GLOBE-IT: Globalization of Learning using Open Based Education and Information Technology

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Abstract:

Industry today operates in a globalised, competitive environment, where it has to deal with constant change and endless pressures to adapt. Education has to respond to these new industrial realities. How? New curriculum, constant restructuring of whole education, and the advent of Information and Communication Technology are just some of the varied challenges facing education and universities. Within these constraints, GLOBAL-IT project attention is more shifted to the quality of applied research, the distribution of skills, the availability of distance education services and the provision of efficient information, communications, and other learning infrastructure. GLOBE-IT project will improve the access to technical training and know how; develops teachers and learners resources and skills; promotes networks and co-operation; and encourages the use and diffusion of best e-learning practice. GLOBE-IT project main objectives are to create the physical hardware and software tools to build up an industrial IT know how and to design and implement an e-learning environment that is coherent with the industrial IT concept. This project is not just about e-content delivery but it offers an advanced e-learning system, which integrates high-tech automation and information technologies in real time to provide better learning support and to emulate real life situations and standards. The target groups of this project range from undergraduate engineering students to teachers and researchers in the field of industrial IT and any organization interested in Open Distance Learning.

1. Introduction:

It is quite obvious that educational institutes must follow the latest technologies to be able to provide the students and learners with a decent education and training program. However, it requires more than just the conventional methods in transferring the required knowledge to the learners. Just reading a textbook or e-content is not enough, since one also needs to get experience from the field. Especially in the field of Industrial-IT[1], it is very important to develop such skills, but providing students with the equipment used in real-life situations is very expensive. Therefore it is virtually impossible for most educational institutes and other similar organizations to buy all the equipment needed by the students and concessions have to be made. To be able to provide the students with all material needed, the institutes have to work together and share their resources, but letting students travel from one institute to the other is highly impractical. Quite often the machines and equipments are immobile as well, so bringing the equipment to the students is also out of the question. One of the possible solutions that emerged is the creation of an e-learning environment in combination with the e-automation[2].

The benefits of such a system are quite numerous and can make the system available for a large audience, not confined to one physical location. The resources can be shared among the partners of the institute and that greatly improves the efficiency of the investment, since the idle time of the devices will be minimized. The only resources needed to access nearly all devices and information a student requires, is an Internet connection (or GSM/WAP) and a web browser. Even though the idea of e learning is not new, this project can certainly be called unique, since it not only concerns the sharing and exchange of information, but also on physical resources. The software industry has already jumped on the bandwagon of e-learning with several solutions (e.g. IBM’s Mindspan Solutions; http://www.ibm.com/mindspan), but for many educational institutes these solutions are unaffordable. Furthermore, the in-house development of this kind of system has many benefits, since one is able to create a system that fits the needs and the experience gained by the R&D thereof can be perfectly used as a basis for future projects and can serve as a great source of information of both experience and knowledge. There are many aspects that need covering in the set-up of the e-learning environment and most of them are still un-trodden paths for the Vaasa Polytechnic and its partner institutions. At the moment the greatest need lies in the creation of a customized Industrial IT environment, so that Industrial IT students or other learners can have access to the devices from home, work place or anywhere there is an access to the Internet (students now have to come over to the laboratory to perform most of the operations). Furthermore there is a need for e-learning facilities, which empowers teachers to keep track of their students and which enables the students to access all necessary documentation related to the project he is doing.

2. Objectives and target sector addressed by the project

The main focus will lie on the disclosure of the required equipments (Water Process[3]). However, the implementation and creation of some kind of remote interface covers only one aspect of an e-learning environment, namely making resources available for usage, but much more is needed before one could speak of an e-learning environment.

In this environment several user roles can be distinguished and for the moment they are as follows:

The system administrator has the responsibility of keeping the whole system running and must therefore have access to all parts of the environment. He can define user policies; add new environments (not only learning spaces but also devices) etc.

The teacher or tutor should be able to create assignments for the students and distribute them, he must be able to keep track of their progress, give feedback, do some system administration (e.g. give students access rights to certain environments) etc.

The student should only have access to the parts, which the system administrator and/or the teacher have designated to him. Furthermore he must be able to make the assignments his teacher gave to him, access the equipment he needs …etc. Last comes the spectator, who will only have read-only access to certain parts. For example, he may only watch what is happening with the Information System (Water Process), but may never get control of the devices. This kind of user is mainly intended for demonstrations and the like, or for people who only need to retrieve information.

A common facility, which is also highly desired, is the integration of a context sensitive document library, since that would make the e-learning environment almost complete. This system should provide the user with relevant documentation on the project he is working on. For example, if a student has to set up a controller loop for a PID-controller and he has forgotten how the formula works, he can do a query on the document library and get the document that describes how a PID-controller works.

