E-Learning Environment of Building Automation

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***Abstract* - Automation systems offer many possibilities when developing safety and energy efficiency related to resident housing. Automation has been most widely used in public buildings but the use of these systems is constantly generalizing in residential housing. Teaching of building automation is not very common today. In HAMK University of Applied Sciences the degree program in automation and research center AutoMaint are specialized in process- and material handling automation as well as in remote control- and diagnostics applications related to industrial business service. With the increase in the use of building automation more is invested also into developing teaching of building automation. A learning environment for building automation has been created, which can also be used as a web-based learning environment.**

Key Words- Automation, building, remote laboratory, softPLC..

ROLE OF E-LEARNING ENVIRONMENTS IN STUDYING AUTOMATION ENGINEERING IN CHANGING BUSINESS ENVIRONMET

Engineer education is met with many challenges today. Technological development is continually increasing. In many fields technology will become totally outdated in ten years. Development causes continuous needs to change content and tools of education. Teachers must follow cautiously follow trends and strengthen and renew their competences. As product processes become digital, this also causes considerable changes in working methods. Product life cycles shorten, but new products are launched on the market ever faster dew to digitalization. In manufacturing industries products are designed and built digitally in an internationally networked environment.

Traditional engineer education has spawned strongly product oriented technocrats. Today the shift has been more toward a solution based customer oriented model, where the product no more has such a central role, rather than how the customer's needs can be satisfied. More increasingly those needs can be satisfied also with service products. The general consensus in the educational facilities would better answer companies' personnel's' educational needs. Company training must be built and organized when very differing boundary conditions prevail, as when compared to traditional degree oriented education. Educational facilities must operate more flexibly in educational product markets and in some respect utilize the same flexibility degree oriented education.

In the development of educational contents and used methods educational facilities must stay alert, because educational environments are also under major change. A common-European degree system will lead to congruent degree requirements and create a common-European educational market, that which itself will not be closed. International applications in Finnish educational facilities are becoming more and more general, which is quite natural, because the final customers are themselves international operators. On the other hand competition in domestic educational markets is increasing as generations become smaller and as the population ages. Development of web-based learning environments opens up new possibilities in a changing environment. The development of technology enables, when looking at learning, the creation of pedagogically excellent interactive learning environments, which mimic actual operational environments and which can be used independent of time and place as a part of enhancing the student's professional growth.

In the education of automation practical exercises have had a significant role and the students are in most cases action oriented. How can these matters be taken into consideration when developing learning environments depending on new technologies? The goal is to answer these questions with interactive web-based learning environments for automation, which bring learning-by-doing familiar in practical exercises into online-learning. In many cases these environments are not used to replace work with real devices, systems and applications, but rather as dry running in order to facilitate transfer to practical exercises. Technological development also enables the safe use of work station based application over the internet.

The automation development center AutoMaint in HAMK University of Applied Sciences has developed learning environments related to engineer education in many ways. On the grounds of projects related to R&D-operations several devices and programs suitable for r&d-operations

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and teaching have been acquired to the center. Implementation of these has been possible through r&d-operations, but after that it has been possible to utilize them in teaching. Concurrently project operations have generated a good and up-to-date equipment- and program base to the center. AutoMaint's assistants during their work placement periods have further developed learning environments as well as develop teaching and educational materials related to these environments. It should be noticed that this infrastructure is utilized in all of the center's operations, thus also in training directly targeted toward companies in addition to degree oriented education. Perhaps AutoMaint has even a more significant role in developing web-based learning environments; virtual processes, interactive animations and remote laboratories. Virtual and remote laboratories have been developed in several universities during last years [1-6]. Virtual laboratories have many advantages; use of simulators allows students to perform greater number of experiments in shorter time [2] and computer simulations has also proven a valuable tool for better understanding of new technologies [3]. If remotely used laboratories allow multiple access to same instrument, that could be useful also for traditional learning in which expensive instruments can be accessed by all students [4]. Remotely used laboratories can also be built and used internationally by students of different universities [5]. It is also noticed that students response improves with increasing sophistication of the GUI of remote lab installation [6].

Production systems remote control- and diagnostics has a central role in AutoMaint's field of research. This has created a technological foundation for developing interactive web-based learning environments for production automation. So it has been noticed that the same technological competence needed in research operations can be utilized in developing learning environments. A building automation learning environment has been developed in this project, which can also be used as a web-based learning environment.

TEACHING OF BUILDING AUTOMATION

In Finland Teaching of building automation is quite rare in universities. Professionals are educated to the field, but mainly from automation- and electrician programs. System design is being taught in some amount in electric- and automation engineering programs, but even within those programs rarely can an entire subject orientation be found. Traditionally building automation systems have been quite closed and specialized to the control and monitoring of a certain sector. Stand-alone systems have been built for access control, fire safety, heating and air conditioning. Perhaps the detached nature of the systems has caused that the subject cannot be placed under any existing engineer education.

