Challenges and Software Aspects in Engineering Education

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Abstract: This paper deals with new approaches to teaching the subject Process Systems for the students of the Mechanical Engineering Faculty. The technical aspects of introducing virtual PCs into engineering education, application virtualization and portable application design are described. The possibilities for a Remote Desktop Connection to professionally administrated servers with full installations of applications are mentioned. Constraints with licensing policies, which are using software license files combined with hardware dongles for using professional software while teaching students in computer labs at the university, are discussed. Examples of teaching material for the subject Process Systems for full time, as well as part time students in an e-learning environment are shown and issues on secured access to the material are dealt with.

Keywords: process, system, students, software, virtual PC

1. Introduction

Modern control systems in the process industry collect enormous amount of data, which are being used by more and more users at different levels of production or system administration. Some of these users need effective means, methods and tools that are easy to operate, upgrade and maintain in order to monitor and control processes. Others do not require process data continuously, from a non-stop operation, but are daily, weekly or monthly interested in data summaries, production results, product quality, and production history. These users only need simple interfaces to access, inspect and analyze data, such as internet browsers. The internet has changed its environment into an interactive and graphically very powerful tool, which is now closer to visualization systems as the human - machine interaction software is, and is able to bring online and real time data to the end users. Students of Mechanical Engineering Faculty study fields in Design
and Process Engineering (Transport Equipment and Material Handling, Hydraulics and Pneumatics, Design of Machines and Equipment, Machines for Mining and Treating Commercial Raw Materials, Technical Diagnostics, Repairs and Maintenance, Production Machines and Equipment, Earth Moving and Building Machines), or Production Systems with Industrial Robots and Manipulators, Thermal Energy Equipment and Industrial Energetic, Alternative Energy and Environmental Technology and many others. These fields, however, also depend on information technologies applied to different industries; therefore the Process Systems course was designed and introduced into the Master studies, both full-time and part-time students.

2. Description of the Process Systems course

The Process Systems course is taught to students of the Faculty of Mechanical Engineering of the VŠB Technical University Ostrava with the main objective to introduce them to emerging technologies and applied computer science used as the main tools in process industries. At the present time, there are 250 students studying this course. Such a large number of students need to be aided with access to computer labs in smaller teams, 10 to 15 students, supervised and provided with good teaching sources and easily accessible materials regarding lecture topics and prepared lab exercises. The lectures are given by professors and associate professors, who lecture in different domains of process systems, and are experts in the area of creating the main framework for this course. The lab exercises are supervised exclusively in the labs of the Control Systems and Instrumentation Department aided by tools and equipment for Supervisory Control and Data Acquisition Systems – Human Machine Interface (SCADA/HMI).

2.1 The content of the Process System course

The area of process systems itself is so wide that it could complete the whole study field of engineering education, not just a course for 14 weeks of one semester. Therefore, it was necessary to suit all its parts together and get students interested in an attractive form of lectures and practical demonstrations using industrial automation tools, but not making it too difficult to discourage them by the enormous amount of knowledge concentrated into it.

These were the main topics, which built the course framework:

- Principals and properties of process systems. Main characteristics and methods for project supervision and process system operation under production-technological process conditions.
Techniques and tools for process systems implementation (computer-communication-systems and networks, process automation, extensive computer systems—clusters etc.)

Software tools for design and operation of process systems: professional software for Supervisory Control and Data Acquisition systems with a Human-Machine Interface (SCADA/HMI), software support for communication and web technologies and examples of their implementation.

Information systems and process modeling.

2.2 Computer labs, software tools and equipment used

It is challenging to teach a wide spectrum of computer science subjects in a single computer lab. The extent of education can be significantly limited by computer lab capacities and it can be quite difficult to provide students in a class with administrator rights to a system.

2.2.1 Virtual PCs in engineering education

A virtual PC (VPC) is a virtualization suitable for MS Windows operating system.