This kind of system is highly desired but it is still on the wish-list, because the design and implementation is extremely complex and require an encouragement and especially the right funding.

[1] Industrial IT is the real-time integration of information systems, collaboration and automation systems across the entire enterprise

[2] The general definition of e-automation is too elaborate to be able to comply with it. Therefore the definition has been narrowed down for this project. Originally, the definition comprises a complete system, providing total control over all the aspects of automation. However, since our project will be Internet oriented, some real-time demands are impossible to deal with, since the Internet cannot guarantee fixed delays and often the delays are too large for quick response. Therefore we see e-automation here, as the e-automation processes needed for an e-learning environment for industrial IT students using the Internet. It should provide the means to control automation processes needed to perform the tasks required by the students and teachers.

[3] Water Process is the industrial environment available at the laboratory of Vaasa Polytechnic, in which the flow of water to several vessels can be automated and monitored by making use of PLC's (Programmable Logic Controller) and an HMI (Human Machine Interface). The water can also be heated to a predefined temperature or pressurized and it can be redirected to other tanks, by means of monitoring different control valves. This set-up contains all types of sensors, pumps and actuators used in industrial environments, so that the students can become familiar with the working of industrial processes in a real-life situation. Moreover, it also provides them with the ability to gain experience in the programming and controlling of such processes as well as conducting research in the filed of automation, networks and communication. Furthermore, the system will be equipped with an OPC server and filed buses (like profibus, filedbus foundation, modbus and other industrial buses and networks)

The objectives of the project are

- Conceiving, elaborating and testing new methods and educational resources
- Facilitating the access to project results and organizing their dissemination
- Promoting the exchange of ideas and experiences on ODL (open Distance Learning) and the use of CIT (Communication and Information Technology) in the area of education

The sectors addressed by the project are

- Training of teachers/staff
- Vocational & Higher education
- Adult & continuing training

3. Expected outputs of the project

There is little experience in the development in this kind of systems and applications; a substantial part of the project will consist of research and design. However, since the system will be built modularly, it will not be too difficult to come up with some working system. Therefore the expected outputs of the project can be viewed trough 3 points:

1. Through the process involved: The project will create new modes of cooperative work with its partner institution and more transparency and sharing of resources. It will help in creating and updating existing training infrastructures and foster open distance learning with real life cases and projects.
2. Through the product itself: Beside the products to be developed, the project will also results in a high value documentation, not only containing information about the results of the R&D phase and the system architecture, but also designs decisions and some kind of manual on how to use the system, reports and a website.
3. The following software products and tools will be developed:
    a. The local software to connect the instrumentations of the industrial process
    b. The remote control software to control the industrial process (In our case the water process).
    c. The User Authentication module.
    d. A System Administration module.
    e. A History Database for process data and methods to access this data conveniently.
    f. A History Database for student data, so that teachers can keep track of students' progress.
    g. A Document Library containing important documentation/manuals about the system and the assignments to be carried out by the students.
    h. A concept for online teaching / online learning to include into an online lab courses.
    i. Communication infrastructure for the lab courses.
    j. Content for the lab courses

4. Partnership Compositions and Contribution

The following organizations have promised to participate in this project. It is also possible for other organization to join if they found any interest.

- Vaasa Polytechnic, Finland
- Fachhochschule Kiel, Germany
- Technological Educational Institute of Crete, Greece
- Katholieke Hogeschool Kempen, Belgium
- Universität Stuttgart, Germany
- Universität Hamburg, Germany

Vaasa Polytechnic provides co-ordination and ensures responsibilities of items from 3.a to 3.g.
The Institute of Industrial Automation and Software Engineering (IAS) at Hamburg University will take responsibility of items from 3.h to 3.j
The university of Hamburg will provide an interface to the education layer of the system, a control layer interface and a control layer for the general architecture, which can control the application, an application layer interface a tool extension to model the application with a Petri net model. The application can then replace the simulation model of the system. This allows to use formal methods on the control, and to gradually move to the application.

