Role of M2M communications laboratory formed within BENEFIT project in education processes at FEE-UNI

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Abstract. *This paper describes the Machine-to-Machine communications laboratory founded at Faculty of Electronic Engineering, University of Nis, within Erasmus+ project BENEFIT. The laboratory is organized in collaboration with Nis Cluster of Advance Technologies NiCAT that is an industrial partner of UNI at this project. The paper presents the purchased laboratory equipment, some established exercises and measurement setups for student practical work in laboratory and researchers activities at the Faculty of Electronic Engineering.*

1 Introduction

Creation of joint university/industry labs and modernization of the lab infrastructure is the task T3.2 defined in BENEFIT project activities. The University of Klagenfurt (UNI-KLU) is the task leader. Every project partner from Western Balkan High education institutions (WB HEI) are involved in this activity and six joint university-industry labs have been developed during the project:

1. University of Banja Luka: "Signal Processing in Telecommunications Lab" in collaboration with Bicom and AlfaNum;
2. University of Sarajevo: "Telecommunications Lab" in collaboration with BIT Centar;
3. University of Tuzla: "VoIP Services Lab" in collaboration with Bicom and BIT Centar;
4. University of Belgrade: "IoT Networks Lab" in collaboration with CISCO;
5.University of Nis: "Machine-to-Machine Communications Lab" in collaboration with NiCAT;
6. University of Novi Sad: "Wireless Communications and Information Processing Lab" in collaboration with RT-RK and Saga.

The new laboratories equipment and infrastructure established in agreement and cooperation with industry partners should enable students the new trainings and internships. The different teaching methodologies adopted within project BENEFIT, which include student projects, problem related tasks, and competitions, relay on practicing in laboratory. Moreover, collaboration with industry in creation of laboratory challenges and advance solutions will provide new knowledge, skills and job competencies and opportunities.

2 Machine-to-Machine Communications Lab - University of Nis in collaboration with NiCAT

Various kinds of new equipment were purchased in project BENEFIT and have been used for development of new lab sessions for different courses. Laboratory exercises setups have been established and modernized as well as new practicums for lab instructions and video tutorials are under preparation. Operational agreement with NiCAT industrial partner was signed. Due to Covid19 pandemic the join activities implementation in collaboration with industrial partner are impeded but will be continued when the adequate conditions for laboratory development are acquired. The list of equipment in the Machine-to-Machine Communications Lab at the UNI purchased during the project BENEFIT is as follows, [1]:

1. **Software packages**: LabVIEW Full Development System , Matlab for education
2. **Computer equipment**: Blackmagic Design SmartScope Duo 4K + DeckLink Studio 4k, Computer Altos Extreme II, Intel Core i7-8700K/32GB/SSD 480GB/HDD 2TB/nVidia RTX 2080), Laptop HP Envy 13-ah0006nm, 4TT50EA
3. **Software define radio platforms**: NI USRP-2901 , FPGA ZC706 Board + AD-FMCOMMS5-EBZ RF transceiver
4. **Electronic circuit devices and educational kits:** Aaronia low-noise amplifier UBBV 0910 , XBee S2D ZigBee Mesh Kit, NI ELVIS II+ Hardware (For academic use only)
5. **Drone:** DJI Dron Mavic Air Fly More Combo (Arctic White)+Tablet Lenovo IdeaTab4 8 (8504X) + 8.0"HD IPS,QC 1.4GHz/2GB/16GB/FaceUnlock/4GB/Andr 7.1
6. **Measurement equipment:** Vector signal generator VSG25A ,Spectrum analyzer USB-SA44B
7. **Optical equipment:** Mechanism for laser coupling with mono mode fiber MBT612D/M, with Olympus lens RMS20X
8. **Audio equipment:** (Microphon NTi Audio M2230, Sound source NTi DS3, NTi Audio tripod NTI 600 000, Calibrator NTi 94/114 dBSPL)

