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Embedded Electronics Applied in Remote Laboratories Using NodeJs

Abdelmoula Abouhilal*, Amine Moulay Taj, Naima Taifi , Abdessamad Malaoui
Research Team in Electronics, Instruentation and Measurement, Polydisciplinary Faculty, Sultan Moulay Slimane University, Beni Mellal, Morocco

Abstract:
A description of the implementation of integrated practical work in a remote laboratory was presented in this paper. The student, in real time, can access an online web page in order to manipulate a practical work of digital electronics. This work is based on the use of an embedded system PcDuino. The hardware architecture and software solutions are described, as well as the supervision tool that allows the student to follow changes in the output states of the Practical Work remotely.

Keywords: e-learning, embedded systems, online manipulation, PcDuino, Remote labs.

1- Introduction:

Virtual laboratories and real remote laboratories are becoming an essential necessity in the education and teaching of certain disciplines [1–3], given the importance of practical work in order to complement the theoretical knowledge acquired in courses.

Remote laboratories have been the subject of several projects and research axes in recent years [2, 4]. Given the large number of students enrolled in open access institutions, the shortage of laboratory staff, and the lack of inadequacy of Hands-On Labs, the implementation of remote laboratories becomes an important necessity for some Moroccan universities [5]. Several architectures and methods have been used to perform Practical Works [PW] in particular in the fields of techniques such as in Automation, electronics, industrial computing, instrumentation and others [6–8]. We can distinguish the difference between the implemented architectures of remote laboratories on several levels: hardware used, number of connection nodes, number of servers, communication protocols, software platform...

We are interested in this paper on the software and hardware parts. Several architectures use server computers and expensive development boards [9, 10].

The appearance of embedded systems of low cost to give birth to architectures based on these development cards: FPGA, Arduino [5, 11–13], Raspberry [14] and PcDuino [15]. For the software part, the use of the marketed tools was a dominant solution to implement remote laboratories namely LABVIEW and MATLAB / Simulink [16]. These solutions require a significant budget during installation, deployment and also during maintenance.

Indeed, free and open-source tools are recommended to develop remote laboratories within educational institutions [11,17].

This paper presents a detailed description of a scalable architecture by describing its software and hardware parts. The proposed solution could be implemented in several school levels, for beginner or advanced courses [18]. In the first case, learners could use the system under study to get familiar with physical concept and modest hardware.

Concerning advanced courses, this remote lab could be used to implement sophisticated manipulation in several disciplines as in robotics [14], automation [18], electrical engineering [19] and

*Email: a.abouhilal@usms.ma

others practical field of education. This importance of this proposition is consolidated by test and evaluation which discussed below.

2- ARCHITECTURE

The objective of this work is to propose a light and less costly solution for establishments to implement remote laboratories for practical work. This architecture is based on a very powerful embedded system, PcDuino. It plays the role of a web server, it is responsible for providing the command interface, and managing incoming / outgoing communications and controlling the relays via its inputs / outputs. The relays are an intermediary between the PcDuino and the electronic board of the PW. This board is removable according to the requested PW and is to be manipulated remotely. The Web-cam is used to monitor the PW and the measuring instruments.

Figure-1 shows that student can connect to the PW from inside the university campus using the Local Area Network [LAN] or outside the university through Internet connection.

Students with the help of an IP address and device [PC, tablet or smartphone] connected to the lab server can access remotely to the interface web page of the PW. Then, they can manipulate the PW using the interactive buttons of the user interface. In this study, provide remote laboratory included [Laboratory router, webcam, pcduio, relay, practical work card, and the instruments] is located in the polydisciplinary faculty of Beni Mellal.