The project team will be divided according to the responsibilities:

- R&D applied researchers
- Implementation Engineers
- Documentation Secretary
- The remote control software engineer
- Supervising and advising members

5. Activities and work plan

The project will be divided into 7 activities:

Activity 1: Survey of the needs of participating universities
Activity 2: Principles of open and distance as well as e-learning based education models

Activity 3: The software product pilot
Activity 4: The Industrial IT System pilot
Activity 5: Dissemination
Activity 6: Monitoring and evaluation
Activity 7: Project management and co-ordination

Work Plan

Project:					
Stage in life of project	***Outputs: By the end of this stage we will have achieved / produced***	***Activities leading to this output***	***Activity to be started by this date and completed by this date***	***Partners / Persons involved***	***Time input***
1 Activity 1	A study on a new educational and pedagogical methodology on e-learning based and problem based learning models; Possible adaptation of existing models to the project's needs.			All	3 months
2 Activity 2	The architecture of the system achieved Hardware connections to be ready Specification of the application software has to be made with the possibility of future extensions in mind.	Activity 1		Vaasa Polytechnic IAS	6 months
3 Activity 3	New remote control software for the Water Process has to be designed and implemented. Integration of the new software into the rest of the system. The system will be designed and built modularly Control software, user interface, com infrastructure for the elevator model to be used in an online lab course.	Activity 2		Vaasa Polytechnic IAS	8 months
4 Activity 4	E-Courses content, Project and Problem Based Learning materials, Laboratory exercises. Content, learning material for lab course.	Activity 1 and 2		All	6 months
5 Activity 5	Dissemination information about the progress of the project and about its results to main target groups which are not only the partner institutes but also their partners in different context; Web based user community to support teachers, trainers, and course designers in using the system, materials and tools;			All	3 months

6 Activity 6	A monitoring and evaluation system that help in monitoring the project progress; Evaluation report of intermediate and final results;			Vaasa Polytechnic, Finland Fachhochschule Kiel, Germany	4 months
7 Activity 7	The overall management of the project; co-ordinate the activities in different steps; Monitor the performance of project; Ensure the clear separation of the tasks and responsibilities, including fair and reasonable funds allocation.			Vaasa Polytechnic	

6. GLOBE-IT: A Case study, technology for e-learning based laboratory demonstrations and exercises

Leonardo Da Vinci is a EU-Program to finance projects in training and education. . "Internet Based Training Programmes for e-Learning: Building and Industrial Automation incl. Wireless Technologies" is one of the projects that is partly financed by this program. The case study presented in this paper is one task under this project. The partners in this project are Klinkmann, acting as a contractor, Legrand, Rockwell automation, Vaasa Polytechnic (Finland), Kauno Technologijos Universitetas (Lithuania) and Riga Technical University (Latvia) acting as developers. Our responsibility in this project is to

- Design and implement remote programming for PLC
- Demonstrate live video monitoring as a part of automation

This task is used here as a case study to illustrate the idea behind Globe-IT, because it allows students to perform real laboratory activities remotely. More information about this task can be obtained from the following website: http://leonardo.puv.fi/

7. The Waterprocess

The waterprocess is physically situated in the Electrical Laboratory of Technobothnia. The laboratory itself is located in city of Vaasa, Finland. It is managed by the unit of Technology and Communication Department of Vaasa Polytechnic. The waterprocess itself is designed for educational purposes. Most of the measurements and controls commonly used in the process industry can be demonstrated.
The main process flow is: Two pumps are taking the water from a reservoir to three storage tanks and the tanks are then drained back to the water reservoir. There are several different ways, how the flow can be directed. The flows and levels can be regulated. For the regulation can be used frequency converters, throttle valves and back pressure. The temperature of the water can be regulated as well. All the used equipments are commonly used in the process industry, like in pulp and paper mills. Some of the instruments are even equipped with field busses. Figures from 1 to 3 give a general illustration of the Waterprocess.

