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"Национальный исследовательский университет
"Высшая школа экономики"

Факультет компьютерных наук
Департамент программной инженерии

Рабочая программа дисциплины
Экосистемы интернета вещей
(на английском языке)
IoT Ecosystems

для образовательной программы «Программная инженерия»
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1 Course Description

a. Title of the Course

The course title is IoT Ecosystems. IoT is Internet of Things.

b. Pre-requisites

Studying of the "IoT Ecosystems" discipline is based on the following courses:

- Programming,
- Introduction to Software Engineering,
- Operating systems,
- Software Constructing,
- Algorithms and Data Structures,
- Foreign language (English).

c. Course Type

The course is elective.

d. Abstract

The course introduces Internet of Things field of computer science and hardware implementation including terminology, basic concepts, various areas of its application and different approaches to building its software and using its hardware with different kinds of system on modules. Lecture topics include physics on electrical schemes and networking, different kinds of the things themselves, various fields of the things implementation, software needed to code the things behaviour and store the data including Internet of Things operating systems. During the practice classes students have a lot of assignments based on two hardware platforms: Arduino Uno and Raspberry Pi 3 with Arduino IDE and Android Studio for Android Things OS respectively. Then students are given another assignment which replaces the course exam. The assignment is a hardware-software project based on a simple network of the things and has a certain purpose (smart home, smart weather station, smart plant, smart lock etc.). The assignment is divided into two parts: the first part is hardware (with systems on module mentioned and various sensors, controls, LEDs etc.) and the second part is software (mobile application) controlling the hardware. This course is practice oriented - more attention is given to practice, not lectures.

2 Learning Objectives

The discipline goal is to make students aware of the Internet of Things field and its hardware and software implementation including developing a mobile application controlling the hardware part.

Topics to be learnt and tasks to be solved to achieve the goal are:

- getting to know the Internet of Things field including terms, basic concepts and implementations;
- learning to work with hardware (system on modules and various wires and sensors);
- studying coding and programming the hardware;
- studying IoT operating systems (Android Things) and IDEs (Android Studio, Arduino IDE);
- getting skills in mobile application developing to control the hardware.

3 Learning Outcomes

As a result of studying the course a student is supposed:

to know and be able to use:

- basics of Internet of Things functionality, purposes, implementations, applications;
- how to work with the according hardware;
- how to create a mobile application;
- how to use certain libraries in the software environment dedicated to Internet of Things;
- how to code and use the hardware boards to run the code;
- how to work with the according software (Android Things, Android Studio, Arduino IDE).

to be able to:

- install and use Android Things, Android Studio, Arduino IDE;
- work with system on modules and other according hardware;
- create a simple network of things;
- control the network using the system on module operating system and software environment for mobile applications development.
- work with emulators.

As a result of studying the course student develops the competencies shown in table 1.

Table 1 - Student competence description

Competence	Key	Descriptors	Forms and techniques of the study which lead to developing the competence
Being able to work with information: to find, evaluate and use information from different sources needed for solving scientific and professional problems (including system approach usage).	UC*-5	Student shows ability to analyze, verify and evaluate the information given considering developing Internet of Things or a mobile application and find the lacking information pieces if needed using different resources.	Attending lectures, practice classes, working on homework assignments, communicating with colleagues and sharing experience, searching and studying information needed using internet resources during the self-study sessions.
Being able to do researches including problem analysis, goal and problems statement, selecting object and subject of the research, selecting research ways and methods and evaluating the research quality.	UC-6	Student shows ability to do a research with answering the basic questions about the hardware and software being developed goals, problem being solved, purpose of the network being built, etc.	Attending lectures, working on homework assignments, searching and studying information needed using internet resources.
Being able to do industrial or applied work in international environment.	UC-10	Student shows ability to communicate in an international environment and to explain his ideas to his colleagues.	Attending lectures, working on homework assignments, searching and studying information needed using internet resources.
Being able to use operating systems, network technologies, user interface development tools, to apply languages and methods of formal specifications, data base	PC*-15	Student is able to use an Internet of Things operating system, to build the things network and to develop user interface for mobile application controlling the devices of the network.	Attending lectures, working on homework assignments, searching and studying information needed using internet resources, sharing experience with colleagues.

