Annotations of the scientific works
of Associate Professor, PhD, MEng Dimitar Mihailov Tokmakov
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- **PhD Thesis**

Tokmakov, D.M., Distributed Internet-based Performance Support Environment for Individualized Learning (DIPSEIL) - Dissertation for awarding educational and scientific degree "DOCTOR"
(COBISS.BG-ID-1263687652), https://plus.bg.cobiss.net/opac7/bib/1263687652

The dissertation presents our experience in the design, development and using of Distributed Internet based Performance Support Environment for Individualized Learning - http://www.dipseil.net - in students' learning process in engineering disciplines – electronics, informatics and communication systems. The main characteristics of the performance-centered approach in university education are described, as well the architecture of DIPSEIL and its functional and conceptual model.

DIPSEIL apply methods of performance support systems to university educational process and put task performance in the center of learning. The information work-flow of educational content from remote servers to students is controlled by specially designed DIPSEIL communication server which main functionality are also presented. The principles and methodology of DIPSEIL design and implementation are well described. The dissertation also shows the steps for designing a distributed learning management system using a structured methodology ED4.

The following scientific and applied results were identified:

1. The main resources and methods for design of Distributed information systems were investigated and their requirements were defined such as: multilayer client-server architecture in which the third layer consist of multilayer responsible for the business logic of the system; absence of data replication between server nodes and solution for mutual exclusion mechanism;

2. Investigation on standards for modern e-learning such as: IMS LOM, SCORM, PAPI, IEEE LTSA and some of the well-known commercial and open source Learning Management Systems. According to this investigation were made a specification how these standards have to be implemented in a distributed environment and especially for the physical distribution of the learning content;

3. A distributed model – Distributed Internet Performance Support System (DIPSS) were made as an evolution to IPSS model;

4. DISPEIL conceptual model were developed addressing the specific needs of IEEE LTSA for physical and geographical distribution of the learning content.

5. Functional model of DIPSEIL were developed and the corresponding multilayer architecture for the learning content distribution;

6. The models of DISPEIL Learning objects (IPSS_EE Los), Adaptive system model (ASM) and Sequencing and Navigation model were identified with regard to the distributed nature of the system;

7.A whole project for multilayer client-server architecture were developed in which the third layer is a collection of multilayer responsible for the business logic of the Distributed Internet based Performance Support Environment for Individualized Learning;

8. A prototype of DIPSEIL learning environment was made, and was investigated in real learning situations in 5 European Universities;

- **Articles**

➢ **Articles that are referred and indexed in worldwide databases with scientific information**

Г7.1 **Tokmakov, D**., Mileva, N., PROJECT-BASED LEARNING BLENDED COURSE IN COMPUTER MODELING AND SIMULATION IN ANALOG ELECTRONICS, INTED2019 Proceedings,13th International Technology, Education and Development Conference,11-13 March, 2019, Valencia, Spain, pp.5900-5906, DOI: 10.21125/inted.2019.1444, ISSN2340-1079, https://www.webofscience.com/wos/woscc/full-record/WOS:000541042200131

(Web of Science)

This paper describes the results of a blended Project based learning course on computer modeling and simulation of electronic circuits in the field of Analog electronics.

The course is compulsory for students of engineering specialties in the field of communication and computer engineering. The objectives of the course, the structure of the curriculum content, the type and the specificity of the studied and simulated electronic circuits are presented.

The organization of the training activities is carried out through an e-learning management system for project-based training - DIPSEIL. A brief review of the DIPSEIL system is made of its Performance support system implementation methodology in engineering education and the basic learning tools used by lecturers and students.

The design of a course in the DIPSEIL system is organized around task performances from the students. The concept of "learning by doing" is used, with about 9 projects running for 15 weeks and one final project for final assessment of students' knowledge. At a macro level, the course is organized as a blended learning course (face-to-face lectures and exercises, web based learning activities in LMS) in the DIPSEIL e-learning environment - https://v4.dipseil.net

There are 15 class exercises and 15 lectures for the respective semester of the academic year, half of them in a lecture hall, the other half in a computer room; The course organization provides a constant relationship with a teacher and colleagues via email, in the e-learning environment and through chats, monitoring and feedback. The results from experiments show that students who used DIPSEIL system in a blended learning course perform significantly better on learning task for solving problems and simulation of electronic circuits than students that are imposed to traditional methods

