EDUSCA (EDUCATIONAL SCADA): FEATURES AND APPLICATIONS

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Abstract: This paper presents EDUSCA, an EDUcational SCAda with OPC data access. EDUSCA was specially designed for automatic control education, research and operator training purposes. The developed system takes advantage of the facilities offered by the OPC communication architecture. The system allows the students to face real practical problems, could be used to train operators in plant supervision and also allows the implementation of research functionalities. Their main advantages of EDUSCA are: (i) it can be connected to any plant whenever it includes OPC communications; (ii) it is free of licenses, thus it can be installed in many computers as necessary; (iii) it can be adapted to each application requirements and (iv) it allows the implementation of a diverse set of functionalities, as for example, control algorithms.

Keywords: SCADA, Supervisory Control, Process Control, Training, Control Education

1. INTRODUTION

Most educators agree that, in the design and development of educational tools, attention must be focused on learner requirements and characteristics, defined in terms of contents (what to learn) and of learning styles (how to learn) (Felder and Silverman, 1988; Larkin-Hein and Hein, 2001). These needs are best addressed by customized packages, developed for a specific subset of learners, or even for each individual learner. On the other hand, producing such material with a good quality involves extensive authoring work, which, in turn, brings a high cost to the organizations (Corso *et al*, 2005).

A common problem in Automation and Process Control courses often arises at the practical stage. Students have to implement and test their control programs or other algorithms using specialized control devices which do not allow to have a complete perception of the real problem but some times also drastically reduces their motivation. To mitigate this problem, other tools could somewhat help by simulating the general behaviour of the process in the real industrial environment.

One of them is the use of SCADA (Supervisor Control And Data Adquisition) applications combined with simulated process or pilot plants. In these systems it is possible to create several situations that are commonly found in the process industry (Automatas, 2006).

Nowadays, SCADA systems are widespread used in the process industry in order to do the supervision and control of the processes. Thus, the use of this kind of tool in practical automatic control education can be very useful in order to achieve the familiarization with the configuration and handling of this kind of tool, and at the same time, to realize training in different monitored real or simulated processes.

Several commercial SCADA systems are nowadays available. However, in general they are not intended for educational or training purposes, so in most cases they are found inadequate. For the use in the educational and research area it is very important to have a complete control of the tool in order to have the possibility of make the desired changes on the system. For instance, when diverse control structure implementations have to be directly applied to a particular plant, it is necessary to have the source

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code of the tool. For this purposes the licenses of these commercials tools are required, that is an important limitation in education and research activities.

Thus, the creation of special tools like the educational SCADA presented in this paper intends to minimize the main drawbacks of classical tools used for test in educational environments and at the same time avoids the economical and operational difficulties associated to the use of a commercial tool.

This paper describes EDUSCA (EDUcational SCAda), designed and implemented at the Universities of Valladolid (Spain) and Santa Catarina (Brazil) and used on a set of assignments for undergraduate courses in automatic control. EDUSCA has been developed using Visual C++, it is configurable and allows OPC data access.

At the laboratory EDUSCA is connected to several industrial type pilot plants to give students the opportunity to solve control problems and integrate theoretical knowledge obtained at lectures with practical experience. The practical problems are elaborated trying to reproduce, as closely as possible, the typical real-world process control situations, where judging the effect of a parameter variation may take minutes or where any measurement is affected by noise.

During the course of undergraduate education in automatic control at the Universities of Valladolid and Santa Catarina the laboratory activity starts in the first semester and during the course several disciplines expose students to practical issues very early, an attitude that is consistent with many current education trends (EU 5^{Th} Framework Program, 2005). Disciplines like industrial networks, dynamical systems, industrial processes, instrumentation and process control use the EDUSCA linked to the pilot plants to illustrate several aspects in an integrated approach.

This paper is organized as follows. Sections 2 and 3 are dedicated to describe the principal aspects of the process control structure and the EDUSCA features. Section 4 describes some application cases in control education and training and finally section 5 gives the conclusions.

