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VIRTUAL PLC REALIZATION IN ON-LINE LABORATORY

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ABSTRACT: In the article is mentioned the process of the development and implementation of the virtual programmable logic controller (PLC). The developed controller is the basic element of the virtual laboratory project realizing at the Institute of Applied Informatics, Automation and Mathematics. The project includes also the development of the communication dispatcher and the virtual processes. The virtual programmable logic controller is developed precisely according to the Siemens module LOGO!12/24 RC. All the functions, the graphical design and the control logic of the virtual PLC are identical with the real Siemens module. PLC stations with their networks are used to be the essential features by the distributed control system (DCS) in the practice. DCS is the perspective field of the industrial market – it's supported by the market exploration carried out by the Frost & Sullivan consulting company supposing the turnover with DCS in the world in amount of 8,5 mld. USD(in 2008).
KEYWORDS: distributed control system, Siemens, PLC, virtual laboratory, virtual controller

❖ INTRODUCTION

One part of the project of the on-line laboratory realization at the Institute of Applied Informatics, Automation and Mathematics is the virtual PLC implementation. Main goals of this project are the software design and implementation of the logical controller Siemens LOGO!12/24 RC, needful communication infrastructure and controlling virtual objects. LOGO!12/24 RC is a small programmable logic controller (PLC), which is able to manage industrial and technological processes which are many times specialized to tasks mostly logical. PLC stations and their networks present distributed control systems - systems of technical features with hierarchical structure which is built on the elementary properties like modularity, expansibility, logical control, robustness, redundancy or compatibility with the master control system. In the article are presented the theoretical basis, design, applied technologies and implementation of the software realization of the PLC.

❖ ON-LINE LABORATORY

Except the implementation of the logical controller in the project of the virtual laboratory are realized the communication dispatcher and the selected virtual processes.

Communication dispatcher is the universal software device which covers data changing between the virtual PLC and the virtual process. Virtual process is the client's application simulating real processes or object functionalities, receiving/sending the data through the communication dispatcher from/to the virtual programmable logic controller. With the appropriate reconnection of the particular interfaces (communication dispatcher, virtual PLC and virtual process) we are obtaining the possibility for the virtual workstation creating (fig. 1).

Figure 1. Virtual workstation

Virtual workstation presents the independent controlled system, which can be extended about another virtual PLC (e.g. if one controller cannot control all the virtual process and its states, inputs, outputs). Our virtual workstation can be characterized like the system of the controllers communicating with the connected virtual processes through the defined input/output interface and the communication dispatcher, which realize the data exchanging between both workstation's sides. Virtual laboratory (and its virtual workstations) is one of the forms how to expand the education in low-cost way to the all students or realize the e-learning form of the education.

❖ SIEMENS LOGO12/24 RC

Logo12/24 RC is the small relay module with the display and the integrated real-time watch. This type of the PLC in the practice is apposite to the controlling of the less arduous technological processes (small house applications – interior lights, mechanical devices - air conduction systems, hydraulic pumps, signal processing and reconnection with the communication modules for the distributed control).

The module LOGO 12/24 RC can substitute (Ždánsky, 2010):

- ☐ 16 timers,
- ☐ 24 counters
- ☐ 8 switch watches,
- ☐ 3 special counters,
- ☐ 42 pulse current relays,
- ☐ 42 RS circuits,
- ☐ functions for the analog signal processing and text reporting.

Control program can be developed directly in the PLC or in the special environment LogoSoft!Comfort, which has also integrated the simulation tool. For the students it is a good introduction to the control program developing and easy way how to learn the FBD or LAD language.

Figure 2. Logo 12/24 RC

❖ VIRTUAL PLC LOGO 12/24 RC REALIZATION

Logo realization is divided into 2 essential parts:

a) Graphical interface of the PLC – creating the virtual copy of the real Logo!12/24RC with same style of management and buttons. Control should be realized by mouse-clicking or defined keys on the keyboard. Text on the display and the letters should be changing and presenting in the same way like in the real PLC. Designing of the control logic - direct diagrams and algorithms designing in PLC - belong to this part of the project developing too.

b) Core of the virtual PLC – should contain definition of the control blocks (using by the control program developing) and procedures (e.g. using by the block initialization or reconnection). To this part of the development belong also: calculating of the input-output states on the basis of the control algorithm and supplying functions which are necessary for the connection with the graphical interface, virtual PLC cyclic realization and data changing with the other interfaces (e.g. dispatcher).