Figure 1: A general View of the Water Process

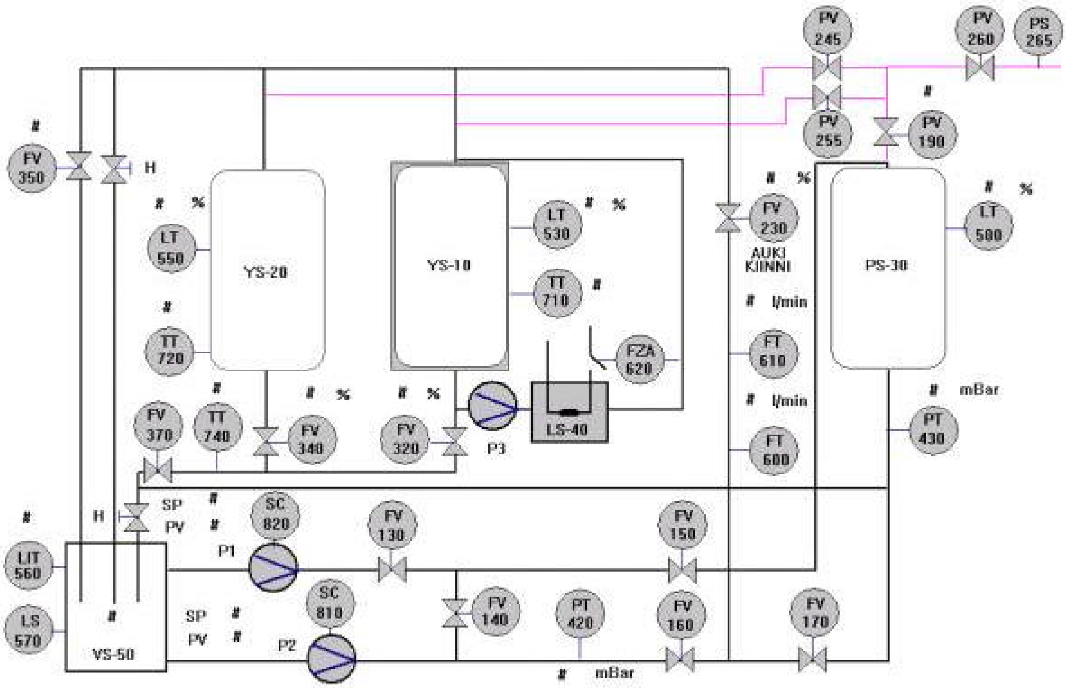


Figure 2: The PI diagram of the waterprocess

Figure 3: The main control cabinet of the waterprocess

8. Present use of the Waterprocess in education

Most of the topics thought in the field of automation engineering and technology are currently applied to the Waterprocess to give practical training to the students of Vaasa Polytechnic. These topics include the following subjects:

Instrumentation - Measurement and actuator technologies
Programming for automation - Controlling and monitoring the industrial processes
Feedback control - Control algorithms
Fieldbus communication - Data interchange between intelligent components
Monitoring systems - HMI, data storage and reporting
Databases for automation system – Handling and connecting databases
Automation system structure - IT technologies used in industry
Automation planning - Methodologies in automation planning

Beside the traditional teaching and laboratory exercises the Waterprocess is also used to provide different services for companies, such as compatibility testing, configuration and calibration.

9. An overview of the system structure used in the case study

The figure 4. shows the technical system structure from the automation point of view. The system is controlled alternatively by two controllers – Siemens S7-300 or Rosemount Delta V. At the instrumentation level those controllers support digital I/Os, analog I/O s and several field busses. The buses that are actually implemented are:

- Profibus DP: intended for fast intelligent device control. On that bus there are connected several frequency controllers using profidrive profile. Controllers can exchange data through a DP/DP coupler.
- Profibus PA: On This segment there are flow and pressure transmitters. The PA bus is intended for slower communication but uses simple twisted pair cable capable to energize the instruments as well. It also has standardized profiles to all common process instruments.
- AS-i: The bus is used here for remote I/O-connection. The bus is intended for fast discrete data transfer.
- Fieldbus Foundation FF: On the FF-Bus there are some valves and measuring instruments like a flow meter. The bus is targeted for the same application area as PA, but do have even more advanced features.
- Most of the instruments are controlled directly with I/O. Some of them are configurable with Hart although.

Supervision and information level is based on Ethernet and TCP/IP communication. At that level there exists:

- Programming tools for the controllers

- Operator station based on InTouch HMI-software
- SQL database for historians and reports
- Portal Server for web-based access to operator station and SQL –database.
- OPC server provides a connection place to the systems that are used more temporary basis.

10. Requirements and solution

To achieve the objectives of the project some requirements has to be fulfilled. These are:

- Accessibility – The services needs to be accessible through open network
- Security – the security of the institutes network has to be guaranteed
- Relevancy - The solution should be directly applicable in the industry
- Mobility - The mobile terminals should be supported

Three different solutions were produced

a) The modem based solution:

The configuration of the modem-based solution is shown in the figure 5. A sub-network from the institute's domain is reserved. The dedicated bus segment is not physically connected to the institutes network. This satisfies the security requirement.

A LAN Modem connects the PSTN and the sub-network. When a call is made the authentication is done with name and password. The routing table in the LAN Modem specifies the IP addresses where the caller is allowed to communicate.

A gateway is used between the dedicated bus segment and the MPI-bus. The proprietary MPI-bus gives all functionality to the connected programming devices.

How the remote computer access the telephone network is not restricted – the GSM option satisfies the mobility requirement. At the remote end there is a need for S7 programming software and client software for the gateway.