2. COMMUNICATIONS

The access to process data could be separated in different communication levels. A possible division of these levels is: device level, control and supervision level, and management and process optimization level (Fig. 1).

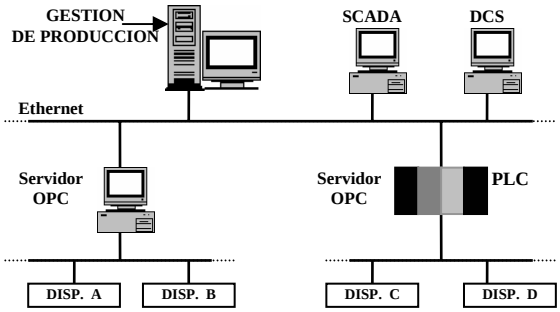

Fig. 1. Communications in an industrial environment.

The communications at field level between devices are located at the lowest level. Normally industrial field buses as Fieldbus, PROFIBUS, CAN/CANopen/DeviceNet, etc. are used at this level (Berge, 2001). These devices connected by field buses are accessed by distributed control systems (DCS) and/or by SCADA systems, which realize communications at a middle level. At a highest level the communications between the office programs, which realize the management and optimization of the production, are found.

Actually, it is possible to realize a uniform and standard access to the information of the different devices using OPC (OLE for Process Control) communications (OPC Foundation, 2006). OPC consists of a standard set of interfaces, properties and methods that can be used for device communication in process control and manufacturing applications (Iwainitz and Lance, 2002). OPC is based on Microsoft DCOM (Distributed Component Object Model) technology. It is managed by the OPC Foundation, supported by the majority of the companies that operate in the process control sector. Its main objective is providing a uniform access to data in industrial applications, in such a way that several clients can access the data managed by an OPC server through a Windows network. Because of these properties the proposed SCADA uses OPC as a standard for data access.

3. FEATURES OF EDUSCA

The main features of EDUSCA are:

- Data acquisition using OPC, that allows the connection to any real or simulated device that incorporates an OPC server. This acquisition can be configured for each data and the number of data to storage or the capturing frequency can be specified.
- Configurable graphic interface. Based on synoptics containing the process information.
- Data representation using graphs, diagram bars, tables, etc.

- Possibility of permanent data storage in tabulated text files or in databases.
- Alarm manager system with visual and acoustic warnings.
- Possibility of including perturbations in boundary variables, ramps, steps, white noise, etc.
- The SCADA can be used as instructor or operator console in personnel training.
- PID controllers.
- Uses Grafcet diagrams to make a discrete control of the system.
- New capabilities can be included.

3.1 Configurability

One of the main features of EDUSCA is the adaptability to almost all existing process. To do that in an easy way EDUSCA includes a tool that allows the configuration of the SCADA system in order to connect it to a real or simulated process.

Thus, a tool named *SetupEDUSCA* was developed to allow the system configuration through a menu and a screen series.

The following steps are required to create a configuration:

- Global: In this configuration the main files to be used are specified: Main synoptic, OPC server name to access. The Database name and locations, etc. (Fig. 3)

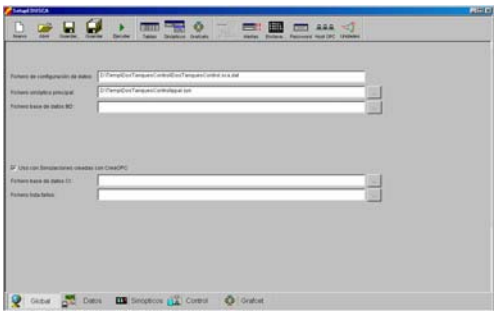

Fig. 3. Global configuration screen.

- Data: The data to be accessed are included here. These data can be of various types: Reading-Writing, supervision, controller, etc. For each one must be specified, the tag, description, representation limits, refresh time, link with the associated OPC variables, etc (Fig. 3).

