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PROPOSAL FOR DISTRIBUTED CONTROL SYSTEM OF FLEXIBLE PRODUCTION LINE

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Abstract

This article describes principal advantages of Distributed Control System and its potential application in the control of a school model of flexible production line. Utilizing the features provided by this method of system control (advanced control and monitoring features, user-friendly graphical interfaces, alarm events management, historical databases, etc.) enables to create a fully automated technological production process that will be used in teaching process. The principal aim is to provide a proposal for a control system of the given model and describe individual distribution levels and communication links among them.

Keywords: Distributed Control System, Flexible Production Line

1 INTRODUCTION

Distributed control system (DCS) is a control system, usually production system, process or any dynamic system in which the system elements are not placed centrally but they are distributed, divided into smaller parts, subsystems that are controlled by one or more control devices. Current industrial information and control systems utilize mainly hierarchic (pyramidal) architectures containing physical and logical distribution elements, integration as a whole, open and scalable. Intelligent features have been applied on a large scale recently whereby direct hierarchic relations are turned into network relations. Emergent trends have also started to appear to a great degree, i.e. merging of originally independent systems, which can result in their new features generation as a whole. Individual world-wide automation leaders develop their own models that are adapted to their scope and production. The pyramid in Fig. 1 represents the usual architecture of such systems.

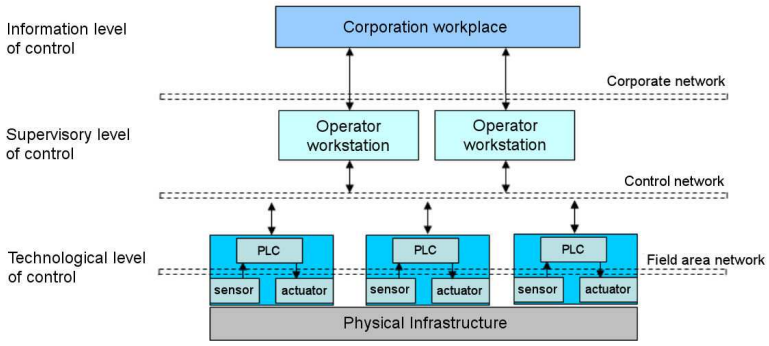

Figure 1: Control systems architecture

Technological level of control represents basic interface with production. It includes production lines and machinery in which sensors and actuators are integrated and these communicate with process control computers, mainly PLCs (Programmable Logic

Controllers) through technological network. Level of supervisory control is a higher level of management which is also alternatively called SCADA/HMI level (Supervisory Control and Data Acquisition / Human Machine Interface). It has been established for primary acquisition and integration of process data, monitoring, visualization, evaluation and direct interference in manufacturing processes. Information level of control represents the top management in relation to the previous levels. Here belong database resources for higher levels of control, management information system and means of Internet visualization. Information level of control is a planning and management level. At this level, data is archived and processed, and long-term strategic decisions for production are accepted.

DCS is widely used to control manufacturing processes in fields such as petrochemical, pharmaceutical, power engineering, food processing and metallurgical industry. Therefore it represents the most suitable way how to control the school model of flexible production line.

2 FUNCTIONALITY DESCRIPTION OF FLEXIBLE PRODUCTION LINE

We, at the Department of Cybernetics and Artificial Intelligence, strive to build up a model of production line that will represent technological process for product assembly and material flow monitoring between the input and output warehouse.

Basic description of technological process:

- production line compiles pallets composed of cubes of different colours to form user-defined patterns. Cubes are transferred from a shaking container along the conveyor belt until they reach the colour sensor where they are sorted into four containers according to colour,
- based on customer's choice cubes are put on pallets using a three-axial manipulator and each pallet is assigned a bar code that helps in their identification,
- compilation correctness of a pallet pattern is verified by the vision system,
- pallets with correct patterns are put into the output warehouse using another three-axial manipulator and pallets with false pattern are transferred to the beginning of the manufacturing process where they are emptied and put into the container with empty pallets,
- the information level of control provides production planning (types of pallet patterns, the number of manufactured items) that meets the customer's requirements.

Line model construction is shown in Fig.2.