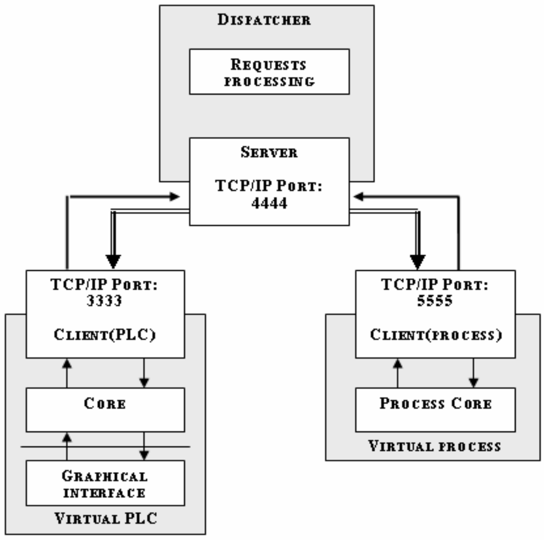
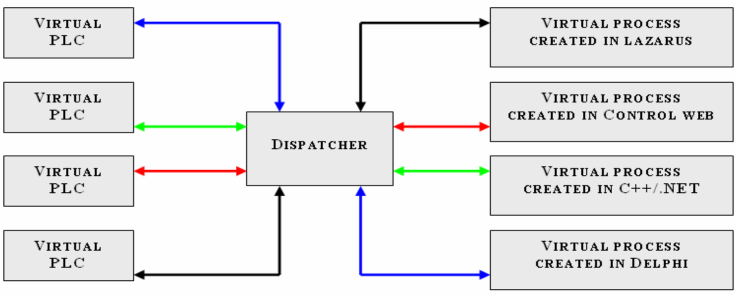


Figure 3. Workstation communication

The graphical interface and the core are developing separately to achieve the independent between the main control block execution and the graphical representation (Huraj, 2009). The communication dispatcher is developed fully independent from any software device, as from the virtual programmable logic controller, also as from the virtual object. All the communication is based on the classic Ethernet. Principle of the virtual workstation operation and its communication is showed in the figure 3.

For the implementation of the virtual PLC and communication dispatcher was determined Lazarus environment. This development tool meets the basic condition of the project realization – software and hardware independence. Contains many of the libraries, some of them were chosen for the project realization (e.g. synapse library – provides the functions and procedures covering the TPC/IP communication). This environment has integrated the facility of the Pascal language using and belongs to the class of the Rapid Application Development tools (Tanuška, 2010). Within the environment are not implemented the libraries which could be depending on the operation system or hardware elements.



NOTE: COLORS ARE INDICATING THE CONNECTION BETWEEN THE PROCESS AND PLC

Figure 4. Dispatcher and several connections between virtual applications

❖ GRAPHICAL INTERFACE

The graphical interface is designed and realized as the complex part of the virtual PLC. There are implemented functions needful for:

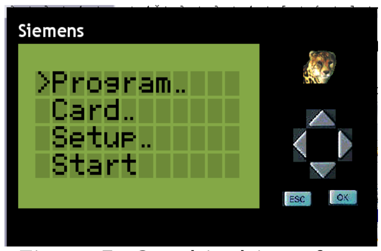


Figure 5. Graphical interface for the virtual LOGO

- visual display of the menu and text,
- movement in the menu with control buttons,
- state´s indication,
- direct design of the control program,
- blocks creation in the control algorithm,
- control program modification.

Display layout of the graphical interface is a combination of the 6 rows and 14 columns.

It's about 2 rows and 2 columns more than on the real Logo display – these parts of the display are serving only like the frames of the drawing area. Drawing area has 48 elements. Each of the elements is divided into the matrix 8x5 – it offers 40 points for drawing on each element. Letter representation is realizing by the lightning of the points.

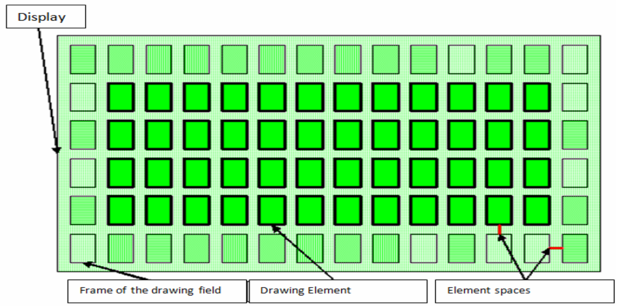


Figure 6. Graphical interface layout

Drawing is realizing by the 2-dimension array named abLetter. It is array of the binary values – true value of the each array element means highlighting of the point. Array indexes represent the coordinates of the drawing area.