Competence	Key	Descriptors	Forms and techniques of the study which lead to developing the competence
management systems.			
Being able to use various technologies of software development.	PC-16	Student is able to develop software using different technologies and approaches.	Attending lectures, working on homework assignments, searching and studying information needed using internet resources.
Being able to use basic methods and tools of software development.	PC-17	Student is able to use environment for software development.	Attending lectures, working on homework assignments, learning from colleagues, exchanging experience.

* UC - universal competence, PC - professional (instrumental) competence.

4 Course Plan

Table 2 - Course topics

№	Topic	Total hours	Classroom activities		Self-study
			Lectures	Seminars	
1.	Introduction to Internet of Things. IoT implementations. Sensors, resistors, breadboard, modules, displays and other usual components of an IoT kit.	18	4	4	10
2.	Arduino Uno. Connections, ports, modules, etc.	18	4	4	10
3.	Practice with Arduino Uno. Arduino IDE.	50	10	10	30
4.	Raspberry Pi 3. Connections, ports, modules, etc.	16	4	2	10
5.	Practice with Raspberry Pi 3. Android Studio. Android Things OS, console.	48	10	8	30
6.	Building IoT project.	40		4	36
	Total:	190	32	32	126

5 Reading List

5.1 Required

1. Arduino IDE and Official Site with Console [Electronic Resource] / Arduino, 2018. – URL: https://www.arduino.cc/index.php
2. Android Things Projects [Text] / Francesco Azzola. - Packt, 2017. - 232 p. - ISBN: 9781787289246.
3. Android Application Development in 24 Hours, Sams Teach Yourself (4th Edition) [Text] / Carmen Delessio, Lauren Darcey, Shane Conder. - SAMS, 2015. - ISBN-13: 978-0672337390. ISBN-10: 0672337398.
4. Android Things [Electronic Resource] / Google Inc, 2018. – URL: https://developer.android.com/things/

5.2 Optional

5. Building Arduino Projects for the Internet of Things: Experiments With Real-World Applications (1st Edition) [Text] / Adeel Javed. - Apress, 2016. - ISBN-13: 978-1484219393. ISBN-10: 1484219392.
6. Building the Web of Things: With Examples in Node.js and Raspberry Pi (1st Edition) [Text] / Dominique Guinard, Vlad Trifa. - Manning Publications Co., 2016. - 344 p. - ISBN-13: 978-1617292682. ISBN-10: 1617292680.
7. Exploring Raspberry Pi: Interfacing to the Real World With Embedded Linux (1st Edition) [Text] / Derek Molloy. - John Wiley & Sons, Inc., 2016. - 720 p. - ISBN-13: 978-1119188681. ISBN-10: 1119188687.
8. Internet of Things Presentation [Electronic Resource] / Laili Aidi, 2013. - URL: https://www.slideshare.net/TheMarketingDistillery/iot-presentation
9. Presentation Slides: Internet of Things [Electronic Resource] / Robert Greiner, 2014. - URL: http://robertgreiner.com/2014/10/internet-of-things-presentation-slides/
10. The Internet of Things – A Trillion Dollar Market Presentation [Electronic Resource] / Vala Afshar, 2014. - URL: https://www.slideshare.net/ValaAfshar/internet-of-thingsslideshare
11. Weave and Android Things Announcement [Electronic Resource] / Wayne Piekarski, 13 December 2016. – URL: https://android-developers.googleblog.com/2016/12/announcing-googles-new-internet-of-things-platform-with-weave-and-android-things.html
12. Weave [Electronic Resource] / Nest Labs, 2018. – URL: https://nest.com/weave/
13. Google's IoT Solutions [Electronic Resource] / Google Inc, 2018. – URL: https://developers.google.com/iot/
14. Android Things Peripheral I/O [Electronic Resource] / Google CodeLabs, 2018. – URL: https://codelabs.developers.google.com/codelabs/androidthings-peripherals/
15. Android Application Development All-in-One For Dummies, 2nd Edition [Text] / Barry Burd. - John Wiley & Sons Inc., 2015. ISBN-13: 978-1118973806. ISBN-10: 1118973801.
16. Android Programming: The Big Nerd Ranch Guide (2nd Edition) [Text] / Bill Phillips, Chris Stewart, Brian Hardy, Kristin Marsicano. - Big Nerd Ranch, LLC, 2015. - ISBN-13: 978-0134171456. ISBN-10: 0134171454.
17. Head First Android Development (1st Edition) [Text] / Dawn Griffiths, David Griffiths. - O'Reilly Media, Inc., 2015. - ISBN-13: 978-1449362188. ISBN-10: 1449362184.
18. Android Application Development Cookbook - Second Edition [Text] / Rick Boyer, Kyle Mew. - Packt Publishing, 2016. - ISBN-13: 978-1-78588-619-5.
19. Android Studio IDE Site [Electronic Resource] / Google Inc., 2018. - URL: https://developer.android.com/docs/
20. Java SE Site [Electronic Resource] / Oracle Corporation, 2018. - URL: http://www.oracle.com/technetwork/java/javase/overview/index.html
21. Genymotion Emulator Site [Electronic Resource] / The site authors, 2018. - URL: https://www.genymotion.com/
22. Thinking in Java (4th ed.) [Text] // Bruce Eckel. - Prentice Hall, 2006.
23. IBM Bluemix Website [Electronic Resource] / IBM, 2018. - URL: https://console.bluemix.net/
24. Microsoft Azure Website [Electronic Resource] / Microsoft, 2018. - URL: https://azure.microsoft.com/en-us/
25. Amazon Web Services Website [Electronic Resource] / Amazon Web Services, Inc. or its affiliates, 2018. - URL: https://aws.amazon.com/?nc1=h_ls
26. Google Cloud Platform Website [Electronic Resource] / Google Inc, 2018. - URL: https://cloud.google.com/