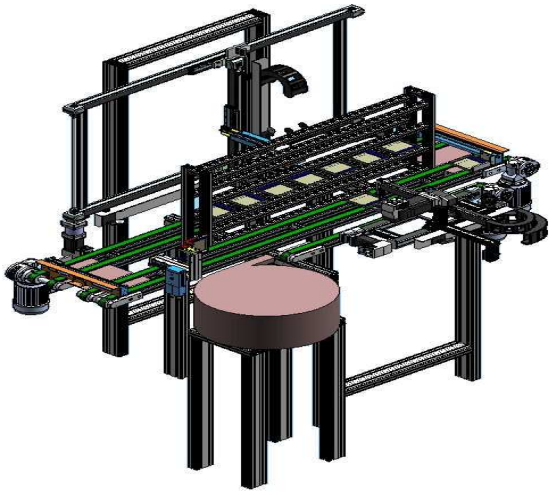

Figure 2: Model of flexible production line

3 PROPOSAL OF DISTRIBUTED CONTROL SYSTEM

Proposal of the control system, as shown in Fig.3, is based on the pyramidal model described in the introduction. At the technological level can be found hardware of the model in which the following is integrated: actuators and sensors, bar code reader for pallet identification, the camera for pallet pattern verification, programmable logic controller that controlls the model locally, and the PC with integrated image recognition software. At the supervisory level of control are placed servers on which SCADA/HMI applications are installed from software packages by companies Wonderware and Rockwell Software. Developed applications enable to monitor and control the model by means of graphical screens, warning signals and alarm messages. The information level at which a database server for data holding has been installed and the MIS (Management Information System) application has been created, represents the top to the previous levels and provides management control, logistics and production planning possibilities. Individual control levels are interconnected by means of standard communication protocols and interfaces that enable technological data acquisition to the database server and also control and plan manufacturing process from the information level to meet the customer's requirements.