The listed equipment purchased within the BENEFIT project enables the students and researchers to get acquainted with capabilities and potentials of new trends in the communications technology. The mentioned equipment includes software packages MatLab and LabVIEW as well as important hardware components. This equipment is planned to be used in

laboratory work and research projects present within various courses accredited in UNI. The hardware can be divided in several categories. The items listed in group 3 and 4 belong to the category that will enable students to have practical experiences of working with architectures and programming of up to date hardware for contemporary communication technologies and systems such as M2M in IoT and WSN. Audio equipment, group 8, will broaden communication opportunities by using different sound-based hardware platforms. Additionally, computer equipment and software defined radio platforms, category 1 and 3, can upgrade students and teachers knowledge related to modern technology in monitoring real time video transmission processes as well as signal processing (video, data) required in communication world. The category of measurement laboratory equipment, 6, containing signal generators, measurement instruments, and supporting devices will enable generating various laboratory measurement setups and laboratory exercises. The laboratory work in the domain of optical communication systems will be modernised using the items from group 7.

In the application for BENEFIT project, we planned the equipment item *NI WSN Starter* for education in the field of Wireless Sensor Networks (WSN), but the manufacturer National Instruments did not offer this equipment in the time of equipment ordering procedure. The equipment set that adequately replaces the *NI WSN Starter kit*, and properly complements the purchased equipment is also acquired, and it includes the following items:

1. **Development boards:** Zigbee Development Tools (802.15.4) OpenMote B (Super LOW consumption IoT board 2.5GHZ / SubGHz SMA Antena), Development Boards & Kits - ARM Zedboard + SDSoC
2. **Antennas:** Ant Ext 0.617-3.8GHz SMA, Antennas Ext ISM868/915/2.4 SMA
3. **LoRa system equipment:** RF Modules LoStik – EU, RF Development Tools LoRa(R) Technology Eval Kit – 800, Gateways 8 Channel LoRa Gateway Kit comes with Raspberry Pi LoRa and GPS
4. **RASPBERRY PI Platforms with supporting devices:** Single Board Computers RASPBERRY PI 4 MODEL B, 4GB, , Acrylic Case with Fan, Power Supply 15.3W USB-C with 1.5M Cable 5.1V 3A, 16GB Card with NOOBS 3.1 for Raspberry Pi Computers
5. **Audio equipment:** Audio amplifier, Art Pro Audio SLA1 , Audio card, Focusrite, Scarlett 6i6, 2nd Gen
6. **Additional equipment:** USB Cables / IEEE 1394 Cables USB 2.0 M TO F STRAT 2M CORD, Interface Modules 7 Port USB Hub

Our standpoint is that this equipment will enable us to offer wide and thorough practical education in the area of WSN. The listed equipment will offer students opportunity to form the diverse topologies of WSN supported by contemporary communication technologies and protocols (such as Zigbee, LoRa etc), as well as to track, measure and visualize the network parameters.

BENEFIT team from UNI is engaged in forming laboratory exercises for students and guidelines with instructions for the equipment usage. The installation of all equipment will be finalized after the pandemic.

3 Description of some measurement setups

In this section, some measurements setups formed in M2M communications lab as well as their functions and activities of students and researchers are described.

3.1 Circuit design

NI ELVIS II+ in combination with LabVIEW software makes a unique platform for circuit design, simulation, testing and prototyping for exercises in the field of electrical engineering. Laboratory and workshop exercises at FEE UNI were designed to support theoretical classes in circuit design areas: voltage and current measurement, Ohm's low, voltage and current divider, amplitude and phase response of passive and active filters, etc. Theoretical and practical teaching is realized, as well as the active participation of students in the creation and performance of exercises.

National Instruments provides a software suite for the NI ELVIS II+, which has an instrument panel that includes LabVIEW VI's for an oscilloscope, digital multi-meter (DMM), function generator (FG), bode-plot analyser (BPA) etc., which are all configured to work with the NI ELVIS II+, so that students do not require LabVIEW experience to use it.