When inspecting building automation application as comprehensively, it can be seen as a congruent automation system. The development of system integration and the increased use of pc-based industrial control include the sector more clearly into area of automation applications, which can be an automation engineer's specialization area. A comprehensive study block can easily be built within this subject matter, where the various sectors of building automation are reviewed and a summarizing final project is conducted, where an overall system is executed, which includes before mentioned elements.

PC-BASED CONTROL IN BUILDING AUTOMATION

Building automation systems have been specialized; independent systems can be found for access control, security, temperature and air conditioning control as well as for the control of some operational equipment (lights, curtains, blinds, etc.). In public buildings some functions have been taken into consideration already in the building faze, but especially in residential houses systems have been installed afterwards. System differentiation can have bad effects on usability and system integration has been difficult. In many cases the independent systems have been built with controls, which have programs that are difficult to change and which don't offer standard interfaces for integration. In many incidents the system user interfaces are fairly limited small liquid crystal displays, which have bad usability. PC-based industrial automation, field busses and especially Ethernet as well as WLAN and the use of browser technology offer many opportunities also in developing building automation applications. Controls designed for industrial automation are excellently suited also for building automation, enabling implementation of various functions under the same control. The use of PC- based controls also makes possible the use of illustrative graphic displays enhancing usability. The user interface can be applied over the building's internal network or over the internet via a secure connection. Since the PC control system is freely programmable, it is possible to implement almost any functionality. If the room layout changes, the building control system quickly adapts to the modified requirements: Modified functions don‘t have to be rewired, but can be reconfigured conveniently via software.

LEARNING ENVIRONMENT OF BUILDING AUTOMATION

The installation consists of a factory miniature model, where is a factory hall and offices. There are models of industrial processes in the hall, which can be used remotely. The building automation application is done by SoftPLC. The system includes functions for access control and security, heating and cooling as well as air-conditioning controls for energy economy and centralized controls for example lights and electricity output for rooms. The factory user interface is browser based utilizing 3D- graphics. The project is related to many of AutoMaint's research projects. By this the goal is to present the opportunities of interactive web-based learning environments in the teaching of automation. On the basis of this an international research project is in preparation. Exchange students from many countries have taken part in the planning and building of this system, and in fact the system will be in the use of many international partners.

TECHNICAL EXECUTION OF THE LEARNING ENVRIONEMNT

Exercises related to contact teaching of building automation as well as web-based learning in the subject can be conducted using the learning environment. In practical exercise work (hand on practices) the building automation system can be programmed to function according to predetermined specifications. Adding new measurable variables or observable processes can be related to these exercises as a part of the system or the addition of new functions. The automation system has room for future extension when considering new functions. In practical exercises the processes in the miniature factory can be programmed as well as cooperation between the production processes and building automation system developed. The installation enables production facility monitoring, control related to heating and air conditioning based on the condition of each production process. This enables fast reactions to changes in the production processes by controlling the environmental conditions to desired directions. Figure 1 demonstrates the installation's control hierarchy.

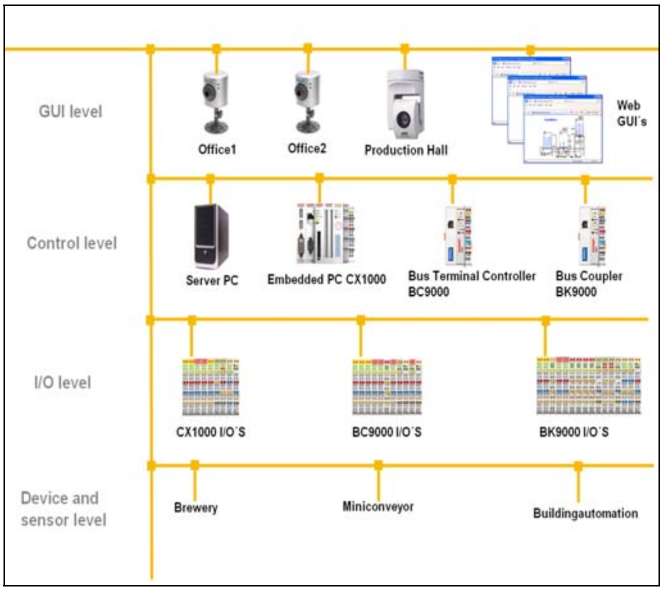

FIGURE 1
CONTROL HIERARCHY OF LEARNING ENVIRONMENT

The processes in the miniature factory and the building automation system are controlled by TwinCat softPLC. Control for the brewery process in the factory is executed using an imbedded PC-driver, to which the controlled operational devices and sensors are connected. The program for the miniature conveyer system has been loaded into an intelligent bus terminal, to which the system's I/O: s have been connected. The control for the building automation system uses a separate PC, which also functions as a server. There is a web-camera in every room of the building. The web-cam in the factory hall is controllable via the internet; the camera can be panned and zoomed. The processes and building automation system each have their own web-based user-interface. All of the i/o:s and controls are in an Ethernet-network and the factory has a wireless network, so the systems can be modified via wireless access.

REMOTE USE OF THE LEARNING ENVIRONMENT

The learning environment can be used in building automation web-based teaching. Various web-based learning exercises have been planned for web teaching, where parameter changes are made into the system control in order to achieve a predetermined state. In this case the student is allowed limited access to controls related to the installation. These kinds of parameter changes are executed using a data broker, where only limited data exchange is permitted between the user interface and automation system. A product under development is utilized in the solution. The operational principals of this product are presented in Figure 2.

