Syllabus

«Architecting smart IoT devices»

Approved by

The Academic Council

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Author	Nadezhda Trubochkina, Prof Dr
Credits	2
Contact work (hours)	10
Individual work (hours)	66
Course	2
The format of the discipline	Blended learning

I. Purpose, Learning Outcomes and Prerequisites

Purpose

Purpose of course is teach how to develop the Smart IoT Devices

Course Description

This course will teach you how to develop an embedded systems device. In order to reduce the time to market, many pre-made hardware and software components are available today. You'll discover all the available hardware and software components, such as processor families, operating systems, boards and networks. You'll also learn how to actually use and integrate these components. At the end of the course you will be ready to start architecting and implementing your own embedded device! You'll learn how to debug and finetune your device and how to make it run on a low power supply.

Learning Outcomes

On completion of the course, the student should

– know:

- the basics of the Hardware & Software for EmS;
- Software development tools and environments;
- Hardware or Software Security;

– be able to:

- Developing an embedded systems device;
- actually use and integrate IoT components.

– acquire experience in:

- architecting and implementing your own embedded device!
- debuging and finetune your device .
- architecting and implementing embedded device working on a low power supply.

Prerequisites

- Internet application development.
- Basic data visualization principles.

Post requisites

Knowledge and skills that a student will gain after successful accomplishment of the course he can apply to prepare a master's thesis.

II. Topic-wise Course Content

Topic 1. Welