INNOVATIVE MOBILE COMMUNICATIONS ENGINEERING TEACHING LABORATORY USING PROFESSIONAL NETWORK TESTING TOOLS

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Abstract

The European Higher Education System represents an opportunity to develop novel teaching-learning methods more focused towards an active participation of the student. These methodologies are bound to play a very important role in engineering education that increasingly requires the understanding of highly complex systems. In this context, this paper presents an innovative teaching laboratory designed to reinforce the understanding of the theoretical concepts taught in lectures, and the understanding of the operation of mobile communications systems. To this aim, the laboratory uses advanced professional network testing tools, and is designed around the active participation of the students in field trials devoted to analyze the operation and performance of mobile communications systems.

Keywords: Innovative teaching laboratory, professional tools, engineering education.

1 INTRODUCTION

The European Higher Education System represents an ambitious plan to promote European convergence towards richer education and develop novel teaching-learning methods that ensure students' mobility, competitiveness and employability. These methodologies should not only be more focused towards an active participation of the student in order to reinforce the understanding and learning of technical concepts, but should also help developing life-long learning capabilities that increase the student's career prospect and capacity to adapt to different professional experiences. However, the implementation of such teaching methods in engineering education is especially difficult when dealing with complex systems characterized by the constant and dynamic interaction of their elements. This is for example the case of mobile communications systems that acquire practical sense when studied at the system level, analyzing how the various component parts interact.

In this context, this paper presents and describes an innovative teaching laboratory designed to reinforce the understanding of the theoretical concepts taught in lectures, and the understanding of the operation of mobile communications systems. The laboratory is designed around the active participation of the students in field trials devoted to analyze the operation and performance of mobile communications systems. To this aim, the laboratory uses advanced professional network testing tools (in particular, Anite's products Nemo Handy and Nemo Outdoor) which are commonly used by telecommunications engineers working on the deployment, maintenance and optimization of cellular systems. The laboratory conducted at the University Miguel Hernández of Elche (UMH) has resulted in a better understanding of the technical concepts taught in lectures, and a more dynamic and enthusiastic participation of the students in the course. In addition, the use of professional tools within the course has further motivated the students, since they see it as an opportunity to improve and differentiate their curriculum as they are ready to enter the job market.

The rest of the paper is organized as follows. Section 2 briefly presents the theoretical concepts taught in the Mobile Communications course. The capabilities of the professional network tools used to analyze the performance of mobile communications systems are presented in Section 3. Section 4 provides a detailed description of the innovative laboratory presented in this paper, and Section 5 concludes the paper.

2 MOBILE COMMUNICATIONS COURSE

The Mobile Communications course at UMH is designed to cover all basic concepts behind the design and operation of mobile communications systems, and introduce with some level of detail the most common communications standards, i.e. GSM and UMTS. To this aim, the course first explains in lectures the basic principles behind the operation of mobile communications systems such as the radio communications fundamentals and cellular system principles. The main purpose of this introductory learning phase is to introduce the student to the basic architecture (Figure 1) and opportunities/restrictions of any mobile communications system. These lectures cover from the characterization of the radio channel and the study of diversity mechanisms, to the analysis of the most significant communications techniques that allow multiple users accessing the radio channel simultaneously. After this introductory learning phase, lectures continue with the study of the basic elements that integrate a mobile communications system. The complex architecture and structure of these elements (base station, mobile station, core network), and the way in which they constantly and dynamically interact, is introduced with some level of detail for the standards GSM and UMTS. The course continues with the laboratory presented in this paper, which is detailed in the next section.