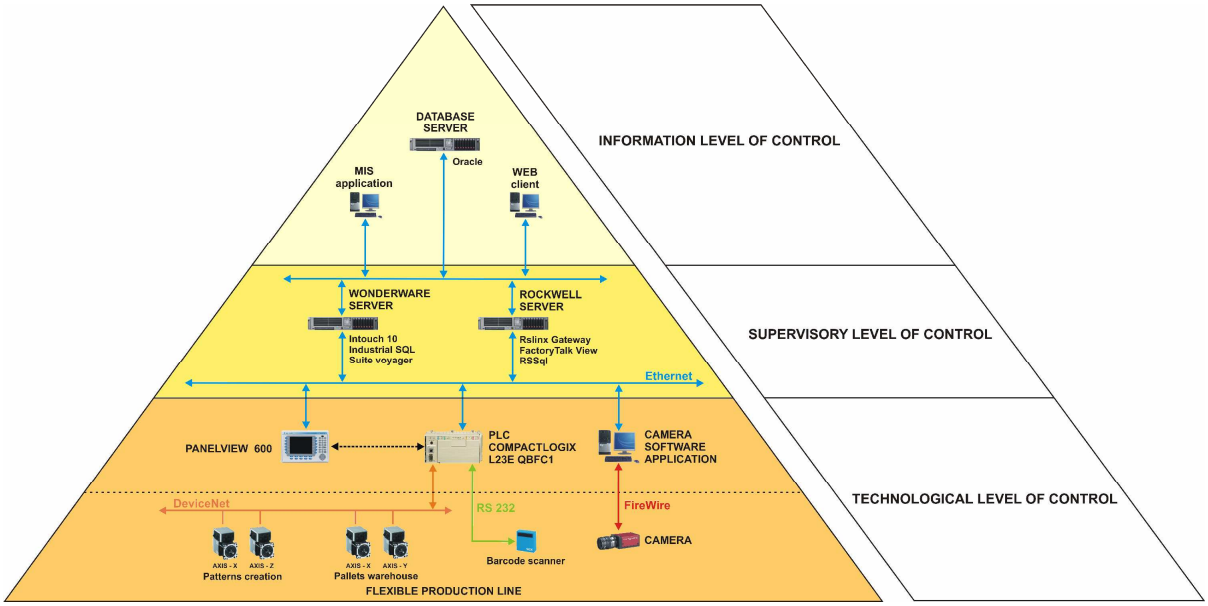

Figure 3: Pyramidal model of the control system

4 TECHNOLOGICAL LEVEL OF CONTROL

Technological level of production line control is made up of wide range of sensors and actuators that are connected by means of control signals to the input/output cards of the PLC CompactLogix L23E made by company Rockwell Software. The control system has been enhanced by a technological network module DeviceNet that is employed to control two three-axial manipulators. One has been designed to compile pallets out of various types of cubes, the other manipulator has been designed for stacking the finished pallets into the output warehouse. DeviceNet network is used only to control two axis of both manipulators, whereby the third axis in case of the first manipulator is represented by a pneumatic cylinder with a vacuum chuck that serves for moving the cubes onto the pallets. In case of the second manipulator is the third axis represented by a technological head that enables stacking the finished pallets into the rack warehouse. A bar code is assigned to individual pallets. This code helps in their monitoring and record-keeping. Code reading is realized through a sensor that is directly connected to the control system using the serial interface RS232. Another part

of the technological level is made up of a camera connected via the FireWire interface to the control PC on which the image recognition software is installed. This camera monitors the correctness of generated patterns on the pallets. A technological panel called PanelView 600 has been designed to control and monitor the production line model locally. It enables the line users to monitor its status, carry out diagnosing and step-by-step operation of the system in case of a failure and also control of individual parts of the line. Technological level interconnection with the supervisory and information control level is realized through the Ethernet network and OPC protocol (OLE for process control).

5 SUPERVISORY LEVEL OF CONTROL

This level is represented by two servers on which SCADA/HMI tools by companies Rockwell Software and Wonderware have been installed. These tools perform complex monitoring and control of the manufacturing process. Part of the Rockwell server is a communication module RSLinx Gateway that provides OPC communication of the control system with developed SCADA application, and RSSql transaction manager which provides data collection from technology to the database. The application itself has been created using the tool Factory Talk View and will enable the users to monitor and directly control the technological process. The second server has been built using the tools by company Wonderware. The application developed in Intouch software also provides local control and visualization of the model. On this server can also be found the Industrial SQL tool for collection and analysis of current and historical data from the line and the Internet information portal Suite Voyager that integrates production data and provides it to the users through a common web browser. Utilization of technology developed by various companies gives space to application of a larger number of extended tools and comparison of their capabilities. Fig.4 shows the view for a proposal of a main visualization window, developed in the Intouch tool.

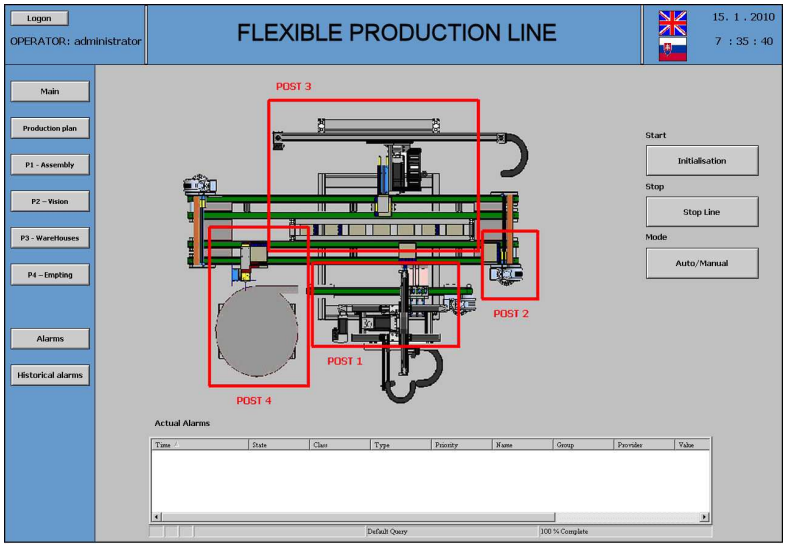

Figure 4: View of the main visualization window

6 INFORMATION LEVEL OF CONTROL

The main part of this level is a database server Oracle 10g and the MIS application ControlLink developed by C# .NET framework 2.0. Data acquisition from technological level of control to the information level is realized by means of the Ethernet network plus OPC and ODBC protocols. The OPC protocol which is provided by a communication server RSLinx is used for communication with the PLC. The ODBC protocol is used for communication with

the database server. These protocols are managed by so called RSSql transaction manager made by company Rockwell Software. Model control and data flow from the information to the technological level is realized by a developed ControlLink application which also works with the OPC protocol. This application represents the information system that enables such users as administrator, storeman, and customer to work with the model of the flexible production line. Customer who loggs in after filling in the registration form can monitor placed orders, both past and present. For the purpose of placing a new order there is a screen shown in Fig.5. Parameters that must be entered are date, order delivery time, type and the number of products. The customer can also view an image of a requested product and is also informed about the price for order.

