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# REMOTE ACCESS INTO VIRTUAL WEB LABORATORY - APPLICATION IN MEDICINE

The paper introduces the need of improving skills level of students using Internet network. The solution has been discussed on an example with remarks for the medical diagnostic devices. The laboratory, which is not large enough, for performing all needed training courses, can be provided the trainee after their main work hours. The elaborated solution is supported by various training interfaces, provided by standard Learning Management System (LMS) and the applications controlling machine called Multimedia Applications Management Shell (MAMS). The example platforms were supported by networking Debian Linux services and an open-source technology that is used freely, by many developers.

## 1. INTRODUCTION

The laboratory experiments usually require very expensive equipment that should be incorporated effectively, for every student separately, into its training process. The laboratory experiments, being a part of the course, cover very demanding qualifications needed in future work - practical skills and theories principles. The engineering control problems and medical diagnosis are very similar in theories and practices.

The laboratory classes, guided by a teacher, are common practice in majority of schools. The students, in majority cases, suffer from shortage of time to recognise fundamentals – especially vital in case of medical study. They also need reminding of any details doing projects or diploma works.

In our everyday work, with the students, many limits are noticed. The student needs an access into the laboratory, in an unpredictable moment, often when the University labs are already closed. On the other hand the devices are too expensive to be provided for every student individually during laboratory classes.

The computer and e-learning technologies with networking (Internet) facilities, provide us with interesting abilities of multiplying the number of users working on virtual machine, pipelining the users' access, via communication server.

The paper presents the solution incorporated in our department. The multiple access into one controller for several remote terminals was introduced. A second paragraph describes several problems of common remote-access techniques. The competitive authors' solution, using the developed LMS interface, was introduced in next paragraphs. The paragraph four shows the implementation details for the system that can be incorporated into the medical devices integration, illustrated by some empirical data. Finally, the further works within this area were also discussed.

## 2. THE SOLUTION'S ENVIRONMENT AND ASSUMPTIONS

The easiest way for more effective training organisation goes through the laboratory equipment size; with many work stations available at any time, for every student. Many reasons one can find that this idea cannot be considered as a proper solution. A critical conditions concern tremendous costs and large space of the laboratory.

The remote access into the laboratory equipment became available thanks to wide area computer network services. This virtual laboratory idea needs specific, dedicated equipment and software packages, fulfilling these expectations. The remote training methods are found very encouraging [1, 7, 8, 9], not only because of remarkable reduction of the equipment costs but also by easy and comfortable access into the laboratory units.

The professional equipment and its software is usually protected by a hardware key, anyhow the same machine is offered many users that are able working on the station parallel; the machine is used in a right time.

The experiments on the machine will be provided with simulation packages, usually used along the studying courses. The simulation packages are guiding the user through the application, with many comments for understanding the programming details (to reach the mastery, as a final goal).

The discussed laboratory organisation was introduced in Fig. 1. It consists of two parts. Part A, with traditional laboratory units, for locally used training stations and programming interface. Part B, provided with workstations joined into the laboratory server via remote access communication systems, with IP interfaces.

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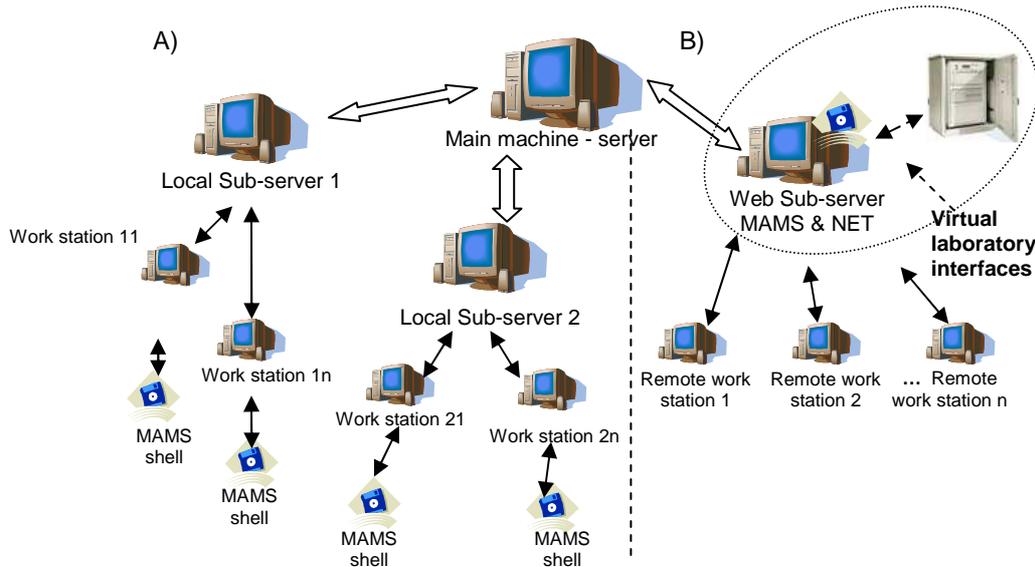
Fig. 1. The laboratory services organisation [4]

