ENGINEERING GRADUATION PROJECTS IN A TRANSDISCIPLINARY APPROACH

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Abstract – This paper presents some project themes proposed by the authors and the methodology adopted in its supervision, in a transdisciplinary approach. We describe the projects and discuss the most relevant aspects of this approach, from the technical and pedagogical points of view. The stronger points of this methodology are some similarities with the environment that recent graduated students might find in the employment market. Balancing the pros and cons we conclude that due to the project interdependencies, benefits are mainly on technical skills improvement and in mutual responsibilities to accomplish tasks on schedule.

1 INTRODUCTION

Any engineering graduation curriculum includes the realization of final projects, whose themes are normally proposed by teaching staff. The main purpose of these projects is to allow students to apply knowledge taught in the various disciplines along the course, to develop their own ideas and solutions and to integrate that knowledge into one solution. Due to the complexity of the engineering problems proposed and its related workload, students are encouraged to work as a team, normally in groups of two.

The curriculum in Electrical and Telecommunications Engineering at EST-IPCB (Superior School of Technology, Polytechnic Institute of Castelo Branco) is structured in two cycles. In both cycles students have to show some practice expertise by making final projects as part of the requirements to obtain the graduation diploma. The duration of these final projects is one and two semesters, respectively, for the first and for the second cycle.

In the past two years the authors proposed to students several graduation project themes, in a transdisciplinary approach, with different objectives but with some common aspects, each one of them under one common and more general subject: domotics. Domotics has relations with a wide range of technical fields in Electrical and Telecommunications Engineering, namely, electronics and instrumentation, control and power systems, telecommunication systems and even with media and signal processing. These relations give to domotics good characteristics to conduct different project themes simultaneously. It also allows students to apply knowledge taken from several matters, to improve their skills in one particular subject and learn how to work as a team with other groups.

This paper is organized as follows. Section 2 describes the main project objectives and previous work that supported it. In section 3 we describe the several smaller projects resulting from the partition of the main project theme. Finally, in section 4 we discuss the most relevant aspects of this experience in different phases of the work and present the main conclusions.

2 MAIN PROJECT AND PREVIOUS WORK

A more general project in domotics described in the following sections supersedes two previous project themes proposed separately by the authors on the same academic year: "*Control of AC Electric Loads*" and "*Management of Intelligent Buildings*".

The project "*Control of AC Electric Loads*" [1] aimed to control linearly the speed of universal AC electrical motors, the intensity of light bulbs and power in a heater resistance. To achieve these objectives one adopted a solution based in two Microchip 16F877 PICmicro® microcontrollers to collect data from various sensors, e.g. for temperature, for luminosity (LDR), photodiodes to measure the rotation speed of electric motors and to control a local LCD display. The 16F877 also implements the communication through RS-232C serial protocol at 9600 bps to a personal computer (PC) running dedicated software application under Windows® OS. The block diagram of the system is shown in figure 1.

The system may operate in automatic or manual mode. In automatic mode the user defines the set points to each individual load either, by software applications or by adjusting knobs. In manual mode the user simply controls the loads directly, by adjusting knobs in the control unit. In both cases the power control of the three loads is made linearly by voltage methods.

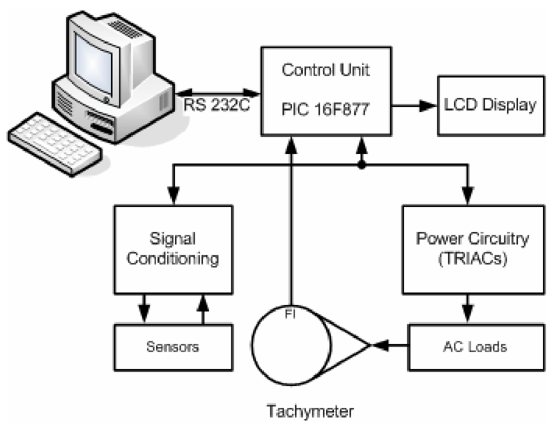

Figure 1: Block diagram for the project "*Control of AC Electric Loads*".

The zero cross detection on the AC mains generates a pulse which by its turn generates an external interrupt to the 16F877 PICmicro®, in order to improve both flexibility and performance. To measure the speed of the AC motor one used a low cost LASER pointer, a reflective band material mounted on the rotor and a photodiode aligned with the LASER beam to detect reflections. This solution was calibrated with an industrial tachymeter showing satisfactory results.

The project "*Management of Intelligent Buildings*" [2] aimed the realization of a flexible and distributed system also based on the Microchip 16F877 PICmicro®, as is shown in figure 2.