Figure 1. Running multiple operating systems on one physical computer using several virtual PCs at once
The principle of virtual PC technology is to emulate the complete PC hardware inside of a common Windows program. The result is that we can run the emulated PC on a real PC. We can even run several virtual PCs at once, on one real PC. Recently, we have upgraded the department’s computer lab with modern virtual PC technology, which has many advantages and removes some constraints in education.

We use virtual PC technology to:

- Run multiple operating systems on one physical computer,
- Run an application from a removable drive (USB drives) saved within a portable virtual machine hard disk, also described in Chapter 2.2.2,
- Connect to the virtual server as a client by a remote desktop connection from another PC, also described in Chapter 2.2.3,
- Eliminate hard drive partitioning,
- Easily supplement the entire computer lab with a new operating system that only copies files,
- Boot and restart a virtual machine much faster than with a physical machine, since it may be possible to skip tasks such as hardware initialization.

The main advantage is that students have administration rights over their development environments and can make any changes on a virtual computer during the course. Otherwise, they would be constrained by the user rights assigned to the student domain.

Figure 2. An example of student project design for process system application
After each lesson the virtual computers stay in the previously set state, and therefore are ready for the following lesson.

But there is another important issue which affects us during teaching. If we want to maintain an application, which was previously prepared and finished during a project, and keep it running in the previously used operating system, the virtual PC allows it, although our computer lab is continuously being upgraded with the newest versions of operating systems. The reason for using virtual machines here is that our applications may not be smoothly running in the newly installed operating systems, until we also receive an upgrade, a service pack or a patch for the process systems software from its distributor, as we experienced before, with newly introduced operating systems such as Windows Vista.

### 2.2.2 Application virtualization and portable applications

In computing, virtualization is a broad term that refers to the abstraction of computer resources. The original sense of the term virtualization, dating from the 1960s, is in the creation of a virtual machine using a combination of hardware and software, called platform virtualization. The terms virtualization and virtual machine have both also acquired additional meanings through the years.

There are several approaches to platform virtualization based on how complete a hardware simulation is implemented. One approach is the application virtualization running a desktop or server application locally, using local resources, within an appropriate virtual machine; this is in contrast with running the application as conventional local software, i.e. software that has been 'installed' in the system. A virtualization example can be a portable application.

The MS Windows platform is well-known for the creation of portable applications, needed for example when running an application from a removable drive (USB drives), without installing it on the system's main disk drive.

The MS VHD file format specifies a virtual machine hard disk that can reside on a native host file system encapsulated within a single file. The format is used by the virtual PC and the virtual server. The VHD format is broadly applicable, because it is agnostic to the virtualization technology, host operating system, or guest operating system with which it is used.

Virtual hard disks (VHDs) are flexible; they can be created in, added to and removed from a virtual machine (VM) quickly and easily. Virtual hard disks can be moved and copied between virtual machines (assuming the VMs are turned off), which is advantageous for our students working out their projects, assigned diploma thesis and communicating with their supervisors while consulting the work. For example, a task demonstrated during lab work is the visualization and monitoring of a technological process using supervisory control and a data acquisition/human machine interface (SCADA/HMI) software for monitoring downtimes and calculating total equipment efficiency in an operator environment in this system configuration:

- Microsoft Windows 2003 Server SP1
- Microsoft SQL Server 2000
As we can see, the system consists of several installed modules. This project was done on a virtual PC and saved on a virtual machine hard drive, which makes the work a portable application. A very important issue is the licensing of the software. This portable application arrangement makes it easier to carry all the licensed modules together with the license files ready for demonstration and presentation in different laboratories or offices.

On the other hand, we must admit that some problems occur from time to time. Another task, carried out by a student, required a sound card necessary for the design of an alarm system communicating with its operator. This was not enabled by the virtual PC residing in the PC, although the sound card was physically installed in a real PC. Therefore, in this case, the designed alarm system cannot be installed, configured, and presented to students with the virtual PC technology.

2.2.3 Using remote desktop connection
Remote Desktop refers to a method to remotely control or login to a desktop via a network connection.

