A SMART LAYER FOR REMOTE LABORATORIES

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Since the mid 90's, there is a growing number of remote labs available through the Internet. Several solutions for harmonizing the software and hardware used for implementing this resource have already been proposed and described in literature. However, the present and perceived situation is the lack of such a thing like a standard approach to implement a remote lab, both in terms of hardware and software. This is also true when considering two common aspects to all remote labs: the physical space occupied by each and the power supply to the hardware used in it. In this paper we try to address these two common aspects by proposing the use of a standard domotic system, usually used in smart homes, able to control both the physical environment associated to the remote lab and the power supply to the devices and apparatus used on the experiments hosted at such remote lab.

Remote labs are expected to be available 24 hours per day and 7 days per week. This condition has consequence in terms of power consummation and in the quality of results obtained from remote experimentations due to the following factors:

- If the remote lab facility has direct sun light and visual feedback is required, then artificial lights are not mandatory to switch on during the day. Eventually, controlling the blinds can provide better light conditions depending on the part of the day and the session. During the night, when not in use, the lights of the remote lab could also be switched off in order to save energy.
- Depending on the type of prototype and equipment used in the remote experiment, the ability to control/monitor the temperature may be required. For that propose, two solutions may be considered. The temperature control can be made automatically by the remote lab, or giving users' facilities to control it remotely. In the first solution, the remote lab is the responsible to control the lab temperature and guarantying that a specific temperature is satisfied to assure the correct lab operation. For the second solution, the temperature should be remotely monitored by a sensor. Based on the read temperature, the users have the ability to change it for a specific value, by controlling fans, heaters or even specifying a temperature value using an air-conditioning circuit.
- Together with the ability to switch off each device of the remote lab when it is not in use, it may also be desirable to reinitialize a certain device by just switching off and then on. These suggestions/requirements depend on whether the device and apparatus to be switched on/off requires a setup procedure or not. In other words and considering a PC for instance, it is not possible to switch it off by just pulling on the plug from the power socket, i.e. by simply switching it off. If in some devices turning off the power socket will take them to a default state, on

others we have to follow a specific sequence for that purpose. Usually this is the case with the apparatus, which usually requires a software initialization made by the instrumentation server. In this situation, if we intend to setup the entire infrastructure by resetting it, first we have to reset the instrumentation server and then the apparatus, so it can be reinitialized using control signals coming from the instrumentation server. Specific attention is the way we can do the reset to the instrumentation server, since it can not be turned off abruptly because it could damage the software installed on it. This server should be reseted by an UPS (Uninterrupted Power Supply) using a *soft reset* that allows turning off the server by software. If all these setup and reinitialization considerations are supported by a remote control, then the usual technical support, made by a technician, may be suppressed, contributing also to reduce the maintenance costs of the remote experiment.

Thus, controlling the lights and temperature conditions may guarantees the correct operation of each device and apparatus available in a remote lab. Moreover, switching off all devices and apparatus when a remote lab is not in use, promotes reducing ageing devices' effects, contributing also to the quality of the results obtained by the experimentations.

To address all the previous points, we purpose using a standard domotic system bus, usually used in smart houses. The advantage of using a standard commercial solution is that all the institutions currently supporting remote labs may quickly adopt this solution with small development efforts. With this in mind we have adopted the KNX/EIB domotic system, since it is a world standard, is platform independent, guarantees interoperability of products from different manufactures and stands for high product quality guaranteed by the KNX Association. To use this domotic system we followed the architecture illustrated in figure 1.