- Synoptic: The configuration of the synoptic is realized using a bitmap as background and adding graphic controls (transmitters, bars, analog displays, gauges, etc.) associated with the variables previously configured (Fig. 4).

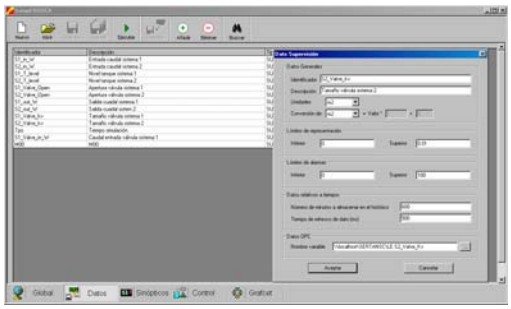

Fig. 3. Data configuration screen.

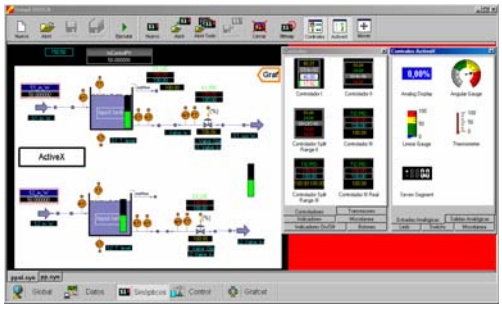

Fig. 4. Synoptic configuration screen.

- Control: In the current version is possible to add PID controllers. (Fig. 5).

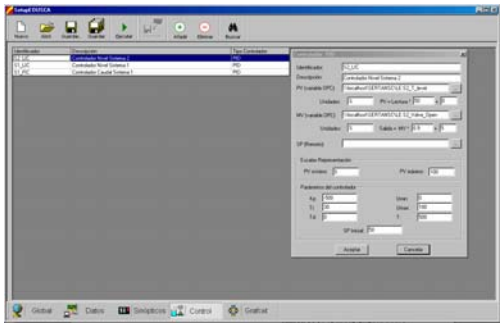

Fig.5. Control configuration screen.

- Grafcet: Includes Grafcet configuration in a visual way. (Fig. 6).

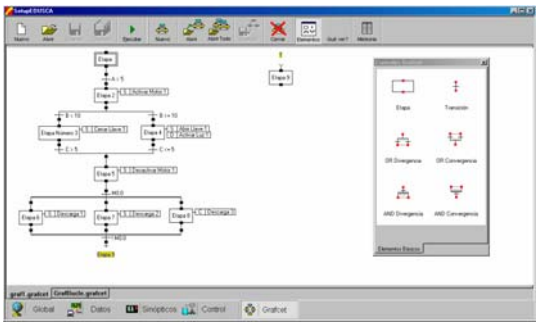

Fig. 6. Grafcet configuration screen.

3.2 Connectivity

One of the most desirable features of any data acquisition system is the capability to be connected to as much as possible devices. To achieve that, the OPC communications standard has been selected, that makes possible the connection of the SCADA with a lot of devices.

3.3 Supervision

The main usefulness of EDUSCA in real or simulated processes is the supervision. To achieve that a navigation system based in synoptic is used, with this system different process diagrams can be accessed. (Fig. 7).

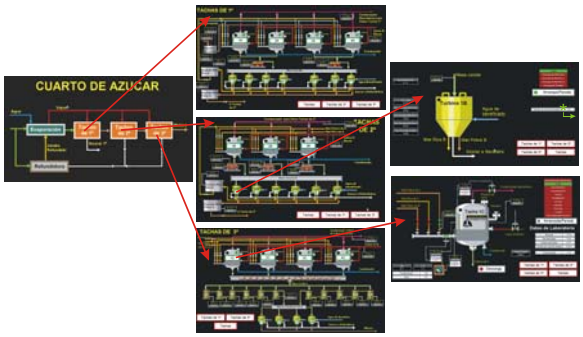

Fig. 7. Navigation through synoptics

In the diagrams there are different controls associated to the process variables showing its values. Pushing on them a graphic showing the time evolution of the selected variable is displayed. If a controller button is pushed a dialog is showed with the different parameters of the controller. (Fig. 8).

