Development of Three Didactical Laboratory Modules Based on Industrial SCADA Principles

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***Abstract* — This paper presents the design and implementation of three different didactic platforms, which are based on the SCADA systems principles and architecture.**

Principles from real industrial applications were put together in these modules in order to familiarize students with the domain and give them useful practical abilities. In this way, after they graduate, they will be able to faster integrate in the working field and meet more requirements an engineer should fulfill.

All three platforms have been implemented in a laboratory in Politehnica University of Bucharest.

Keywords—didactical platforms, SCADA systems, industrial systems for students

I. Introduction

SCADA (Supervisory Control And Data Acquisition) systems represent a very mature and well documented domain. All industrial automation systems are based on SCADA principles and this is why the applications are present in all industrial fields: factory automation, energy producing and distribution, water and wastewater facilities, building management systems, management of transportation systems, etc.

For this reason, knowledge in SCADA systems is mandatory for every student in automatics, electronics or electric engineering faculties.

This paper presents the implementation of three different didactic platforms, which are based on the SCADA systems principles and architecture, in order to familiarize students with the domain. The platforms have been implemented in a laboratory in the Faculty of Electronics, Telecommunications and Information Technology, in Politehnica University of Bucharest.

The implementation of these platforms is intended to strengthen the connection between the educational world and the economic/industrial market, in such way that the students can be a valuable asset for the organization in which they will work after graduation.

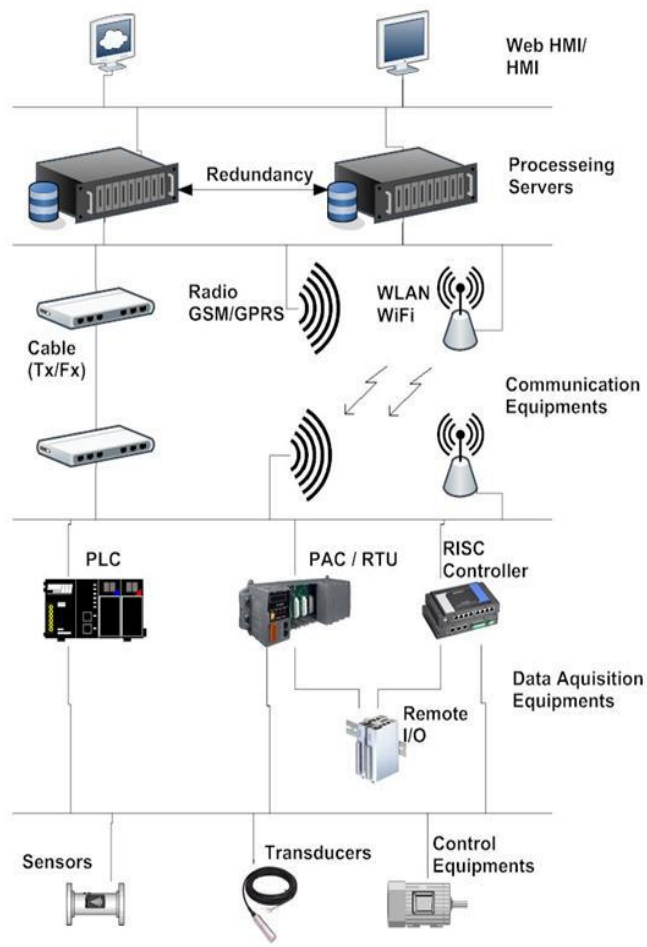

Fig. 1 - A Typical SCADA System Architecture [1]

II. Principles of a SCADA System

A typical SCADA system (Fig. 1) is a hierarchical system composed of: one or more Processing Servers with Human

Machine Interface (HMI), communication equipments, data acquisition equipments (DAQ) and finally sensors, transducers and control devices.

A. Servers and Software

Usually there is more than one server for the SCADA software. Also, for projects in which downtime is a big problem, a redundancy option must be implemented.

The HMI is the way operators interface the system. Depending on the type of the operator, the interface may vary from a simple LED indicator to wide, colored, animated touchscreens. Also the HMI can be local (in the plant) or remote (connected through the Internet). Another classification criteria is the authority of the user: a simple user, a user who can insert manual data or a user who can configure the server [1].

B. Communication Equipments

The SCADA servers must gather real-time data from the field. For this to happen a reliable and fast network is needed. The routing and switching equipments must be linked together in a redundant network (e.g. ring topology) with a small recovery time. Usually high capacity, core switches are used in the center of the system, near the servers and edge switches at the extremities, near the data acquisition equipments [1].

The communication between all kinds of devices is made using different industrial protocols like Profibus, Hart, CAN, Modbus, Profinet, Industrial Ethernet. The transmission environment may be cable (e.g. copper, fiber) or wireless (e.g. GSM, GPRS, HSDPA, WiFi) depending on the location of the devices. In order to create a unified network, equipments like media converters or gateways are needed [2] [3]. These devices make the connection between different transmission environments (media converters) or between different communication protocols (gateways).

C. Data Acquisition Equipments

Programmable Logic Controllers (PLCs) are the main devices used for acquiring data. With their modular construction and different interfaces, the PLCs have been used in industry for a long time. In recent years, other similar equipments like Programmable Automation Controllers (PAC) or Remote Terminal Units (RTU) have evolved. Together with remote I/O devices they made the SCADA systems more versatile and easy to deploy.