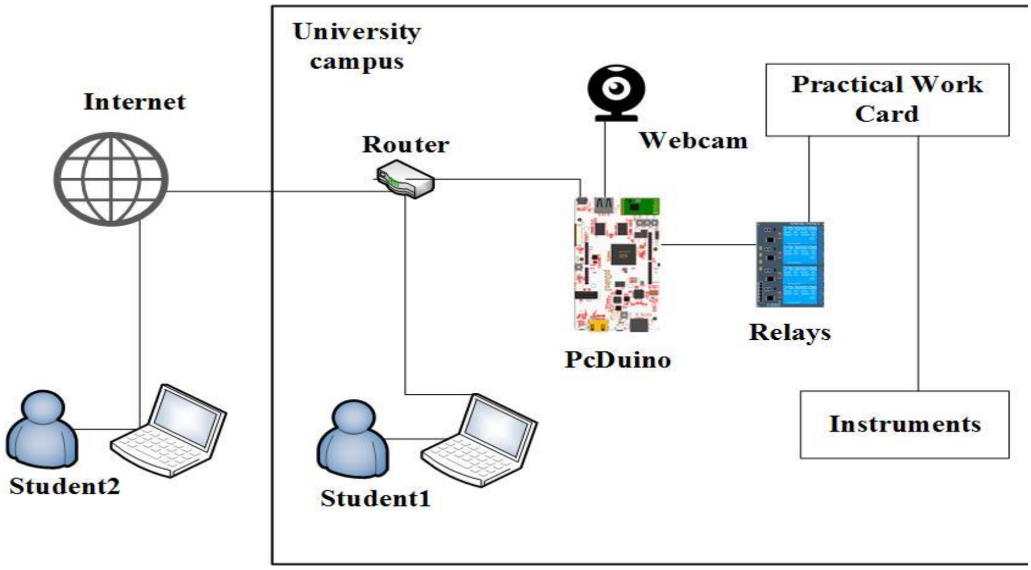

Figure 1-General architecture

3- Experience description

We developed a PW of electronics and industrial computer science for bachelor student in the sciences of physical matter, option electrical engineering, in order to test our architecture thereafter. This PW aims to learn combinatorial logic. The student must manipulate the logic gates remotely to find the type of circuit by its truth table, to measure the voltages and currents of the inputs and outputs of the logic circuits.

3.1 Software

The software structure of this remote experiment consists of 2 parts: client [student] and server.

A. Student part

The user accesses the lab remotely through a web page on a browser. This part is developed thanks to the Python Framework Flask, and HTML5 and jQuery technologies. JQuery allows sending the events that happen on the user interface, for each click on a controlled zone, the web page sends a request using the Socket to the server. This technology and the asynchronous aspect of python provide a real-time experience of handling, without any need to refresh the page. Figure-4 displays the web interface; it is composed of the components used in the card of the practical works, the connections and the control points which allow the user to control by a simple click the inputs of the PW.

B. Server part

This part is developed within the embedded system, PcDuino, which runs on a Linux operating system Ubuntu and provides full server services [18–20].

The web service provided the interface page to the client and remains listening for any new query that comes from the user. When the server detects a request, it processes it to send a command to the Input/output ports of the embedded system. This part is developed using python programming language [20]. The server sends and receives request from the client part using a peer to peer communication.

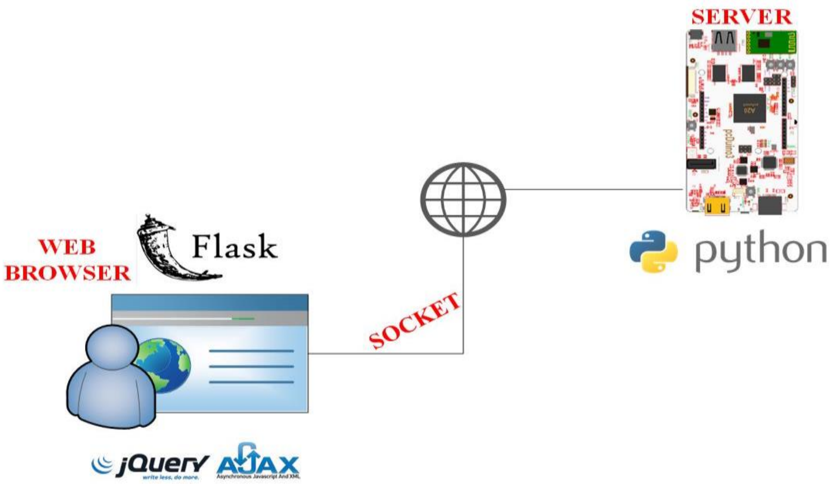

Figure 2-Used web technologies.

