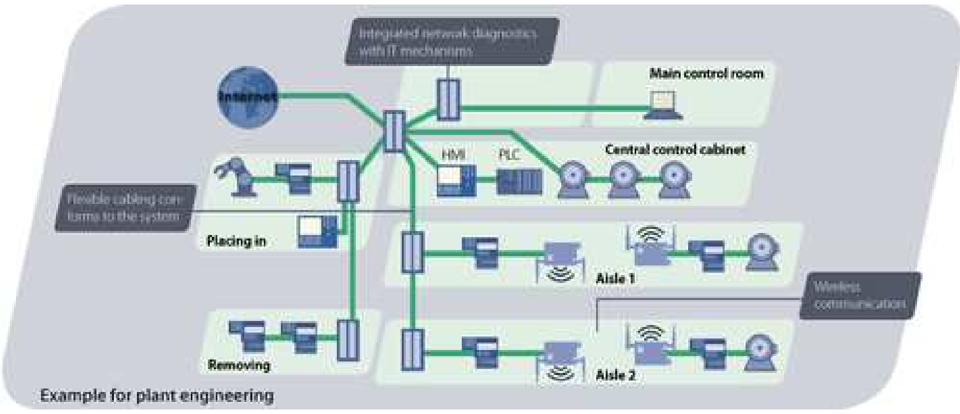

Fig. 2. Example of Profinet network [5]

IO-LINK. It is an independent interface solution between sensors and actuators for use with PROFIBUS and PROFINET. IO-Link is a point-to-point interface for low cost smart/intelligent devices that work at the lowest level of automation. These devices have been "on/off" in the past, but they are currently gaining new features and capabilities such as pre-configuration during operation, greater resolution and improved performance.

In addition, they include higher computing performance and require faster, more intelligent communication with control devices. IO-Link is flexible because it is designed to work with standard devices without modification so its integration and creation of the IO-Link network is simple. This technology is expanded due to independence of the bus and the manufacturers, thus enabling the components of various systems to be connected seamlessly.

Our department is currently working with Balluff, which represents its components as the leading manufacturer of IO-Link elements. The company portfolio covers sensors, high-precision positioning systems, industrial identification systems, object and fluid measurement systems, and network and interconnect devices.

The main component of IO-Link networks or subnets are master modules that represent an IO-Link communication control unit. The Profinet IO-Link master module is predetermined by the built-in system in which Profinet is the main communication bus. This module connects standard and IO-Link elements and collects and sends data using Profinet. [6]

MINDSPHERE. Cloud offers, in addition to the flexible availability of the necessary resources for data storage and processing, also a basis for the horizontal linking of different places. If we want to connect our business, operation, or process to the Industry 4.0 concept, we need to decide whether to provide our data to an external service provider or to use a platform that creates an internal network protected from foreign access. All machines and processes produce a lot of unused data. MindSphere is an open IoT operating system based on cloud technology. It is a data sharing platform that enables the connection of devices and functions and data transfer to MindSphere [7; 8].

The key components of MindSphere are:

– An open interface for connecting devices, machines, departments – in a simple and secure form.
– MindSphere products such as MindConnect IOT 2040 and MindConnect Nano – enable to capture machine and operating data and transfer them to MindSphere.
– Data-based services - tools for machine analysis, energy analysis.
– MindApps - applications for predictive monitoring and intervention.
– Development platform for creating custom applications.

MindSphere serves to monitor world-wide manufacturing plants, machines and equipment. Subsequent data can be used for predictive maintenance, energy management, and stock and resource optimization with platform applications.

In addition to integrated applications, it is possible to create custom applications and make data available to third parties for analysis and processing. This platform creates a new space for application developers who can offer data processing services. In Figure 3, there is a MindSphere environment in which the processed data is displayed [7; 8].

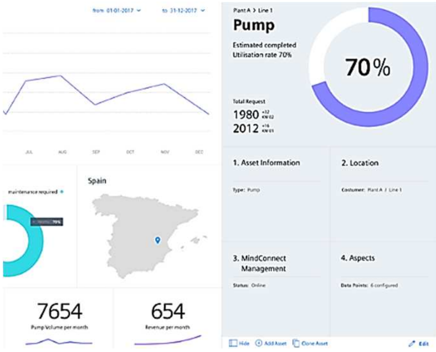

Fig. 3. Visualization of data - MindSphere

For integration of our experimental workplace into Industry 4.0, we have decided to use the Siemens MindSphere platform to create a remote interface for access to the processing of data produced by system.