3.2 RF power amplifier linearization

In order to perform linearization of RF power amplifier by the method that uses even-order nonlinear digital signal, which has been developed by the researcher group from FEE UNI department of Telecommunications. and to demonstrate the results practically the measurement place on Figure 1 was set up. The fabricated two-way asymmetrical Doherty amplifier was excited the useful 64QAM signal and the required second-order nonlinear signals for linearization, which were generated by using NI USRP platforms.

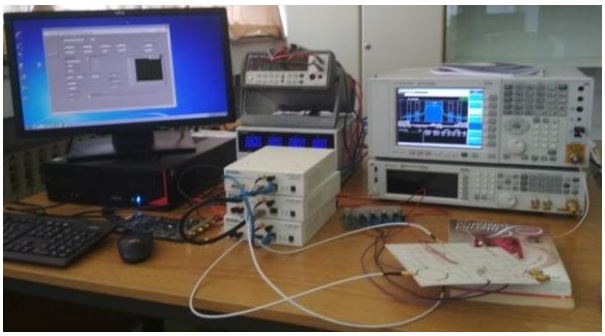


Figure 1. USRPs applied in measurement setup

The USRP platforms were programmed by LabView software to generate the required useful QAM signal,

the signals for linearization, and to control the parameters for the linearization-amplitude and phase. The measurement output spectra for the states before and after the linearization were carried out for different signal power levels.

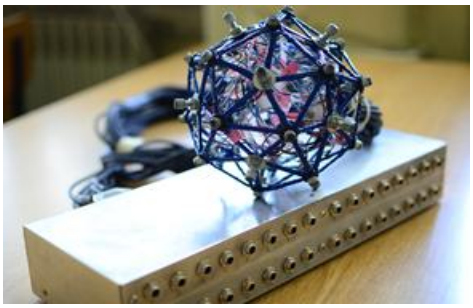
3.3 Smart Home concept

The student bachelor thesis [3] is devoted to the design and realisation of a Smart Home prototype with some basic functions and performances, Figure 2. In addition to theoretical concept of the Smart Home, open hardware platform Arduino UNO and open-source software MQTT Broker and Node-RED are used to monitor and control various devices in the home such as lighting, temperature, movement and some electrical component within the house that can be included in the system. The system is design to operate on a local area network meaning all devices are wired or wirelessly connected to a local WiFi router. MQTT is used as a protocol to communicate between Smart Home devices. Sockets controlled by RF signal and ESP8266 WiFi module are used for switching on and off the device from the power supply. The DHT sensor for temperature and humidity and PIR sensor for movement readings were used. The real-time status of the sensors is displayed on LCD display. The user controls Smart Home system over application on computer or mobile phone. The components applied for the realization of Smart Home concept are procured earlier by some financial supports out of project BENEFIT. It should notice that they are integrated into the laboratory to encompass and complete the concept of M2M communications. In addition, Smart Home example realized in the laboratory is to be further deployed and upgraded by using the equipment purchased in BENEFIT to form another system such as LoRa or by using communications with Zigbee technology.

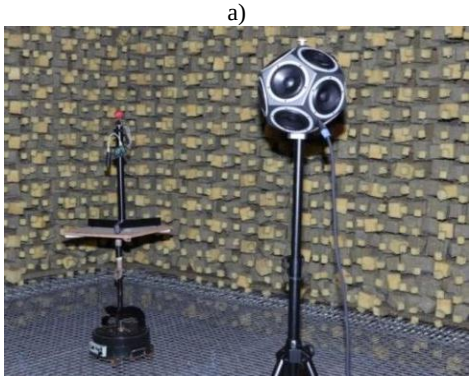
Figure 2. Concept of smart home

3.4 Comprehensive audio system design

Audio technology has recently been passing through a rapid development. It can be considered that important breakthroughs are related to application of digital signal processing, artificial intelligence (AI) and embedded systems. Although classical sound acquisition, processing and reproduction are still widely used, advanced AI-based systems and components have become predominant for a number of tasks. One of such component is a sound acquisition unit based on a spherical microphone array , which are used for spatial sound field analysis.