The laboratory network works under control of a main machine (running 24 hours a day), where the digital controller, with its software units is installed. The access interfaces were developed for the MAMS management shell (the Computer Aided Learning solution) [2, 3, 5, 6]. The platform provides the application with communication facilities for local servers, performing the users knowledge evaluation.

The sub-servers are responsible for communication with the controller, available on the main machine. The network extensions of the MAMS platform were discussed bellow. The sub-server structure with its units are presented in Fig. 2.
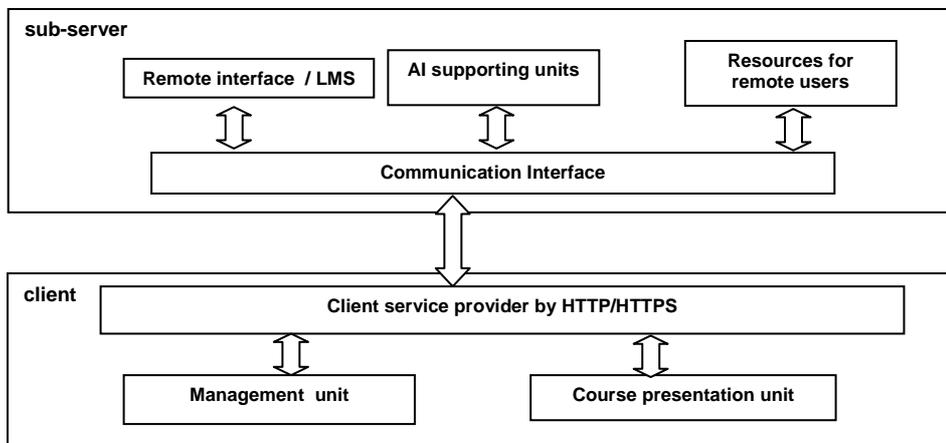


Fig. 2. The sub-server units for a remote approach into the laboratory

The communication processes were supported by a conclusions making unit, installed in sub-servers. They were wider discussed in works [5] and [6]. Although the conclusions concern the user's knowledge, the results of analysis are collected by the main machine, where complete evidences of the training users are kept. The remote users approach is controlled, protected and monitored by the communication unit as it is introduced in Fig. 3.

The controlling engine of MAMS [3] allows running the supervisions and interactions flags, illustrating the user's training progress. These various services were also wider discussed in several works as: [4], [5] and [6].
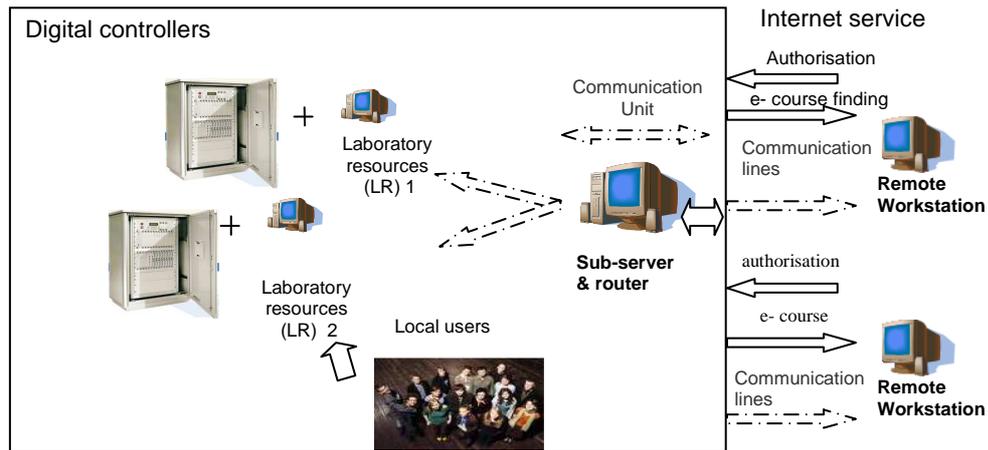
The virtual laboratory units:



Fig. 3. The virtual laboratory components

## 3. SOME IMPLEMENTATION DETAILS AND COMMENTS

All software components of the laboratory, were developed in a professional software environment, using an open-source or freeware technologies, as: Apache 2.0, PHP 5.0, Tomcat 5.5 and JAVA 1.5 EE. The server database is under control of the Postgresql solution - version 8.