Г7.2 A. Bekyarova-Tokmakova, N. Mileva and **D. Tokmakov**, "Classification of Business Processes in Telecommunications," 2021 29th National Conference with International Participation (TELECOM), 2021, pp. 153-156, DOI:10.1109/ TELECOM53156.2021.9659690, Electronic ISBN:978-1-6654-3344-0, Print on Demand(PoD) ISBN:978-1-6654-3345-7,

https://www.scopus.com/record/display.uri?eid=2-s2.0-85124537303&origin=resultslist&sort=plf-f ,https://www.webofscience.com/wos/woscc/full-record/WOS:000802220500037

(Web of Science, Scopus)

The beginning of the 21st century marks major changes in the world economy, associated with continuous globalization, deep transformation of enterprises and organizational culture, turning to an information and communication economy based on large arrays of information and knowledge. The implementation of innovative changes, the transition to new business

models for supply chain management, changes in existing business processes and the creation of new ones has become a vital factor for the existence of the organization. In this regard, the purpose of this paper is to analyze the available classifications of business processes and to determine how current changes in the development strategy of telecommunications companies affect them. A new classification of business processes in telecommunications is presented which is a summary of the changes in the sector using a new developed qualification table. The proposed classification combines the scope, process area, functionality and nature of the process, using as a basis the qualification frameworks for business processes in telecommunications and at the same time pays attention to new processes and interaction with participants in new ecosystems.

Г7.3 S. Asenov and **D. Tokmakov**, "Battery Free Wireless LoRaWAN End Sensor Node for IoT Applications," 2020 28th National Conference with International Participation (TELECOM), 2020, pp. 121-124, **DOI:** 10.1109/TELECOM50385.2020.9299539, ISBN:978-172818717-4, https://www.scopus.com/record/display.uri?eid=2-s2.0-85099440418&origin=resultslist **(Scopus)**

As a major source of energy, wireless Internet of Things (IoT) endpoints rely on batteries. The batteries are short-lived, large in size, and bulky. But the most important thing is that batteries are extremely harmful to the environment. This necessitates the use of battery-free devices, which provide a promising alternative to a sustainable and stable IoT, where the energy collected from the environment is stored in systems of supercapacitors or ultracapacitors. Limited storage of collected energy and the unpredictability of collected energy lead to periodic behavior when the device is turned on and off. Measuring and understanding the current consumption and execution time of various tasks of IoT applications is crucial for the proper operation of these devices without batteries. In this article, we report a successfully designed and tested wireless LoRaWAN end sensor node without battery for IoT applications. The fundamental feature is the realized extremely low value of energy consumption that allows using supercapacitor and solar harvesting energy to power the microcontroller and sensors. We use a LTC3588 nano power energy harvester IC, solar panel and supercapacitor to power the wireless sensor node.

The study reports a successfully designed and tested battery-less wireless LoRaWAN end sensor node for Internet of Things applications. It can be used for measurement of temperature barometric pressure etc. Also can be very useful for industrial purposes and any kind of Internet of Things applications where is not necessary the sensor to send many data for short time. As it is shown , such design is interesting of teaching in Electronics engineering education help to increase students' knowledge and interest in microcontrollers and wireless sensor power optimization.

Г7.4 . S. M. Asenov and **D. M. Tokmakov**, "Power Optimization of LoRaWAN Wireless End Sensor Node," 2020 XXIX International Scientific Conference Electronics (ET), 2020, pp. 1-4, **DOI:** 10.1109/ET50336.2020.9238204, **Electronic ISBN:**978-1-7281-7426-6, **Print on Demand(PoD) ISBN:**978-1-7281-7427-3, https://www.scopus.com/record/display.uri?eid=2-s2.0-85097056753&origin=resultslist&sort=plf-f **(Scopus)**

The paper presents a method for optimizing the power consumption of the LoraWAN sensor node using the ESP32 microcontroller. We use an Espressif ESP32 microcontroller, a BMP280 pressure sensor, and a SX1276 LoRaWAN transmitter. By using the Ultra-Low-Power

Coprocessor, included in the structure on the ESP32 microcontroller, to make measurements, instead of Xtensa® 32-bit LX6 microprocessor, we can reduce microcontroller power consumption. Optimization of the power consumption increases battery life and sensor node autonomous operations for years. We use the Wi-Fi interface of the microcontroller to access the web server of ESP32 to configure the parameters of the wireless sensor node.

