Multi-functional Laboratory Demonstration System

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ABSTRACT: *Virtual laboratories are getting more common in teaching automation technology. They have some unchallenged benefits such as independency of time and place or safe learning environment. However real systems are still needed to give the students a general knowledge of the functions which can be achieved by real production lines. Aim of this study was to make a multifunctional learning environment for PLC-programming. In our solution the laboratories are a combination of a real production line and virtual models of the line. With this installation we can demonstrate in practice how different logical functions work. System can be used by teacher or by students. At contact lessons teacher can control system with wireless device and demonstrate different functions of PLC-program. At home students can use web-based interface, which is connected to real system. They can make changes to PLC-program and so study different timers, counters etc. Same time they can monitor real system on-line via web cam. The real system consist a conveyer system and automated warehouse (scale model) and SoftPLC controls it.*

We have developed a hot spot based system for controlling and analyzing a (laboratory) production line. The idea of such system is that the information that is offered to the end-user is filtered based on the user's location. The information can be data collected from the process or a remote controller of a certain part of the system. The main idea is that by using a singe mobile terminal (a handheld or laptop computer, mobile phone) a user can manage and monitor the equipment near him. With this solution the users can easily demonstrate and study the whole system with a single device. The technology behind all this is web technology which is used together with modern methods to locate the user. The technics we have used so far are bluetooth and wlan localization. Our laboratory contains several bluetooth access points and each one of them offers a localized html frontpage containing links to data adherent to the location. A parallel system has also been built based on wlan localization. In principle it makes no difference whether the device used as data terminal supports thee use of bluetooth or wlan. Of course, since the system is based on www-tehnology it can also be used by a standard network workstation by determining the location manually. The connection between the web server and the real production line uses OPC as a connection method. The monitored data is read from a sql database and can thus be stored also for further purposes.

1 SYSTEM ARCHITECTURE

To be able to control a process – true or virtual – one has to have a tool for that. Previously automation systems were based on using products from same product 'family'. To be sure that the SCADA application was able to control the PLC's the SCADA application and the PLC's had to be bought from the same manufacturer. There were no standard interfaces between PLC's and SCADA applications.

A more flexible way to connect processes to SCADA application is OPC (OLE for Process Control). OPC was designed to bridge Windows based applications and process control hardware and software applications. The purpose of OPC is to define a common interface that is written once and then reused by any SCADA, HMI or custom software packages. OPC is not the only standard used in process automation, but in Windows based SCADA is has a very remarking role at the moment.

Creating hot-spot systems indoors has to be based on either WLAN positioning or Bluetooth since GPS positioning works reliably only outdoors. Also using infrared was marked off due to its vulnerability to physical obstacles.

WLAN positioning is usually based on storing received signal strength intensity (RSSI) samples. When at least three WLAN access points are available, it is possible to create a 'RSSI-map', which then can be utilized in positioning.
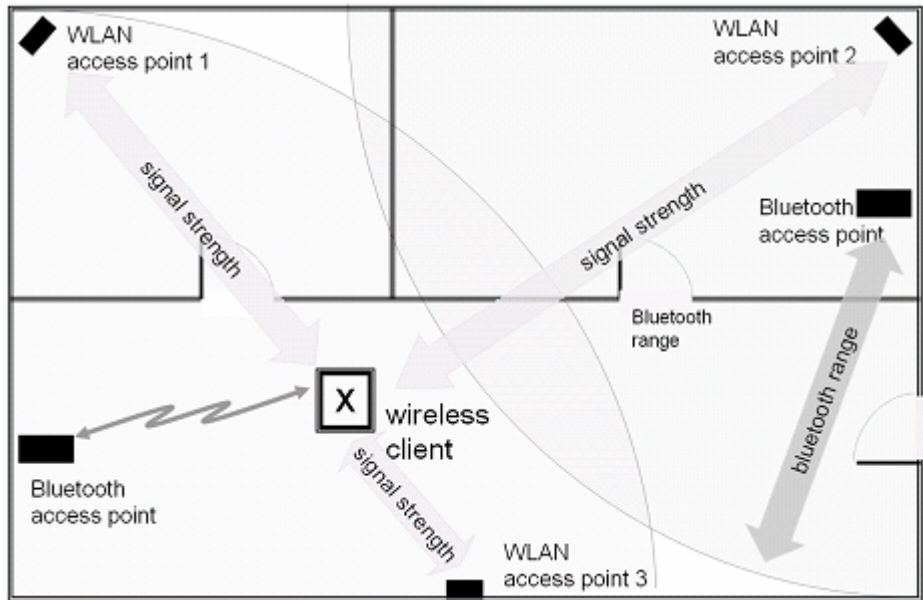

