Low Cost Remote and Reconfigurable Analog Electronics Laboratory

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Abstract—**In this paper we present a model to control the instruments and experiments in a remote laboratory using a low cost control architecture. This model is based on a LAN network and a control methodology through reusable drivers. The objective is to obtain a software control architecture independent of the hardware of the laboratory, so each institution can deploy its own solution according to the available devices and with minimal restrictions regarding to the hardware of the lab.**

Index Terms— **remote laboratories, remote instrument and measurement control.**

I. INTRODUCTION

Since 2007 the Weblab-Deusto research group is partner of the VISIR project [1], in both development and deployment tasks. As a result of this project, since 2007 we are using the VISIR platform in different degrees: Telecommunication, Informatics, Industrial Technologies and Electronics. The subjects related with VISIR at this moment are: Digital Electronics, Computer Technology, Analog Electronics, Circuits and Physics.

From the experience gained during the deployment and use of the VISIR platform, we started to work in the idea of applying to the VISIR platform, one of the main concepts used in the WebLab-Deusto, this is, the independence of the software regarding to the hardware of the lab trying to solve one of the drawbacks of the VISIR: its dependence on the PXI architecture and the proprietary switching matrix developed for this specific remote lab.

PXI is a PC-based platform for test, measurement, and control that present advantages as its high speed response and bandwidth, characteristics that could be really necessary in the industry, but they are not crucial in the area of remote experimentation when we are working in the range of kHz or a few of MHz. In contrast, the price of a simple PXI chassis with an embedded PC, and the basic setup of a remote lab on analog electronics (oscilloscope, DMM, function generator and power supply) can be difficult to justify for a remote lab.

As we can read in the references to the VISIR project [2], [3], [4], the deployment of this platform depends directly on the use of the hardware for which it was designed: a National Instruments PXI and a switching matrix, which has been designed by the research team of the BTH, explicitly for the VISIR laboratory.

So, the method that we propose in this paper combines the best of the concept of remote laboratory proposed by the WebLab-Deusto [5], with the power of the environment designed in the VISIR project. The goal is to eliminate the need for a PXI and a proprietary switching matrix for the deployment of this remote laboratory by abstracting the software of the laboratory of the hardware and obtaining a remote lab platform that can be easily deployed with simple and cheap instruments and a common switching matrix.

II. OBJETIVES

One of the greatest advantages of the use of the VISIR lab is the power of its user interface. It has been developed using Adobe Flash, which allows the student to execute the same actions that would take place in the real laboratory, but in a remote way: place components in a breadboard, perform the connections between them, configure the instruments, and carry out measures over the circuit under test.

Although the use of Adobe Flash suppose a small disadvantage from a practical point of view and a drawback from the technology perspective [5] since the user needs to install the Flash Player plug-in, the great dissemination and expansion of this plug-in makes it a safe and easily deployable tool.

But from the point of view of the deployment of the VISIR lab, there are several important issues to be considered: a) the need for a PXI platform; b) to have a number of modules of the switching matrix in order to accommodate the components of the available circuits; c) to understand how the switching matrix and its management server works [6], in order to set up the matrix and describe the available circuits on the platform; d) the price both the PXI and the switching matrix.

Thus, in 2009 the WebLab-Deusto research group started to work in a new control method in order to confront and overcome these drawbacks, with the following objectives:

a) Independence the control of the instruments, in order to make possible that each institution that wants to join to the VISIR consortium would be able to use their own equipments, satisfying only a few requirements.
b) Make possible that all the instruments of the laboratory are made by a trader, without having to include any expensive and complex proprietary solution.
c) Simplify and reduce the imposed restrictions regarding to the addition of new components and experiments in the VISIR switching matrix.
d) Reduce the price of instument deployment in the remote lab.

In addition, we want to integrate the proposed control method in the WebLab-Deusto platform in order to include in this platform laboratories not only focused on digital electronics. Besides, using this platform we can benefit from its web environment advantages: the most important one is that this management system allows the professor to obtain information on the tasks carried out by each student in each of its connections. This information is not currently available in the analogous web platform of the VISIR lab.