Γ7.5 S. Asenov and **D. Tokmakov**, "Enhancing Energy Efficiency of LoRaWAN Protocol," 2021 12th National Conference with International Participation (ELECTRONICA), 2021, pp. 1-5, **DOI:**10.1109/ELECTRONICA52725.2021.9513667, ISBN: 978-166544061-5
https://www.scopus.com/record/display.uri?eid=2-s2.0-85114123422&origin=resultslist
(Scopus)

In the last few years, IoT devices have multiplied their number and functionality. These devices are located all over the world, and batteries are their main source of energy. In this paper the usage of wireless LoRaWAN sensor node in smart internet of things applications was analyzed. The main focus of the article is on reducing power consumption by wireless LoRaWAN sensor nodes. An analysis of the energy consumption of the various components of the architecture of the wireless sensor nodes is performed. An energy model of the energy consumed by the sensor nodes is presented and analyzed. The result of the analysis provides an accurate identification of the main energy consumers, the magnitude of their consumption and an in-depth understanding of the key mechanisms that need to be applied to improve energy efficiency in wireless sensor nodes. The emphasis is on the presented energy efficient protocol.

Three - action scenarios from the sensor nodes are presented, outlining the main guidelines and strategies for improving the efficiency of the wireless nodes. In addition, the research results reveal the magnitude of energy savings that can be achieved by implementing improved duty cycle mechanisms in wireless sensor nodes.

The result of the analysis provides an accurate identification of the main energy consumers, the magnitude of their consumption and an indepth understanding of the key mechanisms that need to be applied to improve energy efficiency in wireless sensor nodes.

The presented novel energy efficient protocol of LoRaWAN reduces battery power by up to 30%. This reduction in energy consumption significantly increases the autonomous operation of the sensor nodes for several years.

Γ7.6 . M. Asenov and **D. M. Tokmakov**, "Low Current Measurement System For Wireless Sensor Nodes," 2021 XXX International Scientific Conference Electronics (ET), 2021, pp. 1-4, **DOI:**10.1109/ET52713.2021.9579667, ISBN:978-166544518-4, https://www.scopus.com/record/display.uri?eid=2-s2.0-85118969697&origin=resultslist
(Scopus)

In this article, we present a successfully designed and tested system for measuring low currents from wireless sensor nodes. In the last few years, IoT devices have multiplied their number and functionality. These devices are located all over the world, and batteries are their main source of energy. It is extremely important to reduce the energy consumed by the sensor nodes in order to prolong the life of the batteries. Measuring the current consumed by wireless sensor nodes is a process that is of great importance to engineers and designers in terms of reducing the energy consumed by the batteries of the sensor units. Wireless sensor nodes consist of many elements such as sensors, transmitters and microcontrollers. All of them consume different amounts of energy during each operation performed by the sensor node - sending,

measuring, falling asleep, etc. In the individual operating modes, the current consumption is very small, reaching nano amperes. This is one of the main problems in measuring the current consumed by the sensor nodes. The devices for measuring the energy consumed by the wireless sensor units are very expensive, which leads to their limited use. This requires the design and implementation of low current measurement systems to be used in the training of engineers and designers. The engineers and designers of microcontroller sensor assemblies will be able to implement wireless sensor assemblies with low power consumption in their projects.

Г7.7 S. M. Asenov and **D. M. Tokmakov**, "Dual MCU Wireless Sensor Node For Engineering Education," 2021 XXX International Scientific Conference Electronics (ET), 2021, pp. 1-4, **DOI:** 10.1109/ET52713.2021.9580055, ISBN: 978-166544518-4,
https://www.scopus.com/record/display.uri?eid=2-s2.0-85118992745&origin=resultslist
(Scopus)

In the last few years, IoT devices have multiplied their number and functionality. These devices are located all over the world, and batteries are their main source of energy. It is extremely important to reduce the energy consumed by the sensor nodes in order to prolong the life of the batteries. Following this trend, we have integrated in the practical classes of students laboratory exercises in the engineering discipline "Design of microcontrollers" and "Microprocessor technology", software and hardware methods to reduce the consumption consumed by wireless sensor nodes. This article presents a designed and manufactured laboratory kit of a two-controller LoRaWAN wireless sensor node, which is used for educational purposes of students of engineering disciplines. It is made of two microcontrollers - ESP 32 and ATMEGA 328P, as well as RF96 LoRaWAN transceiver. The emphasis in the designed stand is the possibility for the sensor unit to be powered by both batteries and a battery-free harvester system and supercapacitors. In addition to the architecture, a TPL5110 nano timer has been added, which can be used as an external timer to implement an interruption to the microcontrollers. It is possible to additionally connect various sensors to the SPI and I2C communication interfaces of the microcontrollers. Through hardware jumpers, different scenarios of operation of the sensor units can be realized, and students can monitor the energy consumed in each of these scenarios, as well as include and exclude various components of the architecture. In this way, they acquire skills and knowledge for the implementation of low-energy wireless sensor nodes.