RFID. It is a technology for identifying people, objects, products, cities, and so on. The main components of the technology are the read and write device and the data carrier with the antenna. The data carrier provides a unique identifier, and specifies the exact name, description, or characteristic of the scanned object.

An important advantage over a barcode is that the reader does not have to be placed accurately, and it is possible to load the data even from a larger distance based on the reader used.

Frequent problems with RFID are the collisions of the signals of either the readers or the tags. Reader collision occurs when two or more heads overlap and the carrier cannot answer to multiple requests. The collision between the tags occurs when several tags are in a small location, one reader head is requests data, and multiple tags respond.

As one of the new features of the experimental workplace, we wanted to complement the industrial identification. Based on our experience, we have chosen Balluff's RFID components (Fig. 4). With its BIS product family, it meets all the requirements of industrial identification in a modern environment, from low to high frequency. With the control unit, the elements are easily connected to each other and to the IO-Link network [9].

Fig. 4. Components of IO-Link [9]

Siemens SIRIUS ACT. Rapid industrial development places increasing demands on suppliers of automated systems. This pressure has created new interconnection technologies that greatly accelerate the integration and integration of components.

SIRIUS ACT connects the buttons and signaling devices directly to the control unit and HMI devices via the PROFINET interface. Other advantages of using such a peripheral connection are: steady data management, shorter downtime, fast diagnostics and flexible design and modification of systems during operation [10].

Main benefits:

• Effective PLC integration.
• Reduced cabling - fewer sources of errors during installation and debugging.
• Quick installation with flat cable without special tools.
• High level of flexibility – expandable I/O.
• Modular plug-in form of components.
• Safety design option.
• Single IP address for 21 devices.
• Simple replacement of broken pieces.

The above-mentioned technologies are, by their very nature, tools for integrating the experimental workplace into the Industry 4.0 concept. The gradual integration of these technologies is divided into steps that are gradually being followed. The first step of FMS rebuilding is to replace currently used S7-300 controllers and PROFIBUS communication with S7-1500 controllers and Profinet communication. In addition to this replacement, a new FMS-500 module is being developed to integrate IO-Link and RFID.

This workplace is designed for presentation and educational purposes and is created within a doctoral project. The next step in expanding system features is to make process data available for long-term recording and analysis using the MindSphere platform. In the future, we plan to extend communication with wireless connectivity, Wifi and experiment with it. The planned connection of the components of the automated system is shown in Figure 5.