III. PROPOSED CONTROL METHODOLOGY

As we can see at Figure 1, the proposed solution to control the hardware of the remote laboratory is based on three-level architecture. At the first level are placed the servers on which the proposed control methodology runs. This level is based on the architecture defined at the VISIR project [8], but in this case the Equipments and Experiments Server has been defined again. This re-codification is due to the requirements defined by the new control algorithm. The Measurement Server has been also adapted for this new control logic.

Second level provides the communications interface. As we have analyzed before, LXI is the selected communication system to link the instruments with the Equipments and Experiments Server. Using LXI, an instruments network has been created in the lab. Each instrument has an IP address and is connected through a hub, to the equipment server placed at first level. Obviously the physical equipment in which both servers (equipment and measurement server) run is also connected to the instruments network.

In the third level we have located the hardware which contains the components or prebuilt circuits that will be part of the available experiments into the laboratory. In this hardware the instruments are also connected in order to carry out the tests and measures required for the practical exercises. This hardware is in the remote laboratory as the breadboard of prototypes that the pupil uses in traditional laboratory to build and test their circuits.

The reason why we have raised this architecture in three levels is to allow any developer to deploy a remote laboratory based on this methodology, but using the technologies that he wants to or he has available at all times. Thus, we see below as in the first level, the equipment and experiments server is developed in LabVIEW, but following the concepts proposed in this research work based on the use of IVI drivers, this server can be developed in any other programming technology and the final outs should be the same.

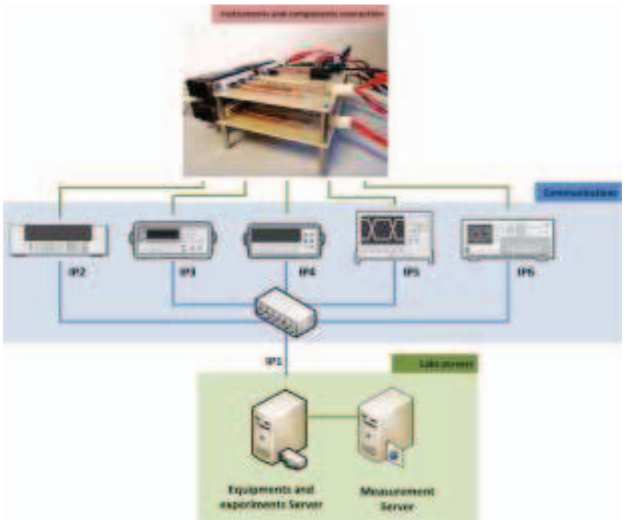

Figure 1. Proposed physical architecture

The same applies to the second level, because in this case we have used a network standard based on Ethernet, but if the instruments implement any other physical transmission interface on which to deploy the standard LXI (used in this solution), the operating result of the proposed solution, is exactly the same.

In the case of the third level hardware, it is a hardware whose function is only to host the components and circuits of the experiment, so it does not contain control logic and it could be built in any other way to rise in this solution. To build these boards, only certain aspects regarding the selected matrix must be taken into consideration [7].

A. *Selected software control methodology*

The control methodology is based on two servers:

- **Measurement server**: on one hand, it is in charge of receiving the requests sent by the user through the web client and check that they can be executed. This validation is done both for instruments and the circuits that the user wants to build in using the switching matrix.
- **Equipments and experiments server**: Its main function is to execute commands processed by the measurement server and perform measures on the available instruments in the laboratory. In other words, this server is responsible of the control of the instruments and experiments, so the control methodology that we propose will be executed in this server.

In the proposed solution, the role of the measurement server is close to the functions of the server developed in the VISIR project. In the server built in this solution, several modifications have done to interoperate with the Equipments and Experiments Server that has been completely redefined.

