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CASE STUDY OF APPLICATION OF OPC TECHNOLOGY IN INTEGRATION OF LABORATORY EQUIPMENT AND SOFTWARE

Abstract: This paper describes case study of application of OPC technology in the Laboratory of Integrated Manufacturing Systems, equipped with various industrial controllers, in order to acquire data for exemplary client application using this data. Communication between the automated equipment of the production system allows efficient and immediate acquisition of data on the state of adjoining equipment and production orders, which are the main postulate of Industry 4.0 methodology. Because of the variety of hardware and software in production systems, it seems necessary to use a standard method of communication, such as OPC, allowing client applications to acquire data in a standardized form. Article presents description of configuration of different laboratory stations controlled by PLCs, development of PLC applications, configuration of OPC server (KEPServerEX) with hardware drivers, testing of communication, and finally, example of usage of acquired data in OPC client application - HMI/SCADA iFIX.

1. Introduction

Companies competing on today's globalized market have to seek for methods of increasing of the efficiency of equipment and reduction of production costs. The continuous improvement of production processes, allowing to meet the requirements of customers and to ensure the optimal operation of production system leading to timely execution of customer’s orders is important part of proper company management.

Optimization of communication processes taking place in enterprises in order to improve economic performance by improving flow of information is one of the main demands of Industry 4.0 methodology, which is presented as the next stage of the industrial revolution made possible by popularisation of modern electronic equipment and communication solutions. [4]. The main pillars of Industry 4.0 are: Big Data and analytics, autonomous robots, simulation, horizontal and vertical system integration, The Industrial Internet of Things, cybersecurity, the cloud, additive manufacturing and augmented reality. Many of these terms are already used in manufacturing, but it is expected that with Industry 4.0 they will transform production model, creating fully integrated, automated, and optimized production flow, and leading to greater efficiency and closer relationships between suppliers, producers, and customers [6].

The issue of integration of different IT systems, forcing the acquisition of data from production systems, is an interdisciplinary problem requiring combination of experience in areas such as industrial automation, computer science, electronics, communication and management. This is a very broad matter, requiring an individual approach to the specific conditions and needs of a particular user [1].

This paper presents an attempt to provide vertical and horizontal integration of automated machines and operation/business area software using standardised communication technology - OPC [3]. The OPC is the interoperability standard allowing secure and reliable exchange of data in the industrial environment. OPC is platform-independent and ensures communication between devices from different vendors. Organisation responsible for the development of this standard is OPC Foundation. The first version of OPC standard was released in 1996 in order to provide standardised interface allowing access to devices using PLC specific protocols (such as Modbus, Profibus, etc.). The OPC standard is a series of specifications, defining the interface between Clients and Servers (also Servers and Servers), allowing access to real-time data, monitoring of alarms and events, access to historical data and other applications. It allows cooperation of various types of equipment (manufacturing, building automation, oil and gas, renewable energy, utilities, and many others). OPC adopts the client-server architecture, isolating client applications from necessity to cooperate with numerous (and sometimes proprietary) industrial communication protocols and devices. Nowadays, the OPC UA specification, including all older functions and incorporating open technologies (XML, SOAP) provides a feature-rich technology open-platform architecture, that is easily accessible, scalable and extensible [5]. OPC technology will be applied as mean of integration of devices and software in the Laboratory of Integrated Manufacturing Systems, located in Centre of Modern Technologies of Silesian University of Technology in Gliwice.

2. The Laboratory of Integrated Manufacturing Systems

The subject of production data acquisition and integration of manufacturing systems with the business area, should be the subject of research and development of new solutions that facilitate the management of processes taking place in companies. For this purpose, in the Centre of Modern Technologies of the Silesian University of Technology, the Laboratory of Integrated Manufacturing Systems, equipped with modern equipment and advanced software that allows carrying out research related to the issue of acquisition of production data, and teaching activities related to the subject matter described, have been established.

The broad issue of integration of the production system with the business area can be divided into several specific tasks, such as data collection through the sensory systems, acquisition of data from non-automated or partially automated production systems, generating data in control devices (PLC, CNC, etc.), supervisory control systems (HMI/SCADA), communication in production systems (fieldbus, Ethernet), production data archiving and advanced operation and business management IT systems (e.g. MES, ERP and others).

The laboratory is equipped with a workstations controlled by PLCs and various additional actuators and sensors, communication systems, as well as the software belonging to HMI/SCADA, Historian and MES classes. The aim of the integration of systems installed in the laboratory is to obtain the possibility of data exchange between all these systems and lab workstations.

Three workstations have been selected as the object of integration via OPC technology:

a) the workstation for "in-line" monitoring of production systems ("in-line" workstation),
b) the Balluff workstation of sensor technology and IO-Link (detection of distance and position) - one of five similar Balluff's sensorics and vision sensors workstations,
c) the Astraada workstation of integrated control (PLC, HMI, frequency converter).