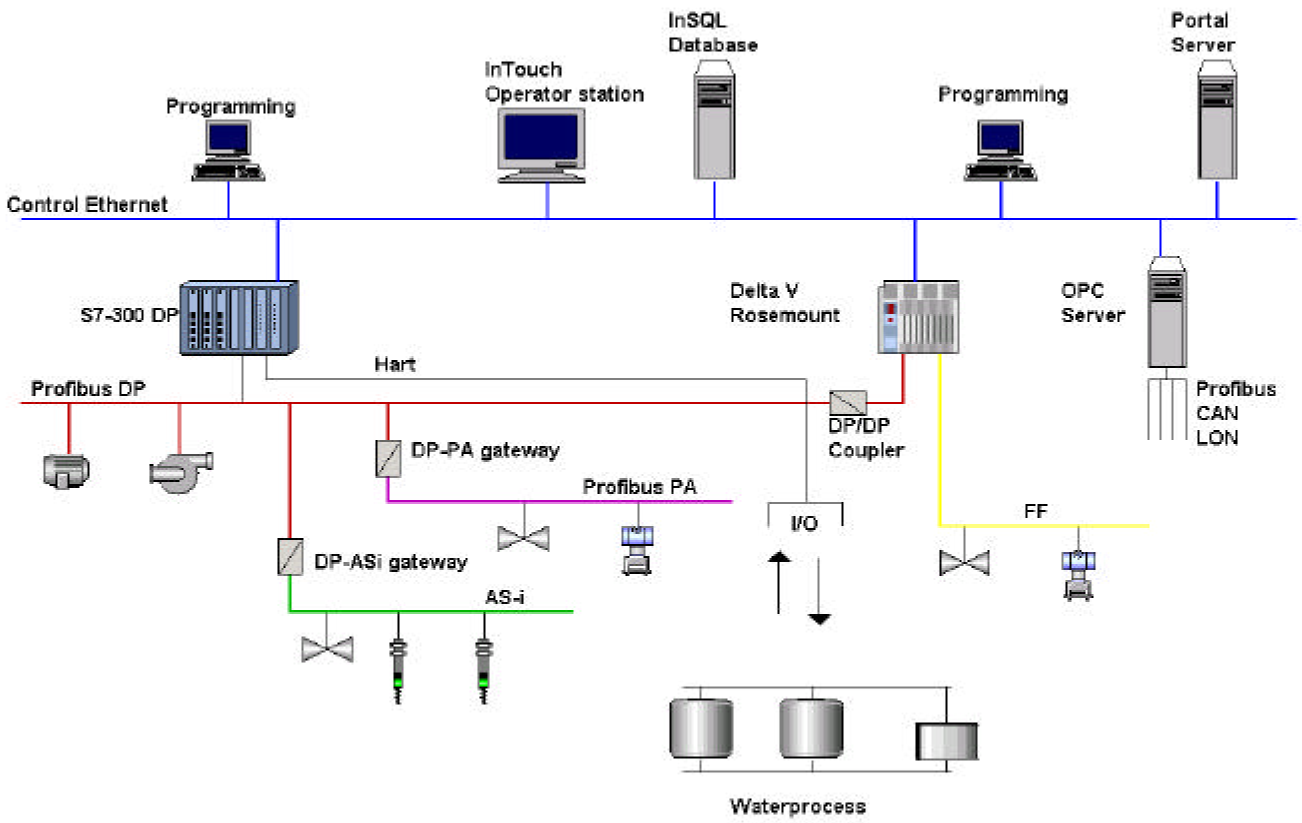


Figure 4. The system structure used in the Case Study

b) The VPN solution:

The configuration of the VPN based solution is shown in the figure 5. This solution provides the remote connection through the open web. Another sub-network from the institute's domain is reserved and the controller is equipped with an Ethernet card with routing capabilities.

A VPN Server is connected before the firewall to satisfy the security requirement. It does user authentication and restricts access to the predefined addresses only. It also provides secure tunnels in the web.

At the remote end there is a need for S7 programming and VPN client softwares. A hardware VPN client exists also. This means that the control sub-network can be virtually extended over the web. In principle any equipment with TCP/IP capability can be connected.

c) Terminal server solution:
This is an extension to the VPN solution. A terminal server is added into the configuration and it is made accessible through the VPN server. The programs in the terminal server can now be run remotely through the open web.

At the remote end there is a need for terminal client and VPN client softwares. S7 programming software is now running locally in the terminal server. The communication between the terminal server and the control network takes place in the local LAN. Only the terminal session is transferred over the web. The sensible communication between the programming device and the controller can now be managed.