The access management services were developed by Debian Linux operating system, version for multiplatform usage that is movable into other operating systems. The conclusion making units were elaborated in JAVA 1.5 release, due to its rich libraries, supporting the conclusions and networking facilities.

The communication interface for virtual laboratory is powered by PHP technology that also supports the Learning Management Systems (LMS) as MOODLE – the most often used recently. These above units are were supported by reach libraries and services, as:

− XML document manipulation units [10]; SUN JAVA (SAX [10], DOM [10]) for the transmission manifests indication,
− the training units graphs description – by Jgraph library and multiple weighted graph structures – JgraphT library,
− fuzzy decisions making engine,
− linux debian environment, for the laboratory networking access management: crontab, iptables, route and ifconfig,
− the Real VNC for the application control.

The laboratory resources are part of the course fundamental unit (called frame). It requires many operations analysis, with additional markers illustrating the course properties. In Fig.4 the units' database with their relations are indicated.
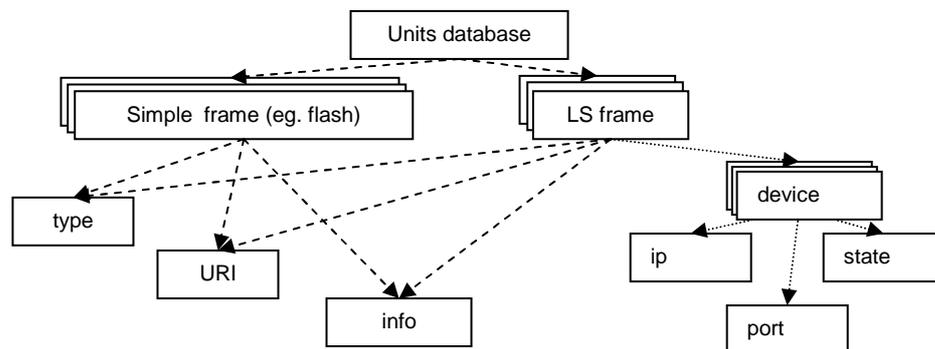


Fig. 4. Additional description of the LS frames

The application basic units, called frames, are assigned by their characteristic features (indicated by dashed lines), as: "type" determining the application content, functions and controlling facilities of the frame. The URI (Uniform Resource Identifier) specifies the data-frame, executed by the application controlling mechanisms (Fig.5).

The communication system supports four execution mechanisms (co-operating with the MAMS interface), by:

AAM                  – collecting and evaluating the users' interactions results,
HTM (HTML)       – for html formats recognition and conversion,
SWF                  – for Flash simulation units recognition,

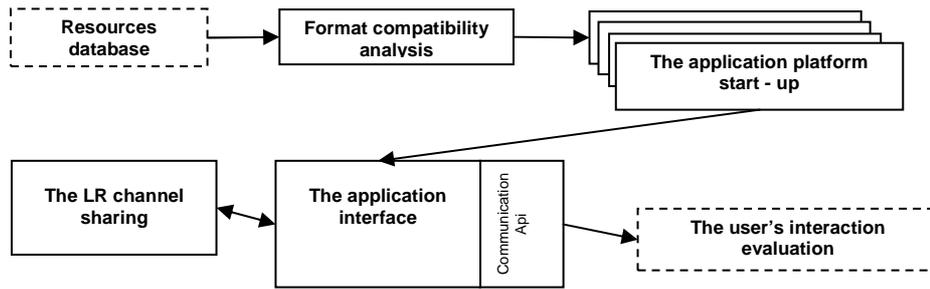CF                  – the communication frame for the LR.