Each of these workstations is equipped with different PLC (Mitsubishi Q, Siemens S7-1200, Astraada HE-RC972) that communicates using different standards and protocols (Mitsubishi proprietary protocol, Profinet, Modbus IP).

The “in-line” workstation (a) have been described thoroughly in [2].

The Balluff’s workstation (b) main components are Simatic S7-1200 PLC (1) and modern IO-Link master unit BNI005H (2), allowing connecting up to 8 intelligent IO-Link sensors or actors (connecting classic “dumb” sensors is also possible), both interfaced using Profinet. PLC is equipped with simulator and analogue inputs ultrasound distance sensor (3), while remaining sensors, optoelectronic (laser) distance sensor BOD0012 (4) and Micropulse accurate position sensors BTL1F5N (5) are connected using the IO-Link standard. The Smart Light BNI0086 (LED programmable tower light) (6) is currently the only output device (Fig. 1, left side).

The Astraada workstation of integrated control consists of simple Astraada PLC (7), Astraada 7” LCD touchscreen HMI panel (8), input simulation module (9), set of discrete sensors (inductive 10 and capacitive 11) and Astraada frequency converter (12), powering 3-phase AC motor (13). Main modules of workstation can communicate using Modbus IP, Modbus RTU (RS-485) and CAN interfaces (Fig. 1, right side).

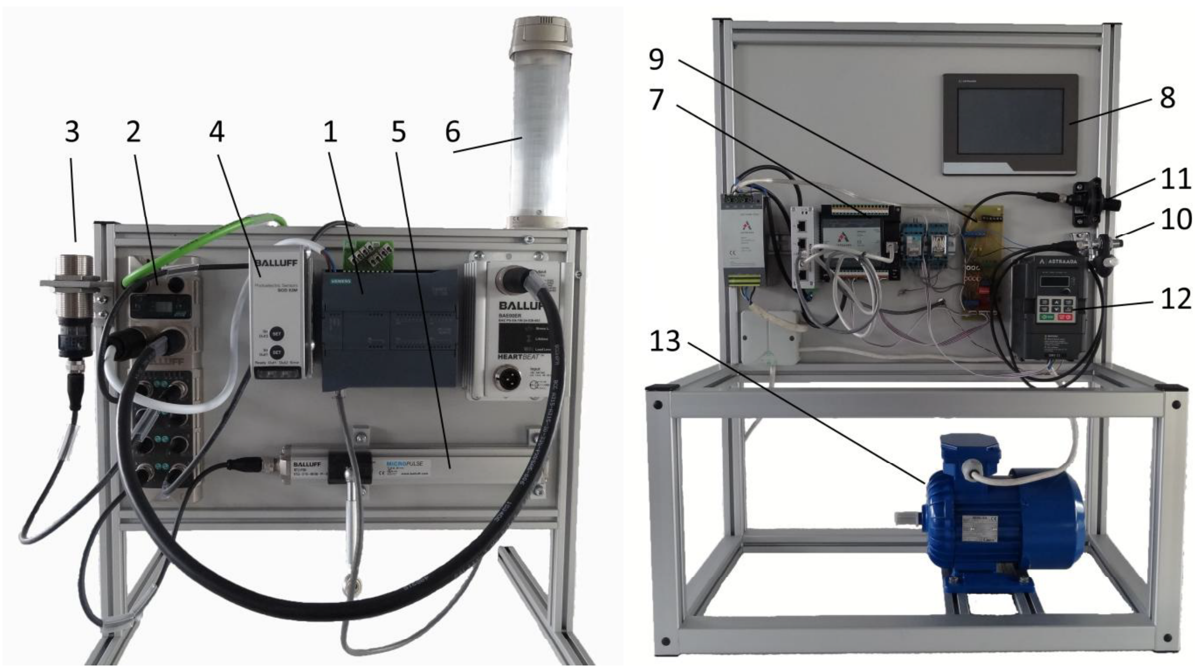

Fig. 1. Balluff and Astraada workstations

3. The integration of laboratory workstations and IT systems using OPC

Kepware's KEPServerEX software has been selected as an OPC server equipped with a large database of drivers for various PLCs. The first task during the integration was to get acquainted with the specifics of communication protocols of existing equipment and checking of availability of OPC drivers. The next steps were: creating of a demonstration programs for each PLC and workstation, installing the appropriate OPC drivers in KEPServer, configuring of PLC - OPC server connection, creating of a database containing tags retrieved from the physical addresses in the PLCs, and validation of the communication using the OPC Quick Client application. The last stage of integration was gaining access to the data collected from the client application OPC - in this case HMI/SCADA iFIX was used, in which firstly OPC communication driver had to be defined, then the database of tags was created, and finally SCADA applications using collected data from selected stations have been designed.