5.3 Dictionaries, wiki

27. Internet of Things - Wikipedia (en) [Electronic resource] / authors of the page, last edited on 28 August 2018. – URL: https://en.wikipedia.org/wiki/Internet_of_things

5.4 Software needed for students

Students need the following software installed to successfully study the course:

- Browsers: the latest versions of the Chrome, Opera, Firefox.
- Microsoft Office (including the PowerPoint).
- JDK 1.8 (Java SE 8.x).
- Android Studio 3.1.4.
- Arduino IDE 1.8.6.

6 Grading System

Current control is evaluated as following:

$$O_{current} = 0.5 \cdot O_{AP} + 0.5 \cdot O_{RP} ,$$

where O_{AP} – Arduino Uno practice mark, O_{RP} – Raspberry Pi 3 practice mark. Both of these marks are evaluated using 10 grade scale.

Each of these marks is calculated according to the following formula (let's take O_{AP} for example):

$$O_{AP} = 10 \cdot N_1/N_2 ,$$

where N_1 is the number of Arduino Uno practice tasks completed by a student, and N_2 is the total number of Arduino Uno practice tasks. The same formula is applied to O_{RP} mark reflecting the Raspberry Pi 3 practice tasks completion. The number of these practice tasks can vary but usually there are 34 practice tasks for Arduino Uno and 5 for Raspberry Pi 3 (the latter are more complicated).

So for example if a student has completed all practice tasks with Raspberry Pi 3 but none of the tasks with Arduino Uno the $O_{current} = 5$ (using the 10 grade scale).

The final control is evaluated as following. A student makes his own assignment which means building a hardware-software project based on a simple network of the things with a certain purpose (smart home, smart weather station, smart plant, smart lock etc.). The student is to show the project and get the O_{final} mark for it. This final assignment is equal to exam on the course.

And the result mark which goes to the bachelor diploma is evaluated according to the following formula using the 10 grade scale:

$$O_{result} = 0{,}7 \cdot O_{current} + 0{,}3 \cdot O_{final}$$

The rounding system is the same for all the marks and is a simple mathematical one: 4.4 = 4, 4.6 = 5, etc.

7 Guidelines for Knowledge Assessment

Table 3 - Forms of student knowledge control

Type of control	Form of control	The whole year / modules				Parameters**
		1	2	3	4	
Current	Arduino Uno practice tasks	*				Arduino Uno practice tasks are usually 34 simple tasks with a real hardware and Arduino IDE which help students understand electrical circuits work and their software control.
Current	Raspberry Pi 3 practice tasks		*			Raspberry Pi 3 practice tasks are usually 5-10 tasks with a real hardware and Android Studio + Android Things OS which help students understand how to create a mobile application controlling the hardware of the Raspberry Pi 3 SoM.
Final	IoT things project assignment = Examination		*			Homework assignment is developing a network of things using one of the system on module boards as a base and following the instructions on the IoT OS using (for example Android Things). Passing the assignment means to show the whole system working and to be able to answer any questions regarding the code of the assignment script and theory. Each student gets different assignments which he/she chooses him-/herself.