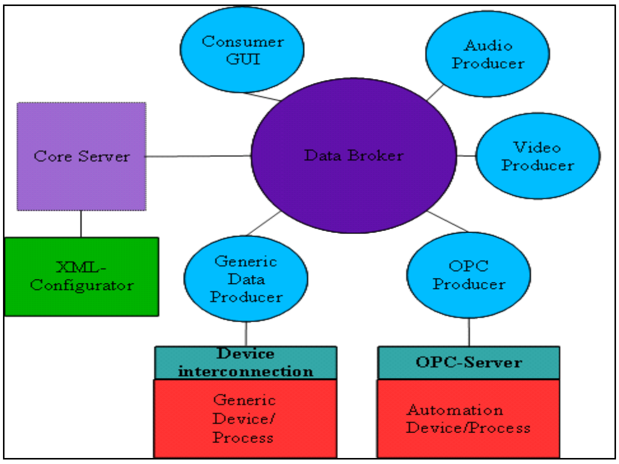

FIGURE 2
DATA TRANSFER BETWEEN DATA PRODUCERS AND CONSUMERS

The system is based on a data broker, which transfers messages between information producers and consumers using web service –technology. Both the building automation system as well as the facility's production process functions as information producers, whose condition information can be transferred forward. Web-based user-interfaces use condition info and present them to students and relay the parameter changes sent via the user interface through the data broker to the automation systems. Also audio- and video information can be handled in the same fashion. A tool is in development for the integration platform, with which new data procedures and consumers can be configured as well as manage all data brokers found in the network.

Also more extensive exercises can be conducted remotely in the installation. In theory the previously mentioned hands on exercises can be preformed in remote control. In this case the PC related to the system is connected to remote control in accordance with the virtual class room concept. Figure 3 illustrates the operational principal of the virtual class room.

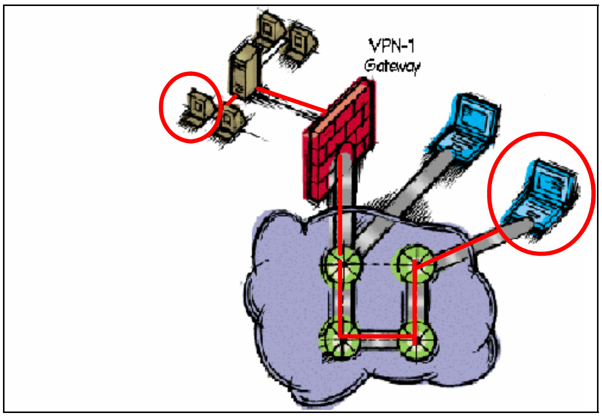

FIGURE 3
VIRTUAL CLASS CONSEPT OFFERS SECURE CONNECTION TO USE PROFESSIONAL APPLICATIONS REMOTELY

REMOTE USE OF PROFESSIONAL APPLICATIONS

The virtual class room concept enables information safe remote use between a terminal and its application. A web-based reservation system is connected to the system, which enables the reservation of a certain terminal along with its applications for determined point in time. This system supports the use of especially profession specific applications from home. In relation to the programming of the building automation system the work station includes a SoftPLC programming environment and from that connections to the control devices. In this installation the same PC functions also as control device running the softPLC-program. Concurrently through the installation the building automation system can be programmed as well as the program started. The functionality of the system can be monitored through the user-interface and web-cameras. Some matters of safety must be assured in this kind of use, in order to prevent the use of a program in remote control that would be harmful to the environment or people. In practice this danger is prevented with certain safety procedures, which are executed electro-mechanically and programmatically.

CONCLUSION AND FUTURE WORK

The developed installation is in a presentation- and testing phase. In the future the installation will be used for advanced studies in building automation and basic studies in automation. The installation is also supposed to function as an example application of remote-controllable laboratory. Previously built virtual models of the miniature factory production processes also support the learning environment. So despite being able to run these miniature processes remotely, there are virtual models of them, which can be run on a server independent of the actual processes. Also the control of the virtual models is done using softPLC. In practice the learning process could proceed so that, the student first uses virtual models while learning the operational principals of the systems and after this moves to practical exercises conducted through remote control and possibly after this onto more extensive hands on –exercises. In the future a virtual model of the building automation system will also be built, which can be used as illustrated before. For the presentation of the whole building a web-site, an animation and a video presentation will built. Interior decoration for the house is being designed by design-students, for them the house will be one reference.

Both AutoMaint's employees as well as foreign exchange students from several countries have been involved in building the developed installation. In the future the installation will be in wide use of foreign exchange students. On a yearly basis 15 to 20 exchange students from several countries work at AutoMaint on automation courses leading to degrees as well as on AutoMaint's various projects. The exchange student can familiarize him or herself to this learning environment through the system before hand and carry out some learning exercises already in their home country. During the exchange period some project of the student might relate to the further development of this installation.

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