Г7.8 S. Asenov and **D. Tokmakov**, "Using of Batteryless LoRaWAN Ultrasonic Sensor Node for Smart Garbage Collection," 2022 13th National Conference with International Participation (ELECTRONICA), 2022, pp. 1-4, **DOI:** 10.1109/ELECTRONICA55578.2022.9874361, ISBN: 978-166548100-7
https://www.scopus.com/record/display.uri?eid=2-s2.0-85139069849&origin=resultslist
(Scopus)

This paper presents the use of a battery-less LoRaWAN ultrasonic sensor node for the realization of LoRaWAN based smart garbage collection, to be deployed for waste management in the Smart Cities context. In particular, the paper presents the possibility of using LoRaWAN waterproof ultrasonic sensor nodes powered by solar harvester systems to measure the level of waste in the waste bin and to cut harmful emissions from garbage trucks by reducing thier fuel consumption and in this way the frequency of the waste collection procedure.

We present a successfully tested and implemented battery-free ultrasonic sensor node and LoRaWAN interface, which successfully reduces the use of diesel fuel for garbage collection in

urban areas. The benefit of using the nodes in order to reduce municipal costs for garbage transportation, as well as to improve the quality of living environment of citizens has been clearly proven. Future work is aimed at building an information system for smart management and continuous monitoring of garbage containers.

Г7.9 **D. M. Tokmakov** and S. M. Asenov, "Autonomous Smart Wireless LoRaWAN Vehicle Parking Sensor," 2022 XXXI International Scientific Conference Electronics (ET), 2022, pp. 1-5, **DOI:** 10.1109/ET55967.2022.9920335, ISBN:978-166549878-4 **(Scopus)**
https://www.scopus.com/record/display.uri?eid=2-s2.0-85141478030&origin=resultslist

This paper presents the use of a battery powered via solar panel and harvester LoRaWAN ultrasonic sensor node for the realization of autonomous smart LoRaWAN vehicle parking sensor. In particular, the paper presents the possibility of using LoRaWAN waterproof ultrasonic sensor node powered by solar harvester systems to manage the parking area. The hardware design and software implementation of the sensor node are presented. The designed and implemented sensor node was actually tested under external atmospheric conditions to guarantee its autonomous operation.Future work is aimed at finding an algorithm to further optimize the consumed energy, aiming to power the sensor node only with a supercapacitor, which completely eliminates the battery. Additional research will be done during the winter months when there are fewer sunny days.

Г7.10 S.Asenov and **D.Tokmakov**, "Using Solar Energy Harvesters in Engineering Education," 2022 30th National Conference with International Participation (TELECOM), Sofia, Bulgaria, 2022, pp. 1-4, doi: 10.1109/TELECOM56127.2022.10017330, ISBN:978-1-6654-8212-7https://ieeexplore.ieee.org/document/10017330 **(Scopus)**

This article presents our experience in integrating solar harvester systems into engineering training. The increased capacities of super capacitors, as well as their advantages over ordinary batteries, together with harvester systems, make them extremely sought after and used by researchers and engineers to implement various projects. Following this trend, we have integrated into the students' practical classes laboratory exercises in the engineering disciplines "Microcontroller Design" and "Microprocessor Technology", software and hardware methods for reducing the consumption of wireless sensor nodes and using solar energy harvesters as energy sources for sensor nodes. The article focuses on experimental studies of different harvesters - LTC 3588 and BQ25570, collecting energy from different photovoltaic panels. Students can design and implement autonomous wireless sensor nodes to be powered by solar energy harvesters. In this way, they acquire skills and knowledge to implement low-energy wireless sensor nodes without harmful chemical batteries. A good knowledge of solar harvester systems leads to an increase in the quality of engineering education.