Hardware

Our scalable solution is based on 4 hardware parts which are: PcDuino, relay card, experience electronic board and webcam.

A. PcDuino

It's an embedded system that acts as a server and an electronic control card at a time. It runs under the Ubuntu Linux system. Thanks to its Arduino compatible inputs / outputs, this embedded system replaces an expensive server and a control board.

Thus, the PcDuino has other advantages:

•ADC : An analog-to-digital converter that will allow us to measure the voltages and currents of the card instead of using other external hardware.

•Processors ARM Cortex A7 Dual Core, 1 GHz.

•RAM: 1GB.

•Network access via RJ45 cable or Wi-Fi.

B. Relays

Control interface that converts each control comes from the PcDuino to a current flow on the PW electronic board. The relays also protect the PcDuino in case of PW of the power electronics or for any electronic board use voltages beyond 5V. The circuit which powers the relay's coil is completely isolated from the part which switches ON/OFF, this provides electrical isolation. So, we can use the PcDuino to control any electrical material safely.

C. Electronic card of Practical Work

The PW card to be manipulated contains the diagram of the PW to be tested. This is the one we will change to implement another manipulation. This card has connectors connected to relays and others to measuring instruments. This card will be designed according to the specification of each practical word.

D. Webcam

Figure 3-Camera module for PcDuino3.

A Camera is connected to the PcDuino to view in real time the changes that pass on the PW board. This camera is PcDuino compatible, inexpensive and replaces the IP cameras that are often used in remote laboratory architectures [Figure-3]. The camera is used as plug-and-play device that is making its setup very easy.

3.3 Prototype of remote practical work

This prototype was developed to test the proper functioning of our architecture. Figure-4 shows the web interface of the TP with control zones [switches] which make it possible to change the input state of the integrated circuit [switch to 0V or 5V]. The indicator LED changes according to the actual output level of the logic circuit. These changes are visualized using a Webcam accessible through a VNC [Virtual Network Connect] connection [Figure-5].