Demonstration programs for PLCs

In order to provide data that can be accessed through OPC demonstration programs have been developed for all workstation’s PLC, using appropriate development environments (Mitsubishi GX IEC Developer, Simatic TIA Portal Step7, Cscape). These programs (Fig. 2) utilise various logic blocks, including Boolean operations, counters, timers, and other functions in order to generate different types of data, like Boolean, integer, real and strings, based on state of inputs connected to simulators, sensors or, in case of the “in-line” workstation, data acquired from barcode and RFID readers.

OPC server configuration and testing

The main steps of setting up of KEPServer OPC server are: adding of channel (at this stage it is possible to choose which communication driver will be used), adding a device to the channel (defining device network address, protocol, communication settings and other parameters), and finally, adding tags to devices.

Three separate channels have been defined because every of workstation’s PLCs required another communication drivers. The Mitsubishi Ethernet, Modbus TCP/IP Ethernet and Siemens TCP/IP Ethernet have been used, respectively, for workstations.

At the second stage PLCs have been added to the channels. Thanks to local Ethernet network and its interfaces, all PLC and PC with OPC server in the same network segment, are available in uniformed TCP/IP address space, it is possible to exchange data with all PLCs and other networked devices (like IO-Link master units) in the Laboratory.

The most difficult part of OPC set-up procedure is defining of tags, because each PLC and protocol has its own methodology of addressing and accessing of different types of data, inputs, outputs, registers, variables and function blocks. In case of relatively widespread Modbus protocol, it is possible to translate internal PLC addresses with Modbus addressing translation table, that have to be combined with knowledge about structure of specific PLC (number of discrete/analogue inputs and outputs, flags, registers, system variables etc.). Mitsubishi and Siemens PLCs are different and for each it is necessary to find technical data and addressing convention. KEPServer help file describes basics of addressing methods.

The final effect of OPC server configuration (Fig. 3) is set of channels with defined devices and tag databases for each PLC device, accessing data changed in PLC programs.