Fig. 8. Trend and bar diagrams.

3.4 Alarm management

When operating a real process is very important that the process variables and manipulated control variables are maintained within a desired range. If any variable goes beyond the allowed limits the process operator must be warned. To include these capabilities EDUSCA has an alarm manager component based on the configuration of the variable limits.

3.5 Data storage

Historic data storage is very important for *a posteriori* studio. Data storage in a Microsoft Access Database is possible in the developed system. These data can be also stored in a tab-delimited text format file.

3.6 Steps and perturbations automatization

In process supervision not only the visualization of the received information in different formats is important, but also it is essential to be able to change the value of some process variables (controller set points, on/off variables, input or boundary signals, etc) at a certain time. EDUSCA includes the possibility of introducing changes in the process modifiable variables. These changes can be steps, ramps, sinusoidal, random noise and programmed changes in time, both steps and smoothed in a ramp shape. This is made with a special control to configure and trigger these actions (Fig. 9).

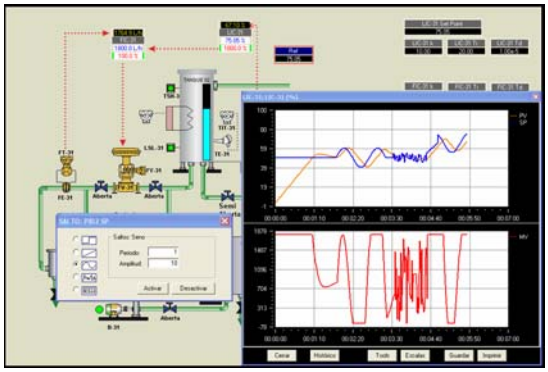

Fig. 9. Set point changes in a controller.

3.7 Instructor console

To use a SCADA system in a training simulator some specific capabilities are required depending if an operator or an instructor is accessing the system. The specific capabilities are related to the activation or deactivation or malfunctions in the process or changing the operating conditions of the simulated process in real time. In a set of graphic controls and failures lists the instructor can select, activate, modify or deactivate different malfunctions or modify operating conditions (Fig. 10). Additionally the instructor can pause, start and accelerate the simulation besides can save or restore the state of a training session.

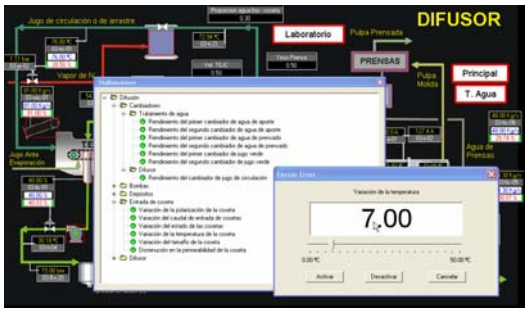

Fig. 10. Malfunction list and activation dialog.

3.8 Controllers

With this functionality it is possible to control the process using the SCADA system instead of the controllers installed locally. At the moment, only PID controllers are available, but in the future, it could be possible to develop another controller to be executed in the SCADA such as predictive controllers, etc.

3.9 Grafcet

When supervising or controlling a plant sometimes a series of actions depending on the state of some variables is needed, these actions must be executed in a predetermined order. In EDUSCA this task is made by configuring and executing Grafcet diagrams.

3.10 Extensibility

One of the main advantages of using a home made tool with these characteristics is the possibility of extending the functionalities as new necessities arises, new graphic controllers, data storage in other formats, etc. New control functionalities could be included to the system with relatively low work load.

4 APPLICATIONS CASES

EDUSCA can be connected to real and simulated plants allowing the supervision, the handling and adjustment of the different controllers, as well as the on-line control operation of the process across the PID controls and grafcet functionalities included.
Integrated with pilot plants at the laboratory allows it use in several educational activities of different disciplines. On the other hand, when connected to industrial simulators, gives a special flexible environment for operator training. Finally EDUSCA is an excellent tool to help in research activities, when for instance, new control algorithms have to be tested.