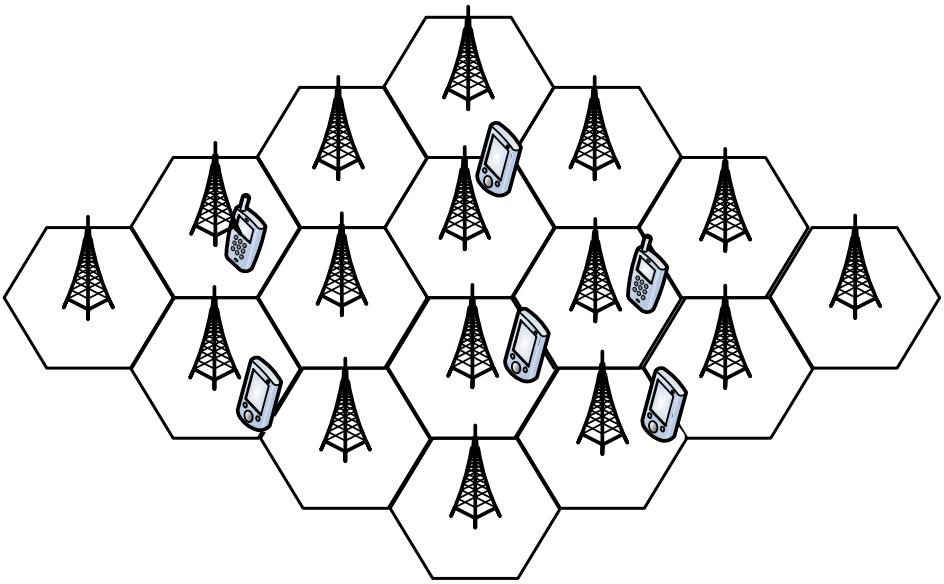

Figure 1. Basic architecture of a mobile communications system.

3 INNOVATIVE LABORATORY THROUGH PROFESSIONAL TOOLS

The laboratory tools used to study complex mobile communications systems need to be reliable, user-friendly and provide detailed analysis results. Anite's solutions, Nemo Handy and Nemo Outdoor, fulfil these capabilities. Nemo Handy is a powerful network monitoring application that runs on an engineering mobile handset (Nokia 6720c). Nemo Handy is able to obtain extensive network parameter and measurement data captured over voice and video calls, FTP/HTTP data transfers, HTML/WAP browsing, iPerf testing, video streaming, SMS/MMS messaging, e-mail and ping services. The Nemo Handy application also provides spatial and time synchronization through an external GPS connected via Bluetooth. With a set of configurable views, the tool provides the status of the cellular network in real-time, although it also offers the possibility to store all the network parameter monitored by the mobile handset (including signalling messages) for post-processing. This post-processing is done using the Nemo Outdoor tool, which offers a comprehensive workspace and a valuable set of key performance indicators (KPIs), such as the operation band, the strength of the received signal or the end-user performance of the service demanded. The analysis of the obtained measurements let telecommunications operators plan the base station deployment, and carry out maintenance and optimization tasks. Figure 2 and Figure 3 show an example of the potential of the Nemo Outdoor tool used by the students, as well as some of the measurements exported to Google Earth.

Figure 2. Nemo Outdoor's workspace.

Figure 3. Measurements exported to Google Earth.

4 ORGANIZATION OF THE LABORATORY

The following sub-sections describe the learning program based on the use of professional tools and designed for the Mobile Communications course.

a) *Sessions to introduce professional tools and training*. Following the theoretical lectures described in the previous section, the laboratory begins by introducing students to the use of the tools Nemo Handy and Nemo Outdoor. Through faculty-led classes, students discover the potential of the tools, and learn its configuration options and the most significant parameters, graphs and statistical characteristics of mobile communications systems that can be observed, measured, and analysed with the tools. Figure 4 shows the handset employed in the laboratory, as well as some views of the software tool Nemo Handy. These views provide real-time information and statistics on the performance of the cellular network.