Fig. 5. The training process controlling functions

For the CF unit additional communication features (assigned by the dotted line) were defined. The features identify the devices by their port-codes with IP numbers. Moreover they provide the machine / equipment with its current status, as:
- the application status, if the machine is ready for working (the machine on-line / off-line),
- the state of the system, if the machine is currently occupied by a user, (free / occupied),
- no_c / no – variables describing the current number / maximal number of users,
- restrictions, defining a time when the system is available for the course execution,
- time window given the user, defining a maximal time for a student's training,
- the access mode; defining the number of users working at the same laboratory resources (LR):
    - o    0, means the multi-users mode, acting at the same time,
    - o    1, for a single user access,
    - o    2, for combination (a combined mode), where one user is active (tutor) and remaining users of the group observe his activities.

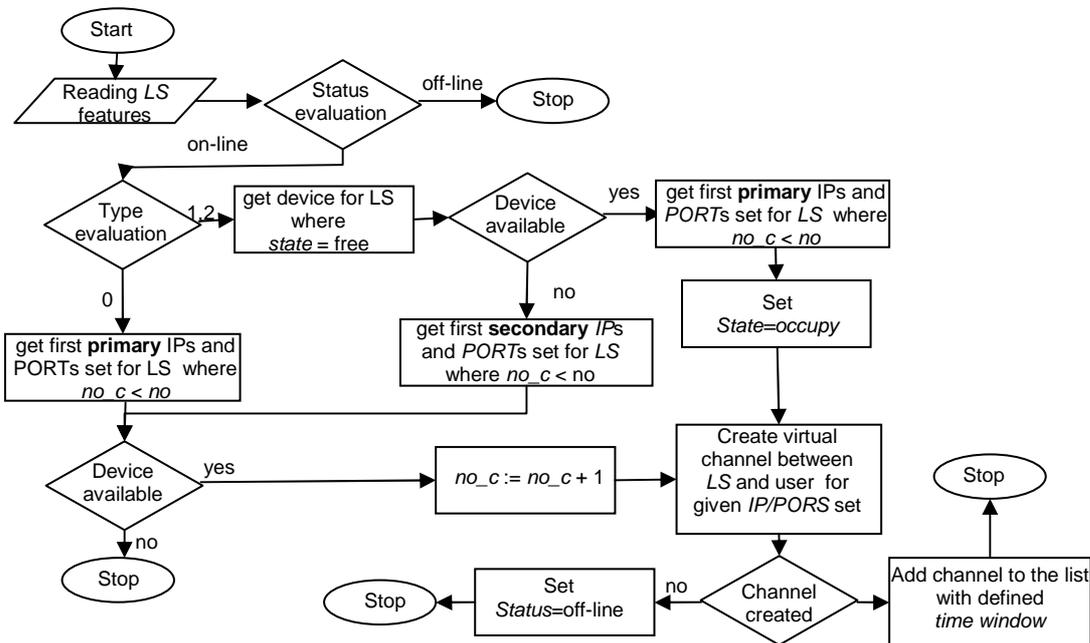The CF works according to an algorithm introduced in Fig. 6.



Fig. 6. The LS sharing procedure

The laboratory resources' sharing process is performed by several services. The first one provide the user with the dedicated communication link. This service uses the PHP script for the network routing operations and communication management. The PHP script occupies the laboratory equipment for a defined period of time, using Bash (Bourne-Again Shell) Linux Layer; the script for "iptables" service.

For a multi-access mode the IP service and its communications ports are used many times; not more than the predefined users' limit. In case the combined mode was defined, the first user address is mapped into a primary IP port that is set and the remaining users are redirected into a passive mode (at an alternative IP / port set). The IP address of the user is read during the authorisation process (available thanks to PHP scripts).

When many users are entering the training platform (multi-access at the same time), they have to be put into a queue. The script.php closes the communication channel for the given remote LR.

If the user's work exceeds the dedicated time (for the given frame), he is automatically disconnected, by a background script.

The described above settings allow us insolating the laboratory equipment from unauthorised users. The programmes: masquerade and firewall services, secure the system against a scanning process of the laboratory ports ("sniffers") and against other scanning attacks.

The above solutions allow the user a safe accessing the laboratory equipment from a remote work stations via Internet interfaces. For these training purposes the MSR – digital controllers were used.

## 4. IMPLEMENTATION

The implemented networking service was evaluated by our students and medical school participants - virtual laboratory users. The first two course we did with several introductions that were given for handling with this new training technologies – the devices and resources presentation.

The next training units were used for evaluation of the users' skills, to analyse if the users' skills (before and after the training sessions) are remarkable different.