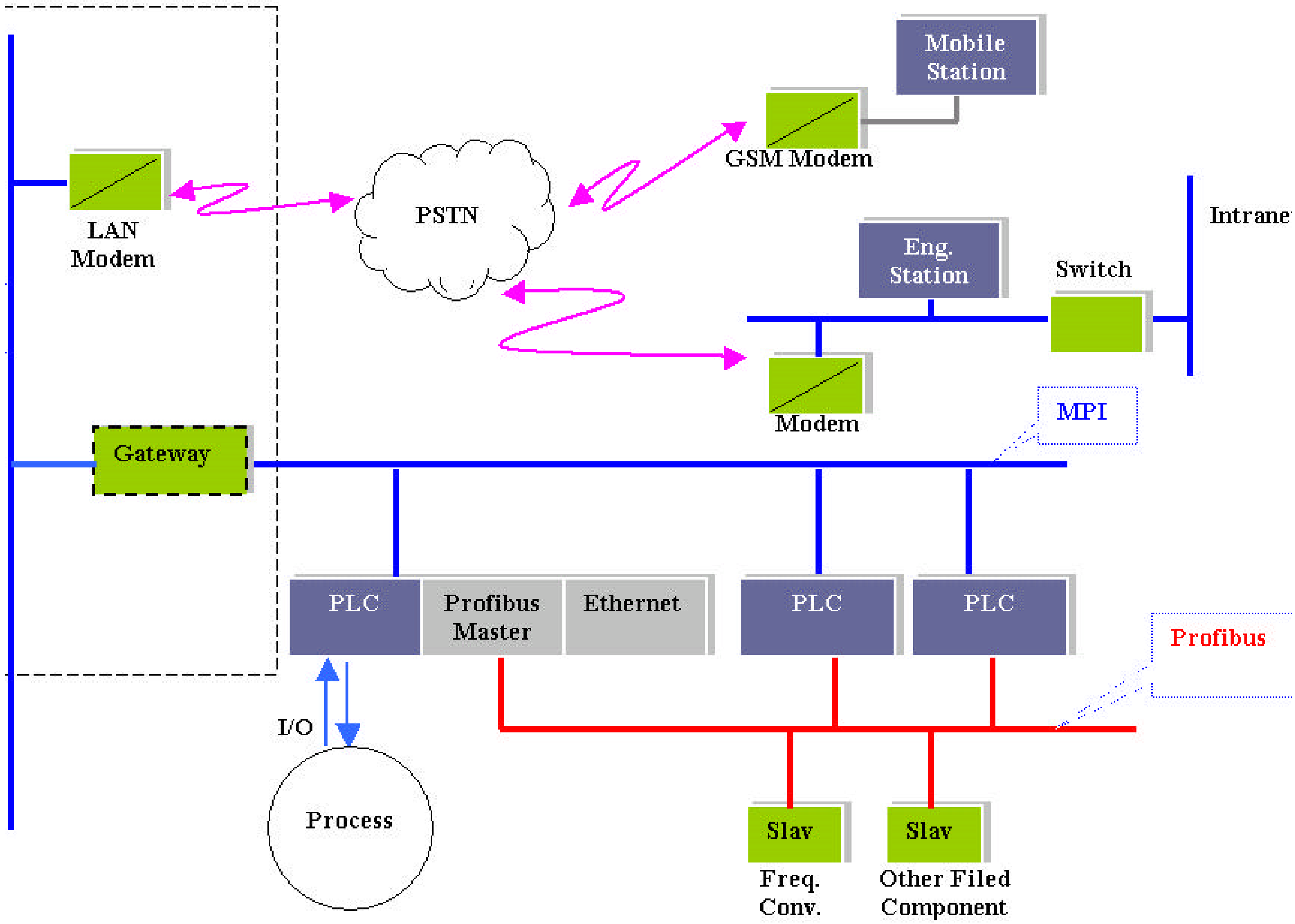


Figure 5. The modem based solution