Figure 1 – Two parallel systems used for localization.

In our installation bluetooth access points use Bluegiga © access servers. In addition to bluetooth the Linux-based access server contains lots of useful tools such as a web server, an ethernet connection and a bluetooth-tcp/ip gateway. In our solution all application data used in hot spots as well as the http-opc gateway is stored onto the main web server of the system. The bluetooth device is used as an html browser and each hot spot has its own unique http-request which causes the data from the main server to be filtered differently for each hot spot. Therefore the hot spots only show data and applications adherent to their location. The principle of the system is explained in figure 2.
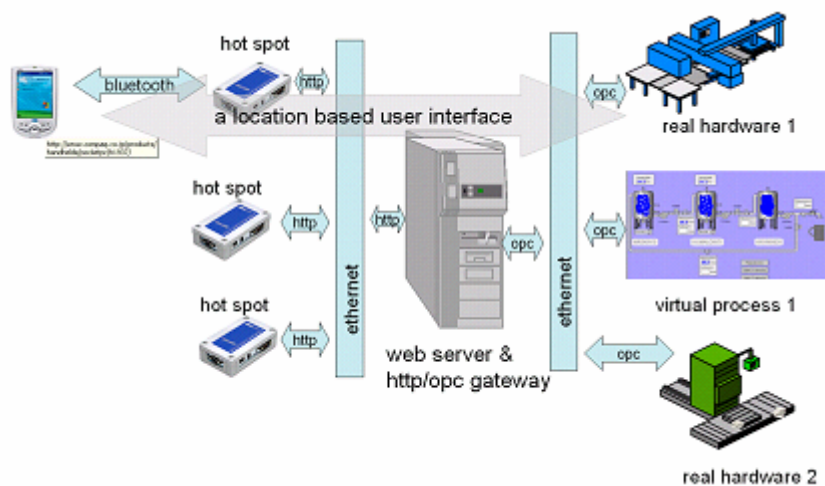

Figure 2 – Bluetooth hot spots used in a virtual laboratory.

2   AVAILABLE SCALE MODELS

In this installation we used three different automation systems, which are scale models of real systems. Major device was a scale model of conveyer system. System consists 2-level conveyer system and 2 pallet elevators. Position of pallets is controlled with 10 sensors. The other devices were scale model of automated warehouse and a scale model of brewery. All devices were controlled by TwinCat softPLC.

Figure 3 – Example system and user interface for PDA.

3   LEARNING PROCESS

Main teaching area of the automation study program is control systems of industrial automation. Because most automated material handling systems are PLC-controlled, PLC-programming is very important skill for automation engineers. Actually it is very important for automation engineer to know all categories of control systems (Supervisory Control and Data Acquisition, sequencing systems and closed loop systems) [Snyder 2003]. Course modules of material handling automation consist courses of PLC-programming, design of user interfaces using SCADA-softwares, remote controls and diagnostics of automation systems, automated data collection, robotics and integration of automation and information systems (e.g. with MES: Manufacturing Execution System, MIS: Maintenance Information System). In teaching we use very much real practices with real automation systems. Part of the lectures is carried out in computer class, where students can also use scale models of automated production systems. After computer class practices students can continue with more independent larger practices with real automation systems. Typical larger practice consist all elements mentioned above.