The laboratory device was provided with the "RNC Real" java applet, for communication services running, with the laboratory resources. The laboratory stations, due to their pioneer implementation, were set into the combined training mode.

What is more the user was able to work a defined period of time (per example ten minutes) at the controller from his remote workstation.

The most troublesome problem concerning medical device integration is its interoperability that is still under investigations [11]. The technological standards were not defined till the time. Moreover, there are no regulatory issues and adaptation standards defined for these purposes.

Analising the MD-ADAPT solution [12], using SOAP standard or Zigbee solution [13], one can find a devices interfaces that allow to put into the courses various medical devices. The discussed above system can be easily used without any modifications under the one condition - the device is plugged into the system via IP protocol.

In Fig. 7 the users' knowledge increase, for basic theories of the controller structure with the defined task solving, was presented.
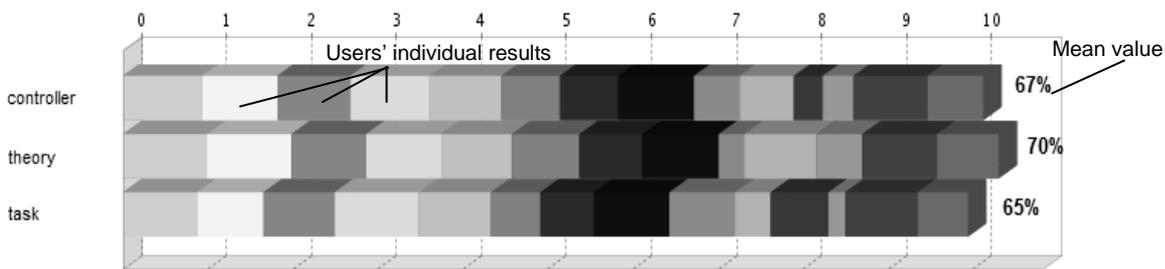


Fig. 7. Students' separate results and their mean value

The given opportunities of studying at home (via virtual laboratory) were checked by 93,3% of the laboratory students. The remaining part was studying in traditional way. The students' training sessions completed the introduced experiments within 4 days (including weekend). A medium time of being in virtual laboratory room is equal to 8,5 hours. The users' feedback and willingness of working at the virtual laboratory illustrate the references given in Fig. 8.

It seems to be very encouraging statistics, as the students were not enough familiar (beginners) with this new services.
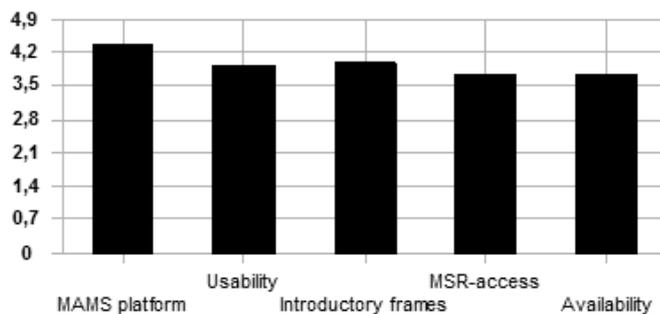


Fig. 8. The users' feedback for multiple aspects of the system in a scale from 0 to 6

The students' score rate was above good. The only weak-point of this solution concerns a not demanding condition; JAVA plug-in installation available on the work stations. The indicated restrictions are relatively simple in comparison to a feedback with training abilities, with an MSR-access and very valuable training quality measures.

## 5. CONCLUSIONS

The developed training platform is able to solve many limitations of training, using a real industrial equipment at home (e-training) as well as working by diploma student (e-work) any time they need the machine.

The solution uses the existing laboratory infrastructure giving the students additional opportunities for improving their skills. Additional advantage of this solution concerns remarkably lower implementation costs.

Moreover, the idea illustrates changes that will be soon observed in everyday didactic processes. The laboratory can be used continuously any time it is needed. The group of 16 users is able to work in the same time at the controller plugged - into the virtual laboratory. For bigger groups the communication line reservation mode has to be used; as the only efficient solution.

The given solution can combine together any e-learning dedicated courses, provided by Internet services, assuming that the device will not disturbed its main functions. Anyhow it is providing the user with very fruitful training platform. The training facilities are defined as a feedback loop of the training complex process analysis.

The next step will concern the laboratory reservation system improvement. Additionally, the simple interfaces for the laboratory medical equipment integration is under development.

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