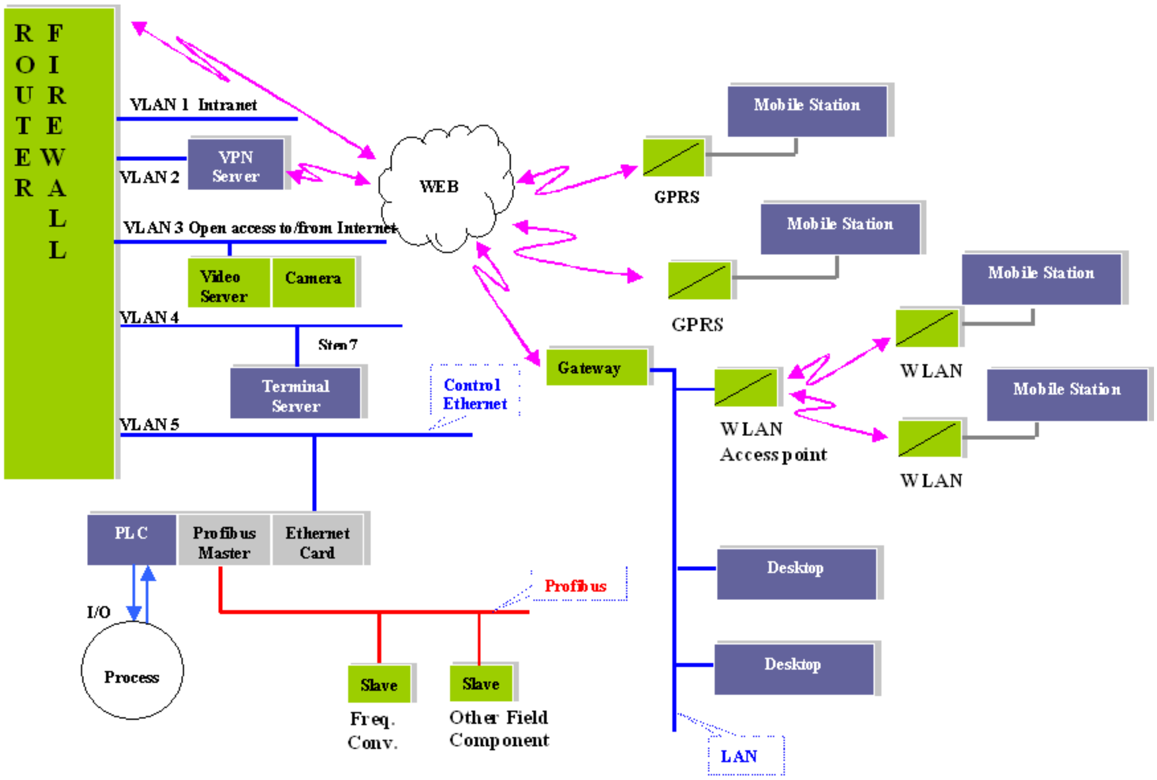
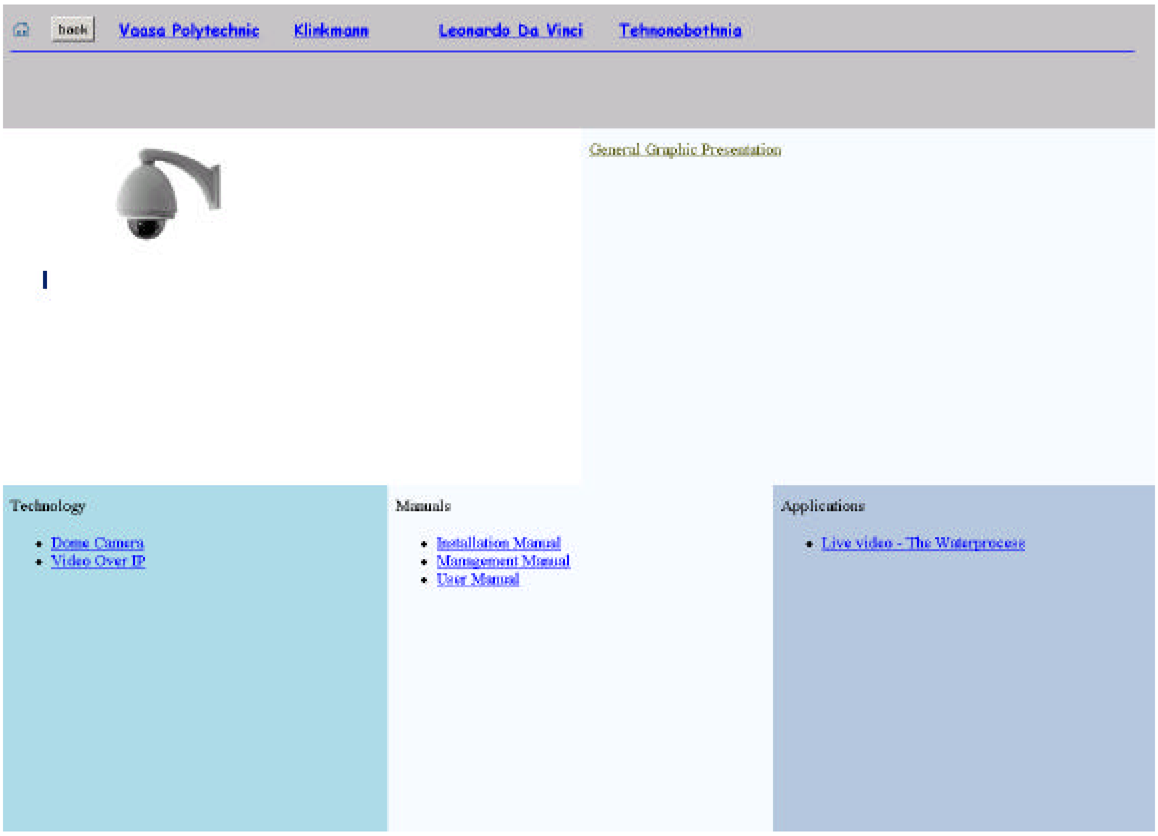