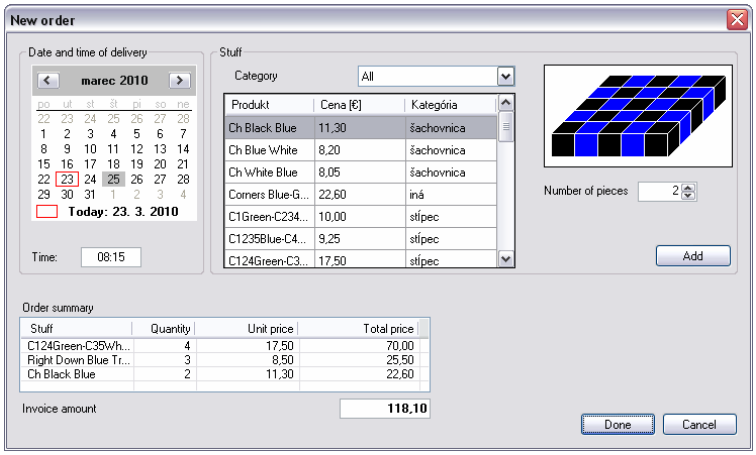

Figure 5: Placing a new order by a customer

The administrator is in charge of sequence administration in which orders are sent to a generating plant (implicitly is this sequence determined automatically depending on the time when an order is received in the system). He is also authorized to enhance the portfolio of offered products. An example of a new product addition can be found in Fig.6. The administrator selects a category a new product will belong to, its name, price and graphically do the compilation of what the cubes layout on the pallet should look like. Then it is automatically computed how many cubes of corresponding colours are necessary for a new product and the application generates a special sequence that is sent to the PLC controller to control the production line in case a newly added type of a product is manufactured.

From the storeman point of view it is more about stock monitoring at the input warehouse and about finished products monitoring at the output warehouse.

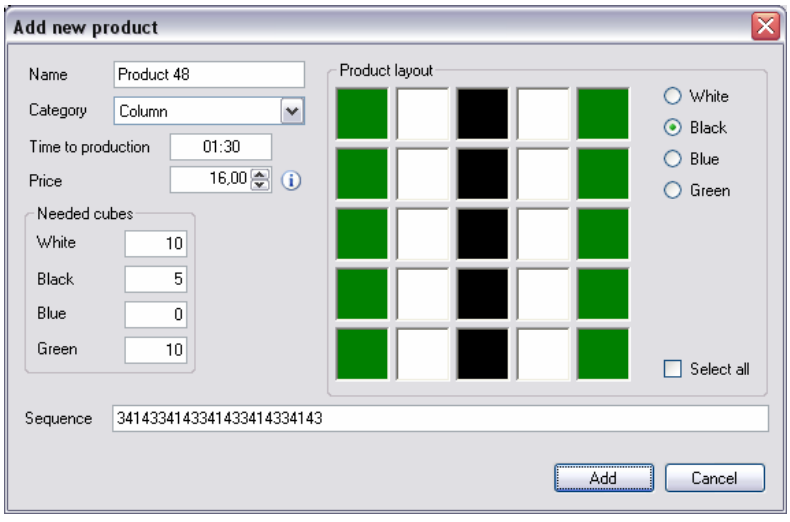

Figure 6: Addition of product into the portfolio

7 CONCLUSION

Utilization of Distributed Control System brings many advantages such as flexible hardware architecture, robust communication technologies among hardware components such as working and control stations, intelligent sensors and actuators, ability to manage alarms and abnormal events, integrated diagnostic functions, present and historical data administration, user-friendly graphical interfaces and safety providing that various access levels for users are set. Thanks to these features stands the DCS as the most appropiate way how to control the given model of the flexible production line used in teaching process where students will have an opportunity to acquaint themselves with various issues such as PLC programming, generation of SCADA/HMI applications, image recognition, database server administration, implementation of information systems and communication protocols in the object-focused programming languages and many others.

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