Virtual laboratory enables online control of laboratory experiment based on real hardware, which is taking place somewhere else in the world, anytime and in real time (Brunet, De Lafontaine, & Schilling 2003).With virtual laboratory installations we could improve students ability to continue with more independent practices with real automation systems. With this solution students can practice PLC-programming safely and learn how different functions and programming elements really work. Web-cam connection offers clear, straight visibility to system and system could be used independently from time or place. In Hame Polytechnic we have also used virtual processes where virtual automation process is running in our server with no connection to real system (Horelli, Väänänen 2003). Both technics have their own advantages. Virtual processes could be duplicated, so they offer same time connection for many users. Virtual laboratory installations do not offer this feature.

Learning by doing is an effective learning mechanism that is pertinent to laboratory courses. Through learning activities students can learn how system works and also improve their diagnosis skills (Wu, Lin & Tsai 2003). The pedagogic base of the installation we build, is based on learning by doing and with this we enable use of problem based learning (PBL) in more independent larger practices. At teachers point of view installation gives a great opportunity to demonstrate how different logical elements

(combinative elements, arithmetic elements, delay elements, bistable elements, counters etc) work in practice. Used graphic symbols are based on standards EN 60617-12, EN 60617-13 and IEC 61131-3.

4   CONCLUSIONS AND FUTURE WORK

Remote laboratories where access is not limited to laboratory hours it is possible to increase the educational coverage (Jordan, Martinez, Martinez, Olarte & Eugenio 2003). Learning environments like this can also improve students ability to succeed in independent practices with real automation systems. However, we can not say for sure, how remarkable these benefits are, because evaluation process is still unfinished.

This study and installation is a part of larger e-learning environment. Whole environment offers access to different learning objects via web-portal. Via portal we could distribute documents (pdf, doc, etc) video-clips, net-lectures, slideshows, animations etc. System offers also access to virtual process applications and to virtual laboratory installations. Documents are saved in database, which is connected to application for planning courses and course modules.
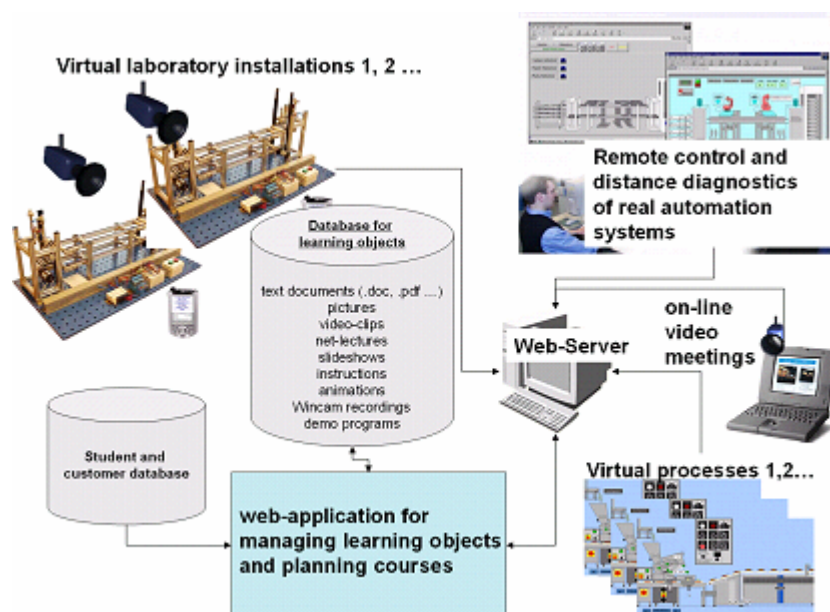

Figure 4 – Role of the different learning objects as a part of web-based e-learning environment of automation.

Portal is in very important role when we integrate different e-learning environments and manage learning objects. In future we are going to improve this integration. Also we intend to improve virtual laboratories so that student can practice PLC-programming using different graphic languages (ladder diagram, function block diagram, sequence flow chart).

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