The "brain" of the system is a PC running dedicated software application in Windows® OS, implemented with threads techniques to allow other software applications to run simultaneously. The PC connects to a central unit (based on a 16F877 PICmicro®) via a serial port using RS-232C protocol. Each central unit can support up to 10 subsystems, each one of them also based on the 16F877 PICmicro®, which communicate with the central unit by RS-485 serial bus. Each subsystem can support up to 5 sensor/transducer or actuator modules (STA modules) and each STA module allows the connection of up to 8 sensors/transducers or actuators (the output from the sensors should be in voltage). This architecture allows a maximum of 400 sensors/transducers or actuators which are enough for small/medium size applications.

Among the many possible parameters for this type of applications, it was decided to consider the average temperature, relative humidity, the intensity of light, the presence of heat bodies (e.g. people) with PIR devices to switch on/off the lights, the presence of water in the basement floor and air quality. The latter especially by safety reasons, namely for the detection of carbon monoxide – CO. According to the information provided by the sensors the system has to actuate switching on/off a water pump, windows shade motors, and heating. Its also has to open roof windows in case of emergency (e.g. presence of CO).

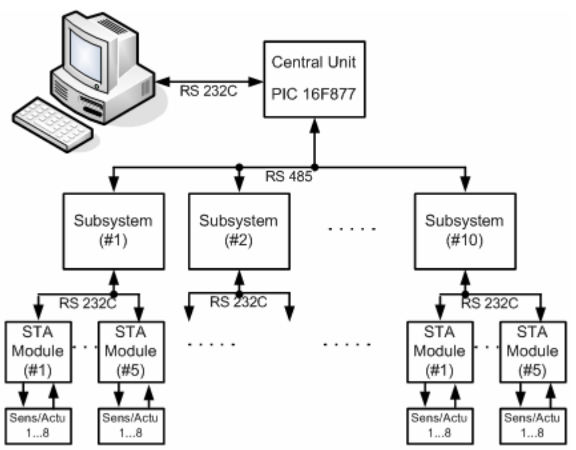

Figure 2: Block diagram of the systems for the project "*Management of Intelligent Buildings*".

Following the results obtained with these two early projects, benefiting from the experience acquired and also due to some interest shown by students and companies, we decided to join efforts to propose and supervise a more general and complex project on domotics. However, by practical reasons, due to some logistical and pedagogical aspects we decided to split it into smaller projects whose objectives, workloads and execution phases have intersections and dependencies both, in time and in technical solutions. A more detailed description of this methodology is presented in next section.

3 DESCRIPTION OF PROPOSED PROJECTS

The main objectives of the more general project in domotics involved the realization of flexible and configurable systems, able to monitor and control several parameters in buildings, namely, environmental conditions (temperature, humidity, air quality, etc.), control of AC and DC electric motors, access control, video surveillance and alarm messaging using the GSM and TCP/IP networks. This required knowledge on several multidisciplinary subjects. Among these matters one has to mention analogue and digital electronics, instrumentation, control systems, RISC processor architectures, microcontroller based systems, high and low level programming, digital signal processing and telecommunications systems (e.g. GSM and TCP/IP networks.

These objectives were somehow ambitious and it could result in a quite heavy task for students for a two semester period. In order to make it feasible in that period of time, and also to balance as much as possible the workload for the different groups, we decided to propose and co-supervise three different graduation projects, though, the workload and objectives of the main project were splitted into three graduation projects: "*Control of Intelligent Buildings with DSPs*", "*Access Control by Personal Remote Identification*" and "*Video Surveillance and messaging using GSM and TCP/IP Networks*".

3.1 Control of Intelligent Buildings with DSPs

The specific objectives defined for the project "*Control of Intelligent Buildings with DSPs*" [3] are a mixed of those defined for projects "*Control of AC Electric Loads*" and "*Management of Intelligent Buildings*". The various parameters to monitor include environmental average temperature (for each room), humidity, intensity of light (using LDRs), the detection of heat bodies and air quality, specially the detection of CO. Additional objectives for this project include environmental noise monitoring and analysis, and the possibility of communicating through TCP/IP protocol, thus facilitating access to remote installations. The system also can actuate on simple switches, AC motors, step-motors and light bulbs.

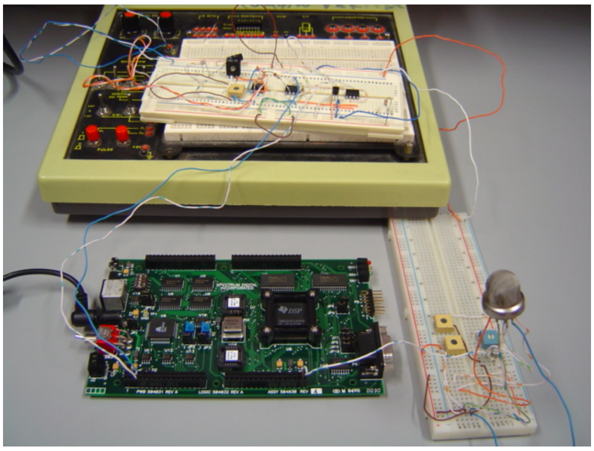

Figure 3: View of the TMS320F243 EVM and some sensors used in project "*Control of Intelligent Buildings with DSPs*".