- **Scientific publications in non-refereed peer-reviewed journals**

Г8.1 Slavcho Bozhkov, Ivan Milenov, Danail Danchev, **Dimitar Tokmakov** and Penko Bozhkov, "Researching the signals of the automobile electromagnetic sensors", 12th International Conference on Applied Electromagnetics-PEC 2015, pp.1-3, ISBN 978-86-6125-145-0

The basis of the control system of the automobile and automobile engines are built on the information, which is derived by the automobile sensors. The sensors signals are an object of researching for obtaining the feedback for the condition of the processes and devices, which are the sources of these signals. The analyzing of the signals form is precondition for diagnostics of the systems, in which these sensors are integrated.

The initial derived records of the automobile electromagnetic sensors signals ensure opportunity for a comparative analyses and diagnostics of the automobile technical condition. The results explained the application and the features of the inductive sensors, which are using in the automobiles.

Г8.2 Stanislav Asenov, **Dimitar Tokmakov**, „RESEARCH AND OPTIMIZATION OF LOW POWER WIFI SENSOR NODE“, Scientific Works of the Union of Scientists in Bulgaria - Plovdiv. Series C. Technics and Technologies. Vol. XVIII, pp.67-70, ISSN 1311-9419 (Print); ISSN 2534-9384 (Online), 2020. (НАЦИД ID № 2494)

This paper describes the realization of a low power wireless temperature and relative humidity measurement node using MQTT and Node-Red to transmit and visualization data. The measurement is made thru ESP EASY firmware for ESP 8266 microcontroller, which optimizes the power consumption of the wireless sensor node

The measurement system presented in this paper measures real-time temperature and relative humidity. The work project presents WiFi low power sensor node for IoT applications, which was successfully designed and tested. The main features of this design is its low power consumption, WiFi communication and secure data transmission. By using ESP Easy firmware is possible to reduce the end node consumption current Ic from 72 mA to 18.6 mA. This increases battery life and sensor autonomous operation.

Г8.3 Svetoslav Dimitrov, **Dimitar Tokmakov**, „ACCESS THE LORAWAN DATA TELEMETRY USING MQTT PROTOCOL AND SERVER APPLICATION FOR DATA DECODING“, Scientific Works of the Union of Scientists in Bulgaria - Plovdiv. Series C. Technics and Technologies. Vol. XVIII, pp. 71-74, ISSN 1311 -9419 (Print); ISSN 2534-9384 (Online), 2020. (НАЦИД ID № 2494)

The present work describes an algorithm and a console server application for retrieving data from LoraWan sensor nodes via cloud application and MQTT protocol. The console application creates a MQTT client subscribed to The Things Network's MQTT broker. The received data in JSON format goes through the developed algorithm that decodes the payload part of the received JSON message from Cayenne LPP format in decimal analog values. It is possible to integrate the obtained data with other heterogeneous wireless sensor networks.

The algorithm presented in the article makes it possible to extract data from LoraWan wireless sensing nodes by using the MQTT protocol and a method to decode the payload part of the application. This integrates the cloud application of The Things Network with a dedicated server application that can integrate data from heterogeneous wireless sensor networks.

Г8.4 **Dimitar Tokmakov**, Sotir Sotirov, Nikolay Vakrilov, Raicho Minchev, „A NON-CONTACT VOLTAGE MEASUREMENT SYSTEM USING SURFACE POTENTIAL SENSOR“, Scientific Works of the Union of Scientists in Bulgaria - Plovdiv. Series C. Technics and Technologies. Vol. XVII., pp.169-172, ISSN 1311 -9419 (Print); ISSN 2534-9384 (Online), 2019, ((НАЦИД ID № 2494)

This work presents the results of a new design of a complete non-contact voltage acquisition system, based on surface potential sensor EFS-22D by TDK. The system is capable to measure DC voltages from 0-950V with distance between the surface potential sensor and the probe within 1 – 3.5mm. The signal from EFS-22D sensor which is in the range from 0-4.5V dc is converted from the built in analog to digital converter in ATMEGA328 microcontroller. The results from the measurements are send to LabVIEW application using Bluetooth module. The LabVIEW application provides interface for further data acquisition and visualization. Keywords: LabVIEW non-contact voltage measurement, surface potential sensor.

The measurement system presented in this paper measures electrostatic voltage in the range from 0-950V within 0.5-3.5mm distance between the measuring probe and the measured surface. Achieved accuracy in the range of 0-950 V is 500 mv, which allows the measuring system to be used for various applications as well in university education in physics and electronics. The voltmeter proposed in this paper can be used for studying various types of dielectric materials, as well as for investigating voltage sources with ultra-high internal resistance. The use of LabVIEW virtual instrument software allows the system to be used in industrial production environments for express ESD measurement and control.