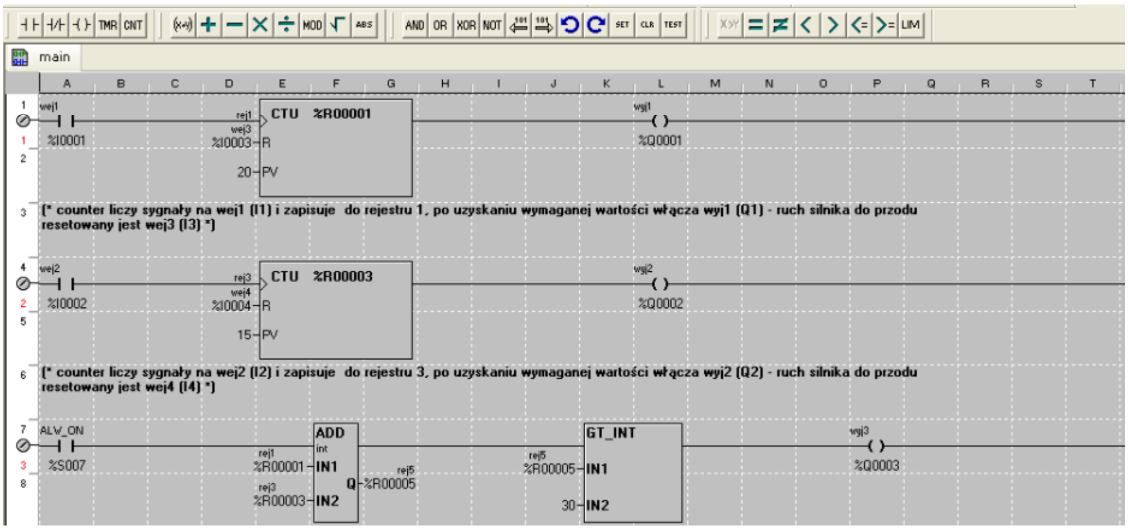

Fig. 2. Exemplary Astraada PLC program in Cscape

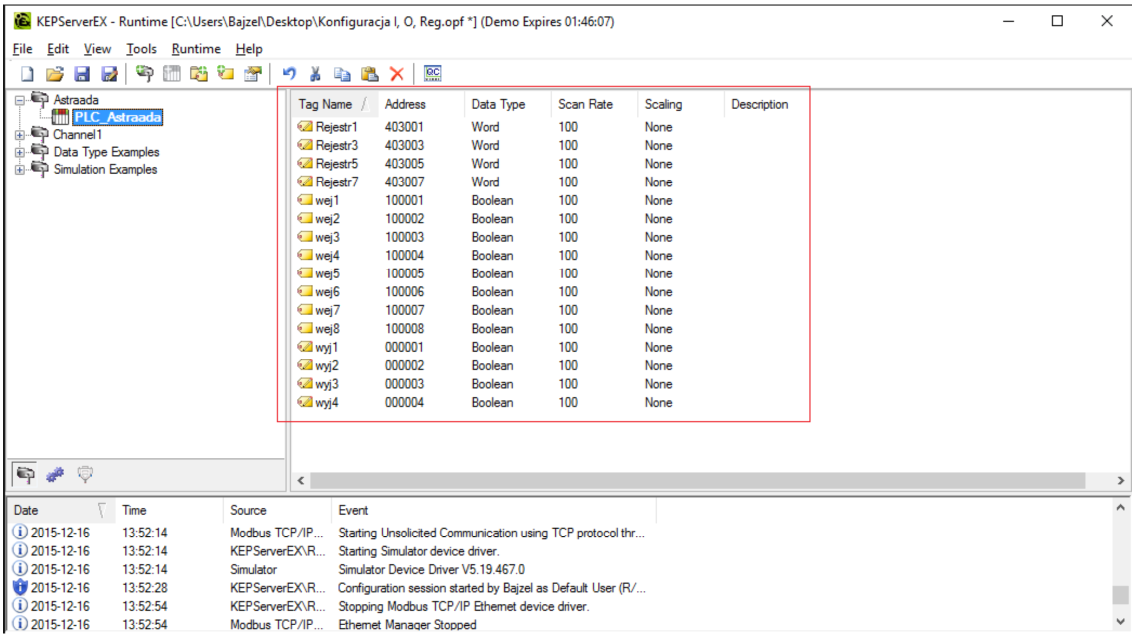

Fig. 3. Exemplary KEPServer configuration for the Astraada workstation

Validity of KEPServer configuration and communication can be verified using OPC Quick Client, available in KEPServer set of programs. Status of communication with PLCs can be displayed, data quality on all defined tags should be "good", and value of variable in Quick Client should change together with changes in PLCs.

HMI/SCADA iFIX applications

In order to check last stage of OPC integration, GE Intellution Proficy iFIX applications, displaying data acquired from workstations, have been developed. It required configuring OPC driver in iFIX configuration module, adding tags to iFIX tag database, and then designing HMI screens displaying data from PLCs in various forms, like numerical display, bit lamps, character string displays, animated objects (Dynamo), charts (Fig. 4), etc..

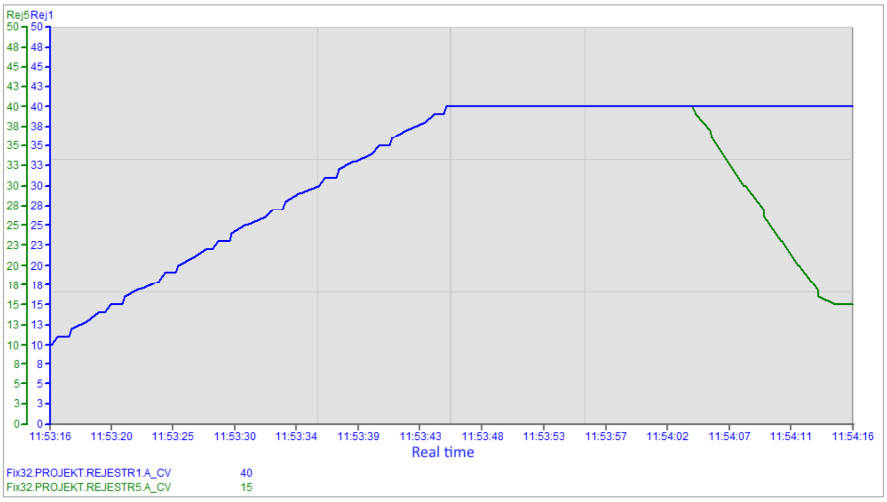

Fig. 4. Time-based chart in iFIX exemplary application

4. Conclusions

Advantage of the OPC technology is that data acquired once from PLC can be reused many times in client applications. Experiments have shown that, thanks to the OPC, data can be obtained from different devices, but various difficulties have also been encountered. Access to simple data such as the states of PLC's inputs, outputs and registers is relatively easy, but it is not always possible to obtain more complex data stored in function blocks specific for PLC manufacturers (e.g. to get data from optimized function blocks, dedicated Siemens software have to be used). Moreover, equipment from different vendors and period of time is often present in the shopfloor - access to older devices, for which we do not have documentation and source software can be a problem because of lack of interfaces or knowledge on meaning of data in the controller's memory - it have to be recovered through the reverse engineering.

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