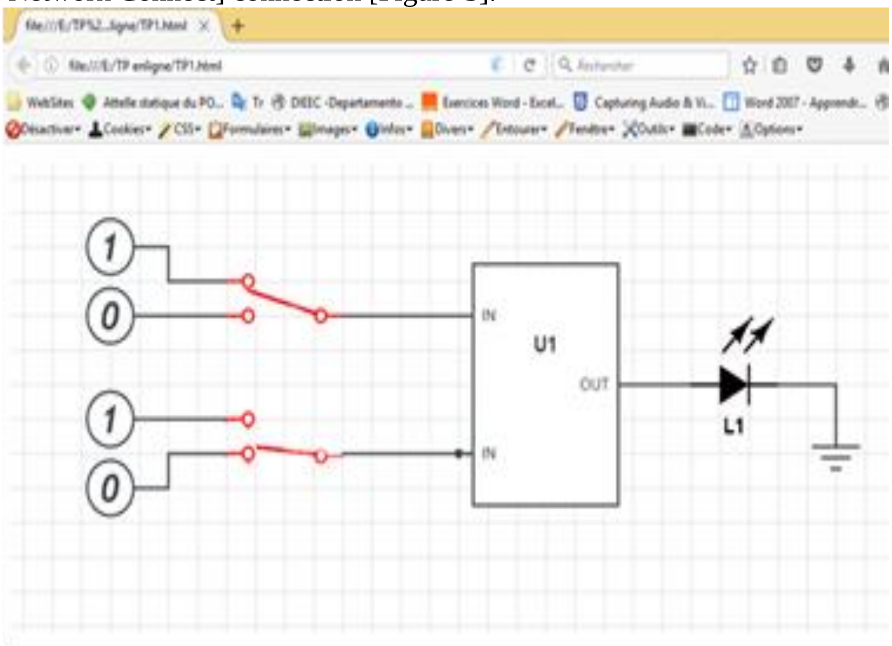

Figure 4-Practical work web interface

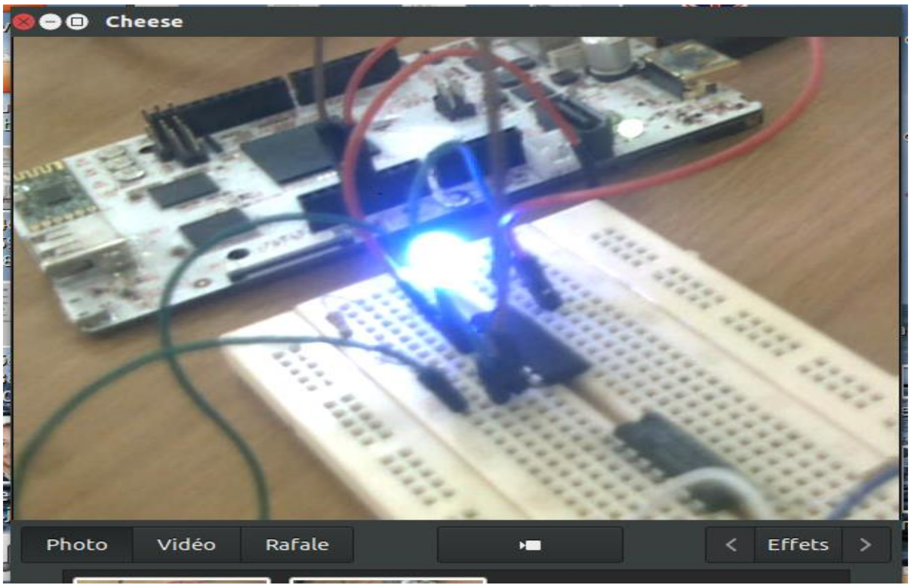

Figure 5-Visualization of the PW on the Webcam

1. Analysis and evaluation

The tests of this manipulation show that the architecture is well operational. This will lead to make other technical tests as response time, bandwidth and Competitive access. The time of realization of this experiment is in the order of one week, which is encouraging to duplicate this prototype. At the cost level, compared to the architectures mentioned above, this proposal is 3 times cheaper. Moreover, thanks to its scalability, we can develop other manipulations in a short time.

The developed interface and the embedded system used allow a real-time reactivity, which makes it possible to compare several manipulations on-line at different places. The use of this architecture can be exploited in other areas of remote control easily, thanks to lightweight and portable equipment. At the end of the test, an open question was asked to the students to express the pedagogical utility, the accessibility and the interaction of this manipulation comparably with the traditional practical works. The majority of students left positive responses.

Students were asked to give the best positive point of this system. The common answers were the flexibility and the simplicity of this study.

2. CONCLUSION

This work presented architecture of a laboratory of remote practical work developed by free open-source tools and low-cost embedded systems. This architecture is scalable and adaptable to other PWs or other disciplines. The software part is based on the flask framework of python, HTML5 and JQuery; these tools provide real-time responsiveness to the experiment. This approach is developed at the base of an embedded system that runs with an Ubuntu Linux operating system connected to internet via Wi-Fi connection. A test based on bachelor degree students on electronics and electrical engineering responses has been realized. The evaluation of this system shows its benefits and impact in the practical education. The evaluation of the approach under study shows benefit, such as a complementary or also as alternative method of teaching practical works.

3. FUTURE WORK

In our future work, additional improvements are the integration of measurement instrument in the web interface, the development of other electronic board that allow students to control measurement instrument and the development of a web management system to enable student to book time-slots for their practical works. A questionnaire will be distributed to study the satisfaction of students, teachers and administrative staff that will use this system.

Following students' recommendations given in the phase of test and evaluation, several modules will be developed to facilitate user experience such as:

- Embedding the webcam interface in the web page interface.
- Adding a webpage guideline to show how to use the web interface and to follow the manipulation instructions.

- Developing a wiki in order to keep interaction between students and teacher.
- A module to save practical work result simultaneously with the live experience.

Furthermore, additional improvements are the addition of a booking system to manage students' reservation and collaborative activities.

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