Figure 6: The Complete Network structure of the system

11. Implementation

The implementation phase involves not only the physical configuration and interconnection of the system but also the production of the e-content and the website for the presented structure.
The structure is based on component thinking. Each hardware and software piece is to be documented as a component. The main topics of each component are the same – an image of the component, a descriptive drawing, general documents about relating technology, the component specific manuals and the generated application examples. The content is free beyond this classification. The common frames will automatically give the same look and feel, when material from different sources are to be integrated.

Figure 7. Shows one example about the component page.



The content of the site is the following:

- The instrumentation is documented with still images, technical descriptions and circuit diagrams. This part was realized before the project start.
- The main system components needed in remote programming are documented. These components can be tested in live by following the step-by-step guides
- The PLC-program related to each instrument is documented
- Step7 related Hands On-exercises using the remote programming methods are presented
- The remote streaming video and voice using the video over TCP/IP-technology are demonstrated. The camera controls are integrated in the web page.

12. The impact of the project

The eLearning-based laboratory will have a direct impact for the present usage of available equipment in education. The most relevant ones are:

- **Enhance both the distance learning and on site training**
  It is easier to keep the interest of the audience alive, if teaching can be supported with real demonstrations. The remote control at all levels with streaming video makes the equipments available.

- **Time optimization and improved focus for students**
  The equipments, programs and the documents are available on line. Students can use this feature for studying and teachers for remote assisting.

- **A new service channel for industry**
  The laboratory equipment can be demonstrated remotely for customers as a part of the system with third party products. A remote test field can be set up in case of acute problems.

- **Good practices for system integration**
  The equipments tend to be isolated islands in the laboratory. A common remote interface and document structure is a driving force to connect the equipments and programs into a working system, where each component has a meaningful task. This also leads to a common document structure.

- **Collaboration and sharing of knowledge**
  So far automation and IT department have had very little common actions – at least in Vaasa. The e-based system hopefully tights the collaboration, while it shows, how IT is applied in the industry.

13. Feasibility in financial terms

The feasibility of the increased availability of the e-based platform can also be estimated in euros.

The estimated values for the calculation:

- Estimated value of the existing laboratory system - 250.000 €
- Annual value reduction with interest of 20 % - 50.000 € per year
- The system is used in 5 courses, a' 4 hours per week – together 20 hours per week
- The working hours in a week - 70 hours
- Working weeks in a year - 35 from 50 available (holidays subtracted)
- When made remotely available each course will generate additional load of 4 hours – together 20 hours.

The outcome:

- Utilization factor before: 30 % in a working week, 20 % in a year
- Utilization factor after: 57 % in a working week, 57 % in a year
- Equipment cost before: 71 € per hour, 1 429 € per week, 50 000 € per year
- Saved money after: 1 429 € per week, 50 000 € per year

The increased system utilization in automation area can be valued for 50 000 € per year.

14. Conclusion and the planned future improvements

While completing the task in Leonardo project, we realized that the development is more profound for the future than as it was set at the beginning. The side effect grew to be a demonstration of a platform, where laboratory activities can be performed remotely.

The remote connection was set up and working in spring 2003. So there is no experience in everyday teaching yet.
The reliability of the remote connection methods was tested on the motor highway between Tampere and Helsinki. The connection was realized with Nokia's GPRS card and DNA mobile operator. The testing took place in a normal working day. The connection was lost only once during the test.

The remote programming methods have been presented in live in some seminars (safety in automation, IT technology in machinery).

The system presented is this paper is more a concept than a ready solution. But it is a considerable achievement for continuous development. Every feature, which is added to the system, can be used directly in education and the remote concept will give added value.

The following topics can be listed for activities in the future:

- To get experience, how to apply the presented concept in everyday teaching
- To complete the existing web pages
- To publish already existing exercises on the website

- To add the supervisory level to the remote access concept

- To renew the control program by making it more close to a real industrial application
- To demonstrate the field busses remotely.
- To integrate the streaming video into the supervisory level and more tight with the remote concept.

- To add authentication with resource and priority allocation
- To protect the control software for unauthorized commands and editing
- To examine the license problematic in terminal server applications

- To explore mobile solutions with different terminal types
- To study how to design scalable solutions

15. Last words

The project presented in this paper will promote the use of CIT in teaching and will respond to the future challenges arising from new systems of education and training and will encourage lifelong learning.