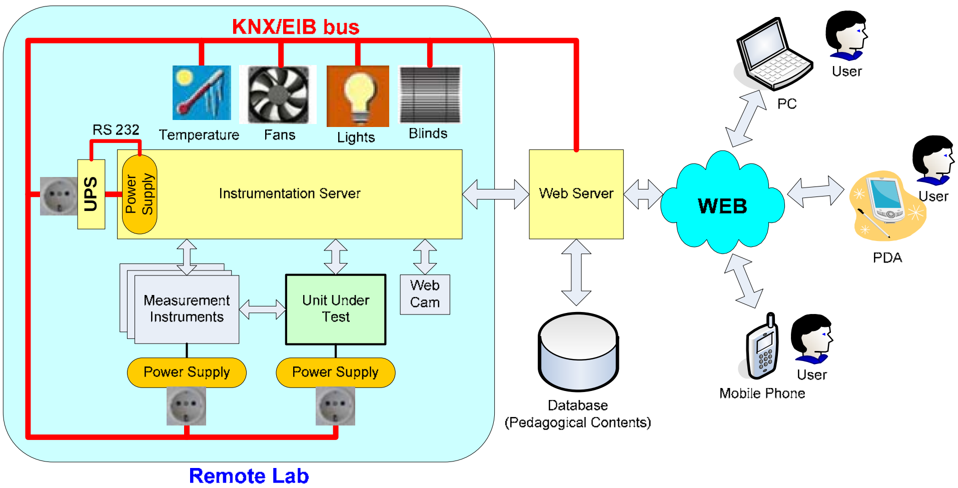

Figure 1: Suggested architecture.

The most relevant aspect in this architecture is the ability to control/monitor the entire remote experiment using the KNX/EIB system using a device connected to the internet (PC or mobile devices). Lights intensity, temperature, power plugs, fans, blinds, air-conditioning circuits, and the instrumentation server (using an UPS) are able to be controlled remotely, given further possibilities for remote users. Besides the new hardware architecture, another software layer was implemented on the Web Server using a Java API named Calimero together with an IP/EIB router.

At this moment we have a sample application developed at our lab that allows controlling a power socket and lights intensity through a dedicated web interface from a PC with a web browser. This interface, illustrated in figure 2, may also be embedded within any original remote experiment interface enabling larger control/monitorization capabilities by the user. This also contributes to decrease technical support costs made by a technician, since his/her support may be reduced. In the future we intend to develop another interface for mobile devices, with the same control facilities available in the web interface accessible from a PC.

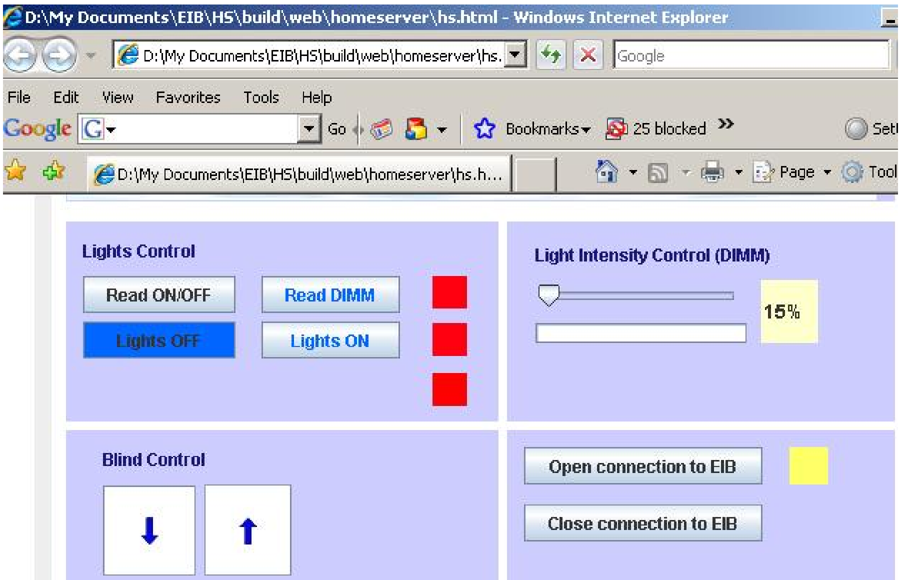

Figure 2: Web interface to control the domotic system from a web browser.