The main difference to the previous project "*Management of Intelligent Buildings*" is the adoption of the Texas Instruments TMS320F243 DSP as controller, instead of the Microchip 16F877 PICmicro®. The option for the TMS320F243 is justifiable by the need of having an alternative to the Microchip PICmicro®, and also because DSP controllers can easily run typical DSP algorithms for signal analysis and filtering. The TMS320F243 DSP is manufactured in special for control applications and can be programmed using high level C/C++ language. One has to mention that although TMS320F243 become obsolete in 2003 it is code compatible with the new generation of DSPs from Texas Instruments for control applications: the TMS320C2x. Figure 3 shows the use of the TMS320F243 Evaluation Module (EVM) in an early stage of the project. On the right side one can see the NAP-11AS (Nemoto & Co. Ltd) air quality sensor.

3.2 Access Control by Personal Remote Identification

Access monitoring, control and management are usual requirements in both particular and public spaces. In this type of systems, information is relevant for entrance allowance, to know if someone is authorized to stay in one particular area and for any management purpose one may find useful. On the other hand, remote identification by radiofrequency (RFID) systems also has a wide range of applications.

Based on these two types of systems we defined the main objectives for the project "*Access Control by Personal Remote Identification*" [4]. These objectives include the realization of a system composed by base stations, fixed on walls, and remote mobile stations (e.g. a badge) that any user must carry with, and which act like a portable identifier. The block diagram of this project is shown in figure 4.

Base and mobile stations can use either the CMOS technology MSP430 microcontroller from Texas Instruments or another microcontroller, e.g the 16F84 PICmicro® devices from Microchip. One must notice that for the mobile stations one must use the microcontroller with the lower power consumption.

Base stations communicate with a remote PC via TCP/IP protocol through the LAN cabling network. However this is not an objective defined for this project at this stage. The defined objectives for this project only include the blocks inside the dashed line in figure 4. Both, mobile and base stations communicate via infrared emitter/receiver devices, using TDMA techniques in half duplex mode.

Base stations are responsible for supervision of a given area (e.g. room), monitoring for any abnormal event, e.g. if the user carrying one particular identifier has not privileges to enter or to stay in that area. In case of normal or abnormal situations base stations have to "inform" the identifier of its status. Then the identifier must show a Green or a Red LED, in case it receives an "OK" or a "FAIL" on the authorization request. Figure 5 shows the prototypes developed for the base and mobile stations where one can notice infrared devices and the MSP430 developer kit.

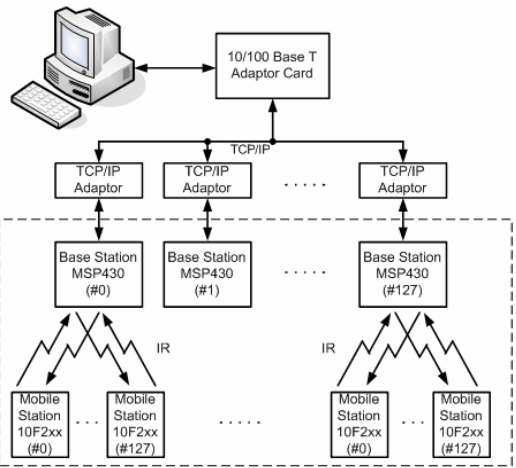

Figure 4: Block diagram of for the project "*Access Control by Personal Remote Identification*".

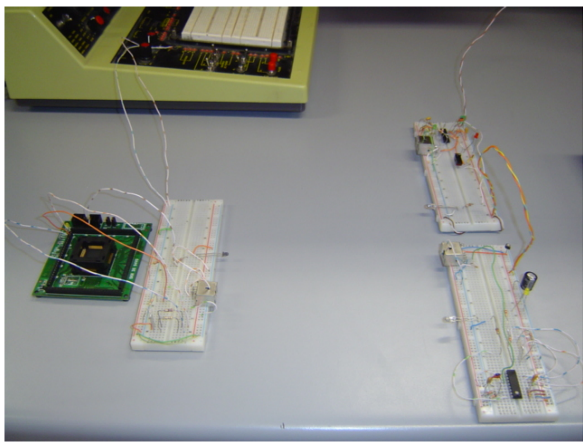

Figure 5: View of the base and mobile stations prototypes (left and right, respectively) of the project "*Access Control by Personal Remote Identification*".