** Parameters specify a control format: written, oral, computer testing, timing, and what exactly a student should do to pass, etc.

7.1 Knowledge and skill estimating criteria

For knowledge and skill estimated criteria please refer to sections 6 and table 3 of this document.

As long as the National Research University Higher School of Economics has the 10 grade scale system all the results above are then transformed into the 10 grade scale as written in section 6 of the document.

7.2 Current control sample tasks

Arduino Uno practice tasks consist of simple assignments, usually concerning a single module, sensor, motor, LED, display or other device. If we take a real example, the components for the 3rd practice task are: Arduino Uno, Am-Bm USB cable, potentiometer, LED, 220 resistor, breadboard and wires. The task is to build the circuit using either electrical circuit scheme or breadboard scheme in the according methodical guide and then copy-paste or write and then modify the code for Arduino IDE. After that a student is supposed to launch the code and check if the hardware works correctly or not, then show it to the lecturer. Each task can be completed from 5 to 20 minutes depending on the circuit difficulty.

Raspberry Pi 3 tasks are somewhat more complicated but eventually students move faster from one task to another. A sample of the Raspberry Pi 3 task is shown in the following github resource: https://github.com/androidthings/doorbell

7.3 Sample questions for the final control

There can be question on the final project regarding the circuitry or the program code; all the questions topics are within the theory and practice classes of the course schedule.

8 Methods of Instruction

Classes of the course are conducted as the following forms:

- seminars/master classes/code sessions of the computer presentation format;
- discussing various questions rising during the seminars, discussing them via email;
- practice (can be part of a presentation) including working with hardware (building electrical circuits) and software (coding in IDEs);
- self-studies with the help of the lectures and seminar presentations, software needed, internet, literature sources.

8.1 Recommendations for lecturer

Lectures should be given in a presentation form which means a lecture followed by info- or just graphics shown with the help of presentation software and a computer connected to a projector and internet. Experience confirms that the presentation lectures are so far the most effective way to teach students during the course.

The practice assignments passing is preparation to pass the final control. If student have questions considering the assignments the questions should be asked right away during the seminar. If they are not asked, the lecturer (reporting student) still should ask students if they have any questions regarding the topic.

When the lecturer tests students who are trying to pass any type of the controls mentioned above it is necessary for the lecturer to pay attention at the way each student tells about his work and answers the questions being asked about the code, hardware, etc. Questions should not be repeated from student to student. If a student can hardly answer some questions or the assignment result does not work or raises errors it is crucial to explain and help student about the code errors and how to avoid them, and give correct answer to the question asked with maximum amount of information and explanations (of course excluding the exam case).

8.2 Recommendations for students

Students have to attend lectures and especially seminars because all the examination questions are described and given during the lectures, and the hardware belongs to the university therefore it cannot be given to students for home usage.

The final assignment should be different for each student. Having the same assignments (if that happens nevertheless) doesn't mean the same purpose of the things network and mobile application interface including the application UI element position, styles and more because people are different, and leads to lowering the mark.

Do not try to pass an assignment you have nothing to do about - it is obvious for the lecturer, and it means you get no knowledge or experience from the course - you are punishing yourself for no reason.

Good work during all the course and seminars especially is a high final control mark guarantee.

9 Special Equipment and Software Support

Computer classes with MS Windows XP/7/8/10, HDMI monitors and section 5.4 software - for the practice.

Classroom with good quality wi-fi or VGA/HDMI projector (not less than 1024x768 px) and section 5.4 software - for providing seminars.

This course is based on two hardware developer kits for IoT:

- Arduino Uno 3 Starter Learning Kit with RFID Module (http://onpad.ru/shop/cubie/arduino/ardiuno_kit/1680.html) and
- Basic Starter Learning Kit 01 for Raspberry Pi (https://onpad.ru/shop/cubie/raspberrypi/raspberrypi_kit2/1893.html).

It would be great if the number of both kits mentioned above matched the number of students signed up for the course.