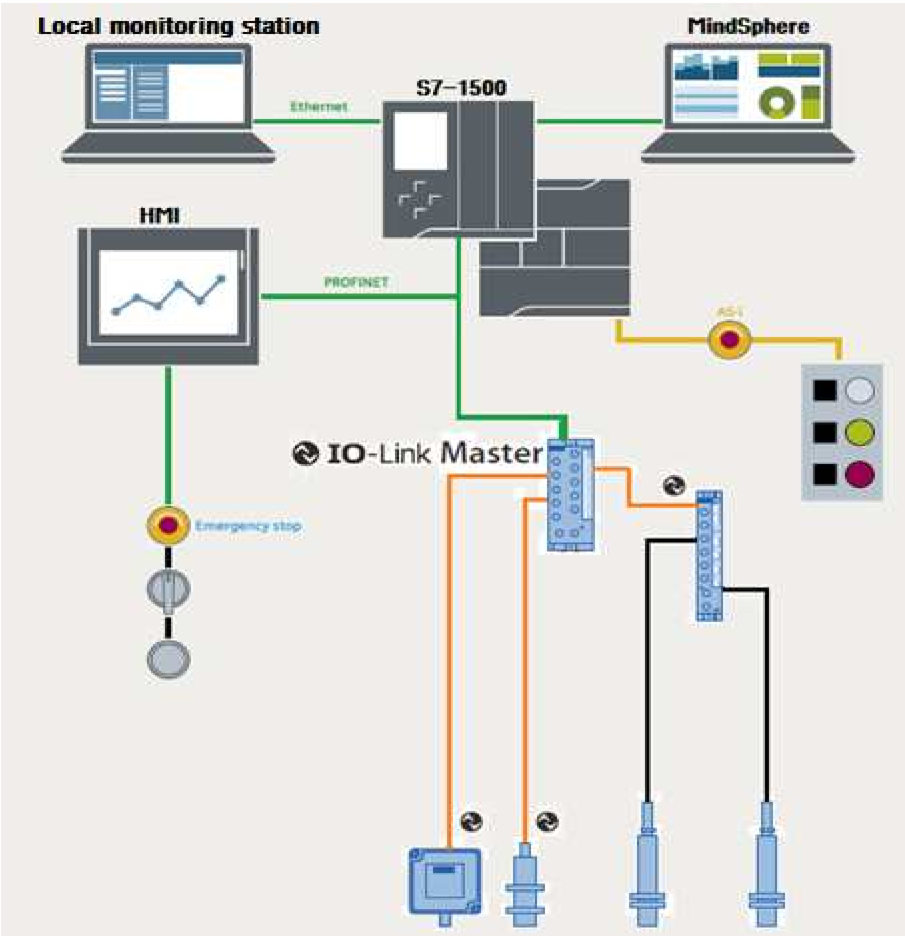

Fig. 5. Interconnection of experimental production system components after rebuilding

Conclusion. This article describes communication technologies that currently allow the integration of an experimental workplace into the Industry 4.0 concept. During the reconstruction of the experimental workplace, new components, controllers, sensing and actuating elements, communication devices are gradually added to the system. Selected communication interfaces are often applied in current industrial processes, and by their integration, the Department of Automation, Control and Human Machine Interactions acquire a powerful tool for research and educational purposes.

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МОЖЛИВОСТІ ПОЛІПШЕННЯ КОМУНІКАЦІЇ ДЛЯ ЕКСПЕРИМЕНТАЛЬНОЇ ВИРОБНИЧОЇ СИСТЕМИ

Актуальність теми дослідження. *Сучасні тенденції в промисловій комунікації орієнтовані на впровадження нових комунікаційних протоколів, бездротовій передачі даних при знижених витратах. Комунікаційна частина будь-якої системи автоматики має вирішальне значення і надійність цих систем дуже важлива.*

Постановка проблеми. *Під час проектування систем автоматики і вирішення завдань підключення різних пристроїв розробникам доводиться вирішувати різні аспекти, такі як адресація, швидкість передачі даних, безпеку даних і т. ін. Сучасні протоколи зв'язку на основі Ethernet і технології передачі даних забезпечують значне зниження витрат і скорочення робочих місць.*

Аналіз останніх досліджень і публікацій. *Для підготовки цієї статті були проаналізовані різні загальнодоступні таблиці даних і експериментальні рішення, а також висновки наших попередніх експериментів були використані для формування уявлення про тему дослідження.*

Виділення недосліджених частин загальної проблеми. *Оскільки існує безліч різних комунікаційних рішень, дротових і бездротових, і кожен виробник промислових пристроїв забезпечує своє власне краще рішення для зв'язку. Ця стаття є недостатньою для їх повного опису.*

Постановка завдання. *У цій статті були проаналізовані різні технології зв'язку та комунікації для майбутньої реалізації в існуючій експериментальній виробничій системі на факультеті автоматизації, управління і людино-машинних взаємодій.*

Виклад основного матеріалу. *Щоб інтегрувати існуючу модель системи промислового виробництва в концепцію Industry 4.0, необхідно впровадити новітні комунікаційні технології. Використання протоколу зв'язку на основі Ethernet, такого як Profinet з комбінацією IO-Link, забезпечує хорошу основу для вирішення цієї проблеми.*

Висновки відповідно до статті. *У запропонованій роботі представлені можливості розширення інтерфейсу зв'язку для експериментальної системи FMS-500. Нині ця система заснована на програмованих контролерах S7-300 і комунікаційному інтерфейсі PROFIBUS. Планова перебудова системи збирання передбачає обмін програмованими контролерами, розширення комунікаційних протоколів та інтеграцію нових функцій.*
Ключові слова: *автоматизація; управління; зв'язок.*

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