3.3 Video Surveillance and messaging using GSM and TCP/IP Networks

The objectives and themes referred in previous projects focus on typical applications in domotics. One of the subjects still open was video surveillance which also allows several potential applications for digital signal processing and telecommunication matters. The main objectives defined for the project "*Video Surveillance and messaging using GSM and TCP/IP networks*" [5] include the development of a low cost video surveillance system based on a PC, with event driven capabilities and able to send messages through the GSM and TCP/IP networks. The main idea is to monitor some areas with video cameras and send SMS messages to predefined users, or send messages trough the TCP/IP network to remote computers, in case of any event detected. At the same time the system has to start recording video sequences (from the camera associated to the event) in the hard disk. The all system is controlled by software application running at the PC. A view of the all system diagram is presented in figure 6.

Because PCs are so popular, and due to the low cost requirement, one considered the use of underused consumer equipment that anyone might have. With these in mind it was decided to use webcams as video sources, mainly because webcams are cheaper, its video signals are digital and communicate with the PC at higher rates through USB ports.

It was decided to add some extra functionalities by using an analogue video camera connected to a Pinnacle Pro PC TV card (mounted inside the PC) to digitize video and a VCR to record its signal. The Start/Stop commands to the VCR are made trough infrared protocols for the major VCR manufacturers. These protocols were implemented in a PIC16F877 PICmicro® with infrared emitters.

To send messages through the GSM network they used a Siemens TC35i GSM module connected to a serial PC port and control it via AT commands. Messaging trough TCP/IP networks is made via the available RJ45 LAN connections on the PC.

The software to control the all system was developed using Windows API modules for media, graphics and TCP/IP, and based on the Microsoft SDK 9.0. The software was customized for a maximum of four cameras, either analogue or digital (webcams). However it is possible to connect more cameras by using the appropriate number of hubs or hub ports, also with the necessary software modifications. The event to start recording video is obtained by considering the changes on sequences of images and analysing the amount of energy on the difference frames in order to a given threshold.

The recording of video sequences in the hard disk considers only the video signal from the event driven source using a very simple DPCM coding with a frame reference for each 8 frames of video.

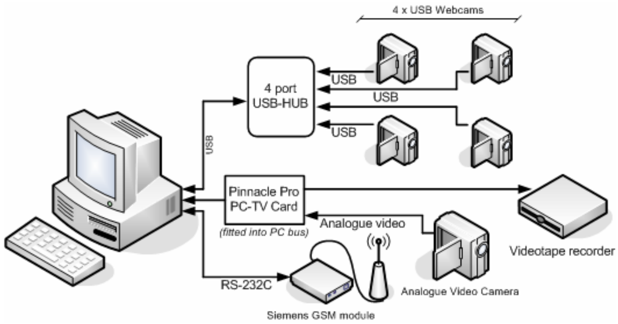

Figure 6: General diagram of the project "*Video Surveillance with messages using GSM and TCP/IP networks*".

Figure 7: View of the project "*Video Surveillance with messages using GSM and TCP/IP networks*".

Figures 7 shows a view of part of the system where one can see three webcams, the TC35i GSM module and a detail of the application running only with two cameras activated. The USB hub is behind the laptop.

4 DISCUSSION AND CONCLUSIONS

In this section we discuss the methodology adopted referring its major benefits and some weak points.

Proposed projects have close relations and dependencies; though tasks accomplishment with success and on schedule is an important issue. This is much like what recently graduated students may find in industry, and at the same time gives students more responsibilities on common success.

As projects have close interrelations, students have to know some details of technical problems and solutions of other partners while, as counterpart, they have to report their own difficulties and proposed solutions. This methodology implies some regular and scheduled meetings, especially on early phases of the projects. This was not a simple task to accomplish as there were some difficulties on finding a common agenda. On the other hand, as students have different individual motivations, objectives and skills one registered different performance results, with direct consequences on the work of each group. Due to this factor, sometimes one needed to reschedule or redefine objectives and readjust the workload.

Other important issue to pay attention for is the student's workload with exams on other disciplines and personal relationship among all intervenients. The first can generate some dispersion and low performance results or even out of schedule task accomplishment. This factor, in conjunction with some bad relationship, bad results on project tasks, difficulties and stress, usually generate anxiety, very low motivation and may lead students to give-up. Fortunately, from our experience, students worked perfectly with each other, and one registered a good partnership co-operation from all.

According to our opinion, based on this particular experience, the main strong points of this approach are the similarities with the possible environment one may find in the employment market, the technical skills improvement due to the reciprocal sharing of information and mutual share of responsibilities to accomplish tasks on schedule. According to the general enthusiasm demonstrated by the students we find that the final result of this approach is positive. Finally we find that Domotics revealed to be a good general theme to this kind of approach due to its intersections and applications on almost any field of technical knowledge in the areas of Electrical and Telecommunications Engineering.

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