a)



b)

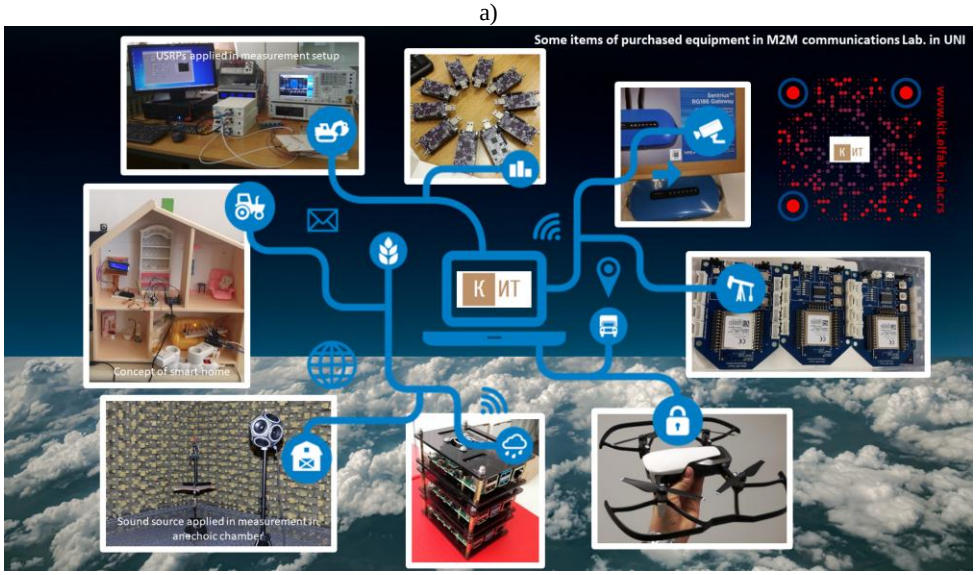
Figure 3. a) Spherical microphone array in an open configuration, b) omnidirectional sound source applied in measurement of closed spherical microphone array in the anechoic chamber

At the laboratory of Acoustics - one of the labs of the department of Telecommunications at FEE UNI, two specific spherical microphones arrays have been realized. The first one is 32 channel spherical microphone array in an open sphere configuration, see Fig. 3(a). The second one, realised by the partner company innSono, is the closed spherical array having 25 microphones. This array in the anechoic chamber of the FEE UNI is presented in Fig. 3(b). One of possible applications of the audio equipment purchased through the BENEFIT project is the measurements of acoustic transducers and systems including spherical microphone arrays. The setup for such a measurement is shown in Fig. 3(b).

3.5 Optical wireless and fiber transmission

Optical wireless represents an indoor alternative to RF transmission which is becoming more congested by the day. Laboratory will make use of this concept to enable student’s hands on experience with free-space optical transmission in M2M environment. In an industrial environment, with lots of noise and interference, signal path may require optical fiber transmission to avoid being contaminated. This is one more topic to be offered at the lab, including exercises with coupling light into optical fiber.

a)



b)

Figure 4. M2M communications laboratory leaflet: a) front page, b) back page

4 M2M communications laboratory leaflet

In order to inform future students of Communications and information technologies module with M2M communication laboratory and its potential, we are proposing in this paper the leaflet represented in Figure 4. It includes fundamental information about M2M laboratory, the equipment, established measurement setups and laboratory exercises. Also, the leaflet includes QR code related to the module enabling the all interested students and others to read more on webpage www.kit.elfak.ni.ac.rs and to find out about our module, study structure and programs, courses, teachers, projects, internships, job offers and opportunities.

5 Conclusion

In this paper we presented the M2M communications laboratory, the purchased equipment, the formed laboratory measurement systems, as well as leaflet that includes relevant information related to the laboratory. Despite the recent global health issues and their impact on education, we have successfully set up the proposed M2M lab in anticipation of crisis resolution. The laboratory will make another useful resource that is going to strengthen the educational direction towards communications, in accordance with project's goals.

References

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