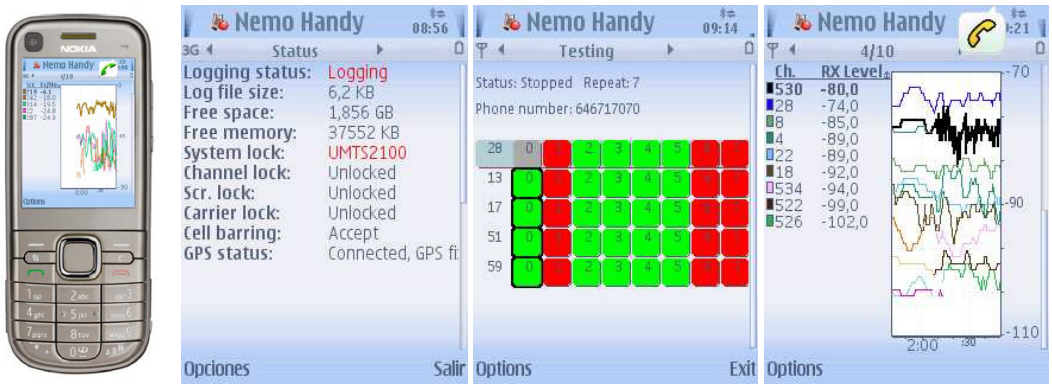

Figure 4. Handset and different views of the Nemo Handy tool.

b) *Field measurements session*. To better assimilate the training acquired in the sessions previously described, field measurements are performed in a particular area of the city of Elche. In the field measurements session, the students learn how to analyze the operation of a mobile communications system by testing the performance of different base stations. The measurements are conducted in the presence of the course supervisors following a guide provided by the lectures that includes detailed instructions to perform the measurements and a list of effects to analyze. The guide also includes the location and identification of the base stations in the area of interest that the students will need to analyze[1]. This phase of the learning program allows students to analyze the performance of a real cellular network, performing tasks typically conducted by engineers during planning, maintenance and optimization of cellular networks. Students configure the Nemo Handy tool to store, among others, all the signalling messages exchanged between a mobile phone and the network during voice calls. In these field trials, additional tests are also conducted to verify the correct operation of different processes such as channel assignment, handover (call transfer between cells), as well as tests focused on data transmissions.

c) *Measurements analysis in the laboratory*. The measurements obtained during the field tests are then analyzed by the students with the guidance of the course supervisor, and using the Nemo Outdoor tool. In this session, the course supervisor teaches the students how to process, analyze and understand the conducted measurements. The objective of this session is not only that students learn how to use the post-processing tool, but also how to analyze the measurements, and draw conclusions about them in a reasoned manner.

d) *In-depth training*. The students have the option of attending the laboratory to further improve their learning and training under the supervision of the course supervisors.

e) *Field tests and analysis*. The students are organized in small groups to conduct themselves a set of field tests, following a guide similar to that used by the course supervisors in the *Field measurements session*. Each group is assigned a different area of the city of Elche, in which the field tests will be conducted. In this session, the students should be able to configure the Nemo Handy tool on their own to conduct and store the measurements, without the help of the course supervisors. Once the field tests are completed, each group analyzes in the laboratory the measurements obtained using the Nemo Outdoor tool. This analysis in groups encourages the debate/discussion on the results and obtained conclusions, which reinforce the understanding and learning of technical concepts.

f) *Presentation and evaluation*. Finally, the laboratory ends with an oral presentation where the students explain the measurements conducted, the effects they have observed, and their main conclusions about the current operation of Orange's mobile communications network. In this session, the course supervisors evaluate the process followed by each group to conduct the measurements, and the depth of the analysis. In this process, the students are encouraged to detect potential anomalies in the operation of the cellular network, and propose possible solutions. Both the individual and the group work are evaluated.

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[1] Orange Lab, through a collaboration agreement with the University Miguel Hernández of Elche, has provided the location and identification data of its mobile phone network in the area of Elche. The agreement also includes SIM cards that allow unlimited field testing at the maximum possible speed of the cellular network.

5 CONCLUSIONS

This paper has presented an innovative teaching laboratory implemented at the University Miguel Hernández of Elche, designed to reinforce the understanding and learning of technical concepts. These methodologies are bound to play a very important role in engineering education that increasingly requires the understanding of highly complex systems. After two years of experience in the Mobile Communications course, a greater dynamism and enthusiasm of students has been observed, as well as a better assimilation of the concepts explained in theoretical lectures. Additionally, the presented innovative laboratory provides to students a greater satisfaction with regards to the use and configuration of professional tools, which clearly improve their position to enter the job market. Currently, the authors are exploring the potential use of the practical procedures exposed in this paper during the whole teaching process.

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