Г8.5 **Dimitar Tokmakov**, Sotir Sotirov , Slavi Gluhov, "LORAWAN BASED SYSTEM FOR MEASURMENT AND MONITORING OF TEMPERATURE AND HUMIDITY IN DATA CENTERS AND SERVER ROOMS", Scientific Works of the Union of Scientists in Bulgaria - Plovdiv. Series C. Technics and Technologies. Vol. XVII., pp.165-168, ISSN 1311 -9419 (Print); ISSN 2534-9384 (Online), 2019, (НАЦИД ID № 2494)

This paper describes the realization of a wireless temperature and relative humidity measurement node used in datacenters and server rooms that transmit data to a LoraWan gateway via a LoraWan communication link. Using a wireless sensor node gives a number of advantages, such as wireless installation, physical independence from the data center infrastructure, battery power supply with low power consumption. Data from the LoraWan gateway are transmitted into an Internet-based cloud application for post processing and visualization, which enables further optimization of air conditioning and ventilation systems.

The measurement system presented in this paper measures real-time temperature and relative humidity in data centers and server rooms. Using LoraWan wireless communication link the data is forwarded by the LoraWan gateway and sent to the Internet cloud application for processing, archiving and visualization. The LoraWan gateway and sensor node described in the present work are installed in the University of Plovdiv Paisii Hilendarski, Bulgaria. The implementation of LoraWan based measurement system has a number of advantages over traditional data center measurement and monitoring systems: possibility of mounting the measuring node at random location without connecting wires, battery power supply with low power consumption, collection and processing of measurement data for their use to optimize the operation of the air conditioning and ventilation system.

Г8.6 **Dimitar Tokmakov**, Nadezhda Kafadarova, „USING A WIRELESS SENSOR NETWORK FOR MEASURING THE OXYGEN LEVEL IN INDUSTRIAL ENVIRONMENT", Scientific Works of the Union of Scientists in Bulgaria-Plovdiv, series C. Technics and Technologies, Vol. XIV., ISSN 1311-9419 (Print), ISSN 2534-9384 (On- line), 2017, pp.103-107 , ISSN 1311-9419 (Print), ISSN 2534-9384 (Online), (НАЦИД ID № 2494)

This paper presents the design and practical implementation of wireless sensor network (WSN) and its use for the measurement the level of oxygen in the air in a production plant. It consists from 4 wireless sensor nodes with oxygen sensor which transmits the level of oxygen to wireless base station and measures the level of oxygen in 4 zones in a production plant. The measurement system have 2 threshold levels for the oxygen - 19% and 18% and there is automatic events for these levels. The data from 4 oxygen wireless sensors are also transmitted to web server in internet for data backup and visualization.

The developed energy-efficient communication protocol between the wireless sensor nodes and the base station provides about 3 months of autonomous operation of the wireless sensor node with a single charge of 2100mAh Li-ion 3.7V rechargeable battery type 18650. Measurement data is visualized on 4 LCD displays for each measurement area. The base station is programmed to handle critical situations – measured levels of oxygen 19% and 18%, to include alarms, nitrogen shutoff valve, and ventilation in the premises. The use of a wireless sensor network gives extreme freedom in the location of the sensors (lack of cables), the possibility of easy change of the physical sensor position, easy addition of additional sensors and measurement points, etc.

Г8.7 D.Stoyanova, S. Stoyanova-Petrova, N.Kafadarova , **D.Tokmakov**, CONDUCT OF A PEDAGOGICAL EXPERIMENT FOR THE EFFICIENCY OF IMPLEMENTING THE TECHNOLOGY "AUGMENTED REALITY" IN MOBILE TRAINING DEVICES, Scientific Research of the Union of Scientists in Bulgaria-Plovdiv, series C. Technics and Technologies, Vol. XII., pp.31-34, Union of Scientists, ISSN 1311-9419, Session 31 October – 1 November 2014.

This article presents our experience using mobile technology and augmented reality technology to stimulate and support learning on the subject "Man and Nature" for the students in 4th class. They participated in the pilot experiment students from two Plovdiv schools. The pedagogical research and analysis done of the obtained results conclusively proved that the technologies used were successful applicable in primary education in the Bulgarian school and have didactic value.