Next, some applications of EDUSCA to different cases in the laboratories of the Federal University of Santa Catarina and in The Center of Sugar Technology (CTA) of the University of Valladolid are described.

4.1 Educational applications

With the use of the developed tools it is possible to configure EDUSCA to realize the supervision of pilot plants. In these situations several aspects of the process control system are discussed in the experimental activities with the students.

Two main pilot plants are used at the Automation and Systems Department (DAS) of the Federal University of Santa Catarina (UFSC) for this purpose. Fig. 11 shows the use of EDUSCA in the level and temperature control in a set of tanks (Alves *et al*, 2004). This process has FIELBUS industrial instrumentation from SMAR and allows the students to analyze several real situations commonly found in practice, as saturations, noise, slow dynamics, time delays, etc. Thus, the process is used together with EDUSCA to illustrate concepts related to process identification, modeling, communications between devices and control design, among others. The complete system constitutes an excellent platform to integrate the different disciplines of the course in the problem oriented approach used at DAS-UFSC (Normey-Rico and Bruciapaglia, 2005).

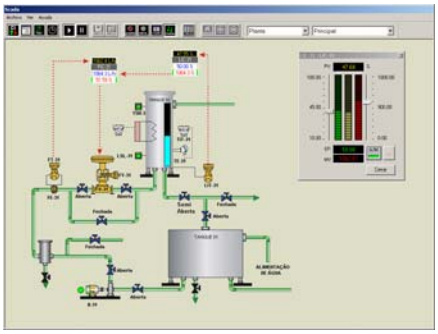

Fig. 11. Level and temperature pilot plant

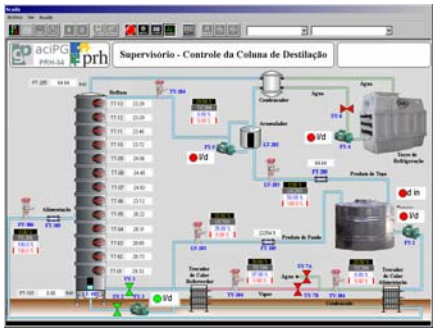

Fig. 12. Distillation column pilot plant.

Fig. 12 shows the application of EDUSCA to an experimental distillation column unit (Sacha, 2005)

used for research activities and for experimental works of the more advances disciplines, as multivariable control, predictive control and adaptive control. This unit is used also for the students in the Final Project of the Control and Automation Course.

4.2 Operator training

In industry the training of operators is a very important activity. In particular the training of the control room staff has nowadays an increasing importance because of the complexity of the installed control systems.

For this activity EDUSCA could be used as an operator console accessing via OPC to several simulations corresponding to the different parts of a factory. As the instructor can access to the simulations simultaneously to the operator, he (she) could realize modifications on the process in order to observe how the operators react. With these exercises is possible to train operators in anomalous situations that can happen in the real system using low cost systems.

The Center of Sugar Technology (CTA), (University of Valladolid - Azucarera Ebro Agrícolas, Spain), has been working with these technologies from several years with the objective of training the control room staff of the sugar industry. EDUSCA has been applied to a training simulator in several situations (Acebes et al., 2003, 2004).

4.3. Research activities

Finally, the easy access to the variables of the devices via OPC allows the fast application in practice of control algorithms, the implantation of supervisor control, etc. EDUSCA is being used in the development of several control strategies, principally Model Based Predictive Controllers, to be applied to the experimental distillation column unit.

4. CONCLUSIONS

This article has presented the main qualities of EDUSCA and the importance of its use in education, training and research. On of the most important qualities of the developed SCADA is its flexibility, that allows the adaptation to many situations. When integrated with pilot plants it gives an excellent platform to develop practical educational activities oriented to the integration of concepts in Automatic Control. Used together with industrial process simulators it also allows a low cost flexible training tool.

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