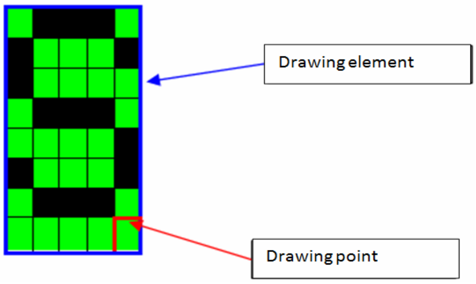


Figure 7. Letter S drawing

[0,0]= FALSE	[0,1]= TRUE	[0,2]= TRUE	[0,3]= TRUE	[0,4]= FALSE
[1,0]= TRUE	[1,1]= FALSE	[1,2]= FALSE	[1,3]= FALSE	[1,4]= TRUE
[2,0]= TRUE	[2,1]= FALSE	[2,2]= FALSE	[2,3]= FALSE	[2,4]= FALSE
[3,0]= FALSE	[3,1]= TRUE	[3,2]= TRUE	[3,3]= TRUE	[3,4]= FALSE
[4,0]= FALSE	[4,1]= FALSE	[4,2]= FALSE	[4,3]= FALSE	[4,4]= TRUE
[5,0]= TRUE	[5,1]= FALSE	[5,2]= FALSE	[5,3]= FALSE	[5,4]= TRUE
[6,0]= FALSE	[6,1]=TRUE	[6,2]= TRUE	[6,3]= TRUE	[6,4]= FALSE
[7,0]= FALSE	[7,1]= FALSE	[7,2]= FALSE	[7,3]= FALSE	[7,4]= FALSE

Figure 8 – Array representation of the letter S drawing

The graphical interface is realizing by the different images and the functions drawing needful signs and letters. The movement through the menu is tracking by the procedures. Depending on the selection in the menu or block type definition are calling different program routines.

CORE OF THE VIRTUAL PLC

The basis of the core realization is in the cyclic program executing which results from the control program stored into the PLC e.g. input values handling and calculating into the output values depending on the particular function blocks in the control program (logical blocks, timers, counters etc.). Each of the virtual logo block functions is represented with the self class containing the specific parameters and functions, which are used for the calculation of the input signals to the output signals. The subclasses for the function block are inherited from the main class called Tblok, which includes the characteristic signs and properties for the all function blocks, e.g. maximum count of the inputs variables definition for the I/O values and etc (table 1).

Table 1. Main class Tblock definition

Class name	TBlok	
Attributes	sLabel	Contains the name of the created block (napr. B1, B2, ...)
	sType	Contains the label of the block type (napr. And, Or, ...)
	abInput	Input array of the pointers referencing to the Boolean values
	aaInput	Input array of the pointers referencing to the integer values
	asInpLabel	String array with stored names of the inputs to the block
	abInpState	Flag array for the negation recognition
	bOutput	Value of the digital output from the block
	iOutput	Value of the analog output from the block
	iNumInp	Number of the block inputs
	Parameter	Defining the additional block parameters
Functions	Create(sMeno)	Procedure for the instance block creation
	Calculate	Procedure for the recalculation of the inputs to the outputs

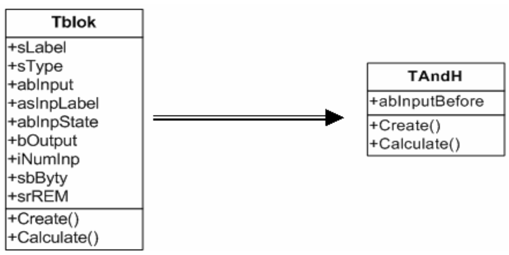


Figure 9. Main class "Tblok" and inherited class "TandH"

All other blocks are inherited from this class. Example of the main class and inherited class is showed in the figure 9.

The program execution is driven by the threads. One thread is proceeding the matrix with the stored program in the cycle. In the cycle is the function which is calling "Calculate" for determining the outputs of the particular blocks. Another thread is carrying about the exact time counting and for the timer's execution.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<program>
    <velkost_pola>3,2</velkost_pola>
    <output>
        <meno>Q1</meno>
        <InputLabel>B1</InputLabel>
    </output>
    <output>
        <meno>Q2</meno>
        <InputLabel>B4</InputLabel>
    </output>
    <marker>
        <meno>M1</meno>
        <InputLabel>B3</InputLabel>
    </marker>
    <blok>
        <position>0,0</position>
        <meno>B1</meno>
        <typbloku>And</typbloku>
        <InputLabel>B2</InputLabel>
        <InputLabel>M1</InputLabel>
    </blok>
```

Figure 10. Part of the saved control program in XML file

Virtual PLC has integrated the possibility of the control program or input-output states saving in the XML files with defined structure (fig. 10).

❖ CONCLUSIONS

Virtual PLC mentioned in the article is already implemented and now being tested and optimized. The implementation of the developing tool reconnection to the virtual PLC is preparing at this time, so the control program could be downloaded from the simulation tool LogoSoft Comfort directly to the virtual PLC.

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