The analysis of the obtained results clearly shows that the use of "augmented reality" technology during a lesson does not cause worry or anxiety students, and makes the learning process exciting and enjoyable. Moreover, it provokes student cognitive activity and creates an attitude for independent homework conditions. The collected data gives us reason to conclude that AR technology has great potential to provide clarity in learning. It helps to develop the imagination to the students and undoubtedly facilitates the study of the learning material. These results confirm the hypothesis that the technology "augmented reality" through use of mobile devices has been successfully implemented in primary education in the Bulgarian school and has a didactic value.

Г8.8 **Dimitar Tokmakov**, Nadezhda Kafadarova, Vencislav Nachev, INTELIGENT SENSOR NODE FOR MEASURMENT OF TEMPERATURE AND WIRELESS TRANSIMISSON OF COLLECTED DATA TO REMOTE WEB SERVER, Scientific Works of the Union of Scientists in Bulgaria-Plovdiv, series C. Technics and Technologies, Vol. XIII., Union of Scientists, pp.218-221, ISSN 1311-9419, Session 5 - 6 November 2015.

This paper presents the design and practical realization of intelligent wireless sensor node for measurement of temperature and transmission of collected data to remote server using Wi-

Fi and Internet as communication media. We present the block diagram of the sensor node and place requirements for battery power operation. We choose the proper elements and present the sensor node schematic diagram. We show the development of server side software for collecting data from the intelligent wireless sensor node using PHP, MySQL with Node.js technologies. Finally, we provide results of the study of the whole communication system.

Г8.9 Stanislav Asenov, **Dimitar Tokmakov**, LORAWAN HELIUM NETWORK REVIEW, UNION OF SCIENTISTS IN BULGARIA - SMOLYAN Scientific Researches Volume 3, part 3, 2022; pp.660-665, ISSN:1314-9490 (online)

The article discusses the main features of the LORAWAN HELIUM network. A comparative analysis was performed between the classic LORAWAN and LORAWAN HELIUM networks. The construction of the LORAWAN HELIUM network at the Faculty of Physics and Technology at the Paisii Hilendarski University of Plovdiv in the town of Smolyan is presented. The authors aim to acquaint students with the opportunities provided by the innovative LORAWAN HELIUM network.

Г8.10 Stanislav Asenov, **Dimitar Tokmakov**, USING SEEEDUINO XIAO MICROCONTROLLER, IN TRAINING OF STUDENTS IN "MICROPROCESSOR TECHNOLOGY", UNION OF SCIENTISTS IN BULGARIA - SMOLYAN Scientific Researches Volume 3, part 3, 2022; pp.672-676, ISSN:1314-9490 (online)

The article presents the possibility of using the SEEEDUINO XIAO microcontroller, with an integrated powerful 32-bit microprocessor, in order to train students majoring in "Hardware and Software Systems" in the discipline "Microprocessor Technology". The main parameters of the microcontroller are analyzed, as well as the main communication interfaces used for communication with various sensors and actuators are presented. A set of three methodical exercises for working with the SEEEDUINO XIAO microcontroller is offered, which students in engineering specialties can use. The introduction of the microcontroller in the education of students inevitably leads to an increase in their experience in the field of microprocessor engineering and technology

Г8.11 **D. Tokmakov**, A. Bekyarova-Tokmakova (2021) TEACHING LAB-BASED COMPUTER NETWORKING THROUGH PERFORMANCE-CENTERED APPROACH, ICERI2021 Proceedings, pp. 2200-2207. doi: 10.21125/iceri.2021.0559, ISBN: 978-84-09-34549-6

This paper describes the curriculum design of performance-cantered learning course of lab-based computer networking.

The course is compulsory for students of engineering specialties in the field of communication and computer engineering. The objectives of the course, the structure of the curriculum content, the type and the specificity of the studied and simulated practical computer networking lab experiments are described.

The organization of the training activities is carried out through an e-learning management system for performance-centred learning – DIPSEIL (https://v4.dipseil.net/). A brief review of the DIPSEIL system is made of its Performance support system implementation methodology in engineering education and the basic educational tools used by lecturers and

students.The design of the course in the DIPSEIL system is organized around tasks for performances from the students.

The concept of "learning by doing" is used, with about six lab experiments running for 12 weeks and one final project for final assessment of students' knowledge. At a macro level, the course is organized as a blended learning course (face-to-face lectures and exercises, web based learning activities in LMS and practical lab experiments) in the DIPSEIL e-learning environment - https://v4.dipseil.net

The course organization provides a constant relationship with a teacher and colleagues via email, in the e-learning environment and through chats, monitoring and feedback. The results from experiments show that students who used DIPSEIL system in a performance-centred course perform significantly better on learning tasks for solving problems and practical lab experiments in computer networking than students that are imposed to traditional methods.