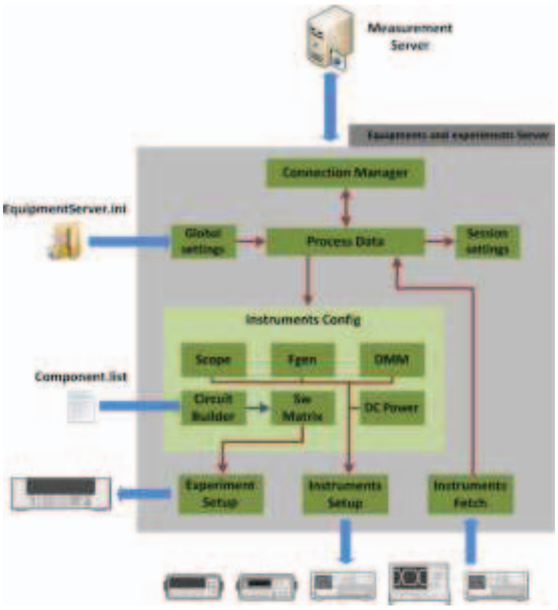

Figure 2. Equipments and Experiments Server architecture

The structure of this server (Figure 2) has been developed to allow future updates with new instruments and devices. Moreover, each developer can select the instruments available in his lab in an easy way. That is, not all the defined instruments in this methodology have to been used in all the scenarios.

The great novelty introduced in this method of control, is that all instruments are controlled and monitored using only IVI drivers. These drivers allow that only by updating certain parameters of the configuration of the server, the instruments can be replaced by others. The only one restriction is that these new instruments have to be controlled by IVI drivers.

To configure the instruments, first, the instrument IVI driver must be installed and the IVISharedComponent must be setup. When this package is setup, the file IVIConfigurationStore.xml is saved. This file contents all the updates and registers about the IVI drivers that are setup in the system. This XML file configures the relationship between the IVI driver of each instrument and its I/O reference. It also saves information regarding with the instruments' models and drivers so that just modifying the reference to the model, the instrument can be controlled without updating the code. The structure of the IVIConfigStore is shown at Figure 3.

Through this configuration system, when we want to replace one instrument with other that complains the IVI standard, we only have to perform three simple and fast steps: a) update the 'Software Module' installing the IVI driver of the new instrument; b) update the IP address assigned in the 'Hardware Asset', c) update the description that relates both modules in the 'Driver Session'.

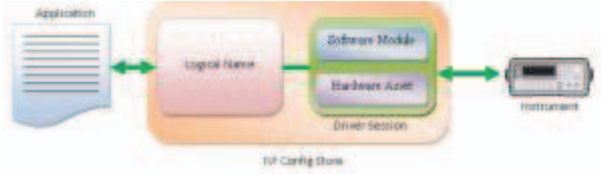

Figure 3. IVIConfig Store configuration

In this way, using generic Logical Names such as 'MyFgen' that refers to a Driver Session with a generic name like 'FunctionGenerator', the relationship Logical Name – Driver Session can be maintained unaltered during the update of the instruments of the laboratory. Thus, in the control algorithm, if the Logical Name is used when the function generator is referenced, we need not modify any part of the code although we have changed the physical instrument in the lab. This design allows the developer to use the appropriate instruments according to the lab requirements and the available resources.

In order to perform this update and configuration process, there are different tools that makes it simply: the Measurement & Automation Explorer (MAX) of National Instrument is what we have used in our methodology, although you can also find similar applications to configure applications developed in Matlab (Test & Measurement Tool) in Agilent VEE (Instrument Manager) or if the application is developed in C++, there are specific routines ready to use.

IV. CONCLUSIONS

In this paper we present a remote lab architecture independent of the instruments thanks to the use of IVI drivers. This characteristic makes possible that each institution can deploy this solution using the instruments that best fits with its performance and economic requierements. The price of this solution can be the half of using the VISIR approach, depending on the instruments adopted in the lab. Also this approach allows easy updates and reconfigurations without software reconfigurations.

This architecture has been tested in real courses where we have obtained high performance results with no errors at the measurements using different instrrments, so we can conclude that the proposed approach can be an alternative to the VISIR architecture with the same performance.

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