For interconnecting with the final devices (sensors, transducers, control equipments), the DAQ devices have different types of inputs and outputs: analog (voltage, current, RTD, thermocouple), digital (contacts, counters) or relay (power, FormA, FormB, FormC) [4].

D. Sensors, Transducers and Control Equipments

These kind of devices are specific to a certain application and are chosen with respect to the types and ranges of values that must be monitored and controlled.

Fig. 2 – Schematic of the Monitoring Platform

III. PRESENTATION OF THE THREE PLATFORMS

From the SCADA principles, a number of three didactical platforms were designed: (A) monitoring platform, (B) control platform, (C) monitoring and control platform.

Each of the platforms was designed with different type of equipments and software. In this way, the students are able to work and to get familiarized with a wide variety of solutions.

A. Monitoring Platform

The main objective of this module (represented in Fig. 2) is familiarizing the students with a SCADA software. For this reason, the hardware part was kept minimal.

The complete list of equipments (organized according to the first chapter of this paper and from right to left in Fig.2):

a) one computer with SCADA software installed;

b) USB to RS-485 serial converter;

c) one data acquisition module with digital inputs and digital outputs;

d) buttons (for inputs) and LEDs (for outputs), implemented together on a PCB.

In the practical part of the platform, the student must work with the software in order to:

- create a new project;
- configure the communication parameters with the hardware equipments;
- import the data from the hardware equipments;
- establish the connection with the database and set the parameters for the data to be stored;
- build a HMI.

This module is derived from the dispatch center type of applications, in which one or more operators are assigned to monitor the overall status of a process, of an installation, of a factory or of an electrical power park.

The accent here is put on the software which is installed on the computer and especially on the Human Machine Interface. The HMI must be designed in an efficient manner and to respect ergonomic principles, so that the operator will be able to spot immediately any problem [5].

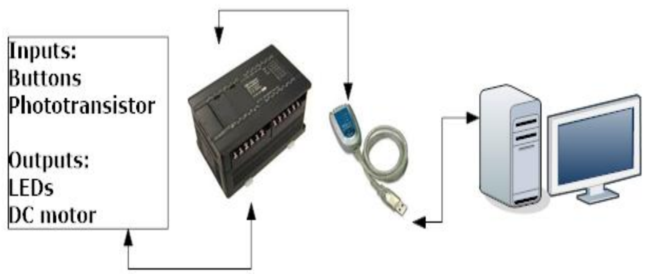

Fig. 3 – Schematic of the Control Platform

B. Control Platform

The main objective of this module (represented in Fig.3) is familiarizing the students with a PLC equipment. For this reason, the software part was kept minimal and is represented only by the programming tool of the PLC.

The complete list of equipments (organized according to the first chapter of this paper and from right to left in Fig.3):

a) one computer with software for programming the PLC (but with no more function into the system, once the programming has been done);

b) USB to RS-232 serial converter;

c) one PLC with digital inputs, digital outputs, analog inputs;

d) buttons and phototransistor (for inputs), LEDs and a DC motor (for outputs), implemented together on a PCB.

In the practical part of the platform, the student must:

- create a new project;
- configure the communication parameters with the hardware equipments;
- open an already made application, in order to analyze the structure;
- create a new application, based on the requirements received;
- upload the application on the PLC.

This module is useful for students because PLC equipments are used in almost every industrial application for controlling a process. They are used in factories (controlling the production lines), in water industry (controlling the running of pumps) or in production of complex equipments (industrial robots) [6].

Fig. 4 – Schematic of the Monitoring and Control Platform

The computer used in this platform is needed only for programming the PLC. After the application has been uploaded in the PLC, the PC can be disconnected from the PLC, with the latter running the application independently.

The programming is made with specific software, which respects the IEC 61131-3 standard. The platform uses the most common programming language: Ladder diagram [7].

C. Monitoring and Control Platform

The main objective of this module (represented below in Fig.4) is creating a complete system (monitoring and control). Also, if the previous two modules had industrial applications, this one is more suited for building management systems.

The complete list of equipments (organized according to the first chapter of this paper and from right to left in Fig.4):

a) one computer with software for programming the controller (but with no more function into the system, once the programming has been done);

b) no communication equipments (the controller communicates directly with the computer and with the data acquisition module);

c) one controller with touchscreen and one data acquisition module with digital inputs, digital outputs, analog inputs;

d) temperature sensors (for inputs) and LEDs (for outputs), implemented together on a PCB.

In the practical part of the platform, the student must:

- create a new project;
- configure the communication parameters with the hardware equipments;
- create the HMI screens;
- implement the logic for the controller;

– upload the application on the controller.

The use of a touchscreen controller makes the application suitable for industrial control cabinets or for building management systems. By using temperature sensors and by creating an appropriate operator interface, this platform has been used as an example for a home automation system.

The computer used in this platform is needed only for programming the controller. The programming has two parts: the controller logic (similar to the PLC programming) and the HMI interface for the operator. In this way this platform combines the functions of the two previous ones.

IV. Conclusions

These platforms were designed with the purpose of creating didactical modules from real industrial applications. In this way, the students can be familiarized with the principles of industrial systems and also with real equipments.

The final purpose of implementing this type of platforms in a laboratory is preparing students for their careers in automation and electronics fields.

The three types of platforms have been implemented for a laboratory at a master program in the Faculty of Electronics, Telecommunications and Information Technology, in Politehnica University of Bucharest. They are used each year by approximately 25 students.

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