Г8.12 **D. Tokmakov** (2021) HARDWARE AND SOFTWARE FOR TEACHING LORAWAN TECHNOLOGY IN ENGINEERING EDUCATION, ICERI2021 Proceedings, pp. 2112-2118, doi: 10.21125/iceri.2021.0559, ISBN: 978-84-09-34549-6

The Internet of Things (IoT) has become one of the fastest growing fields and an increasing number of jobs require expertise in this field.

To connect "things" to Internet we need a radio communication technology, which transmits the data from wireless sensor nodes to Internet like Bluetooth, Wi-Fi, Zigbee, 3G, 4G/LTE, 5G and LPWAN. Each solution has its strengths and weaknesses in various network criteria and is therefore best suited for different IoT use cases.

LoRaWan is the new phenomenon in IoT. By providing long-range communication on small, inexpensive batteries that last for years, this communication technology is purpose-built to support large-scale IoT networks sprawling over vast industrial and commercial campuses. LoRaWan technology connects all types of IoT sensors – facilitating numerous applications from asset tracking, environmental monitoring and facility management to occupancy detection and consumables monitoring.

In this paper, we share our experience in teaching of LoRaWan technology in the discipline "Internet of Things" for the students from the bachelor's degree in engineering at Plovdiv University, Bulgaria.

We present the design of the hardware and software of two sensor nodes with LoRaWan transceivers, which we use in the lab experiments for teaching LoRaWan connectivity.

The first sensor node incorporates Atmega 328p microcontroller, RFM95 Long Range, Low Power RF Transceiver 860-1000 MHz with LoRa® Technology, TPL5110 nano timer and BMP280 - an absolute barometric pressure sensor, which is especially feasible for mobile applications. The nano timer TPL5110 is used to "wake-up" the microcontroller from "deep sleep" mode with external interrupt attached to PD3 of Atmega328p. This decreases significantly the current consumption of the sensor node in deep sleep mode to 290nA which is very low value ensuring a long battery life of several years.

The second sensor node consists of Atmega 328p microcontroller, RN2483 a fully certified 868 MHz module based on wireless LoRa® technology, I2C temperature sensor and MCP16251 Low Quiescent Current, PFM/PWM Synchronous Boost Regulator that converts a single AA battery of 1.5V to 3.3V power supply.

We use Atmega328p microcontrollers that is easily programmed with the Arduino IDE with which the students are familiar.

In our lab experiments, we teach all fundamental aspects of LoRaWan modulation like spreading factor (SF), Coding Rate (CR), Chirps Spread Spectrum and how all this parameters affects the communication range and power consumption of the sensor nodes.

The students are given the opportunity to change all communication parameters such as SF, CR, the amount of payload sent to LoRaWan application servers, as well as the type of authentication between Over-the-Air Activation (OTAA) and Activation by Personalization (ABP).

The developed sensor nodes allows students to fully perform their laboratory exercises in the discipline "Internet of Things" for LoRaWan communication technology and enhance their learning capabilities, increase their interests in the field of IoT and especially in LoRaWan for which technology there is a lack of educational resources and educational hardware modules.

Г8.13 **Димитър Токмаков**, Надежда Кафадарова, Венцислав Начев, "ИНТЕЛИГЕНТЕН СЕНЗОРЕН ВЪЗЕЛ ЗА ИЗМЕРВАНЕ НА ТЕМПЕРАТУРА И БЕЗЖИЧНО ПРЕДАВАНЕ НА ДАННИ" Научни трудове на Съюза на учените в България – Пловдив Серия В. Техника и технологии, том XIII 2016г., стр.222-225, ISSN 1311-9419 (Print), ISSN 2534-9384 (Online), (НАЦИД ID № 2494)

This paper presents the design and practical realization of intelligent wireless sensor node for measurement of temperature and transmission of collected data to remote server using Wi-Fi and Internet as communication media. We present the block diagram of the sensor node and place requirements for battery power operation. We choose the proper elements and present the sensor node schematic diagram. We show the development of server side software for collecting data from the intelligent wireless sensor node using PHP, MySQL with Node.js technologies. Finally, we provide results of the study of the whole communication system.

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