Figure 2. Connecting to a computer with its IP address and its logging dialogue
Based on the Remote Desktop Protocol (RDP), Microsoft used Terminal Services in Windows XP to allow someone to assist the user (Remote Assistance) and to allow a user to take control of his/her computer remotely (Remote Desktop). Microsoft also provides the client software Remote Desktop Connection (formerly called Terminal Services Client) that allows a user to connect to a server running Terminal Services. With our students we combined the advantages of a Remote Desktop Connection with the advantages of virtual PC Server.

Since the faculty server performance is not unlimited and sometimes the access time to it is longer than needed and running application is delayed due to the Local Area Network (LAN) overload, distributed applications, which we have been designed for the process systems are located on the Microsoft Virtual PC (VPC). For one of the demonstration applications three virtual computers were created in this environment to build the process system architecture and our students PC’s workstations are accessing the process system via Remote Desktop Connection as “thin” clients using web browsers. This Service Oriented Architecture (SOA) based system, which we achieved with the help of virtual PC, represents a system solution often used in process industries:

- Industrial Application Server – is the first virtual PC with operation system Windows 2000 Server installed. This computer works with the same settings as the faculty server and serves as a server with a configurable database and running business logic.
- Industrial Application Client – with Windows 2000 Server operation system installed is the second virtual PC, which serves as the node of an Industrial Application Server. For real-time models and equipment connected to our process system software this is the computer, which communicates with real time inputs and outputs. This virtual PC maintains parts of process system applications and speeds up the system (relieves the main load from Industrial Application Server).
- Visualization client – third virtual PC with Windows XP operation system installed. This computer serves only as a data provider and visualization interface for process systems operators and for Industrial Application Server.

3. Study Materials

Teaching texts, tasks, schedules for each week, and other information and materials regarding the Process System course were concentrated into Moodle environment. Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment, which is used for other courses taught at our Faculty as well. The materials are available on-line from the e-learning server for the Faculty of Mechanical Engineering. The course structure is divided by the weeks of the study term. Materials for each week consist of lecture presentations and demo examples for lab exercises.
Figure 3. Web page with e-learning materials

These materials are available for the entire time of the study term to all full-time and part-time students registered in this course. The e-learning server also provides us with administration tools for reviewing student results and enables teachers to test students remotely by a randomly generated set of prepared testing questions.

3.1 E-learning module home page

The seven arrows shown in the figure below point to materials with seven opened source windows with study materials from the area of monitoring process systems, modeling process systems, but also hierarchically lower levels of control systems...
connected to a direct control of industrial resources. There are 14 weeks prepared on this web page for the entire study term, when students scroll the page down.

Figure 2. E-learning page for the course Process Systems divided into weeks

### 3.2 Students examining

The final exam concept was designed according to other certified software courses, where each question has five options and only one of them is the correct answer. A test designed in this way can be passed only by a student well prepared for the exam. Even though the test is designed in question-answer concept, our students are examined from a wide scale of topics and questions are theoretical as well as practical, based on computation and pre-requisites of use experience from lectures and lab exercises. Each variant is generated evenly from all Process Systems course topics and each examination is original. So, in this way we are able to ensure an objective evaluation of more than 250 students within a short examination period.

### 4. Conclusion

Very good contacts of the staff of the Department with industrial companies and system integrators help our students in education and learning good practices
within the new trends in process systems and MES (Manufacturing Execution
Systems). Projects are completed in the area of process systems, their monitoring,
visualization and data acquisition with student participation. Diploma works are assigned and worked out using modern technology and data
processing, as well as the latest knowledge in the area of process system
architecture.

There is a continuous effort to continue in this work and develop education, the
possibilities of teaching integrated software products for industrial automation,
creating conditions for students’ work on concrete modeled tasks, on which they
can demonstrate simple principles of the control of technological systems, as well
as more complex projects.

Successful projects which implement virtual labs into teaching by using thin
client configurations over the internet browser with web and application servers
show the interest of students and ways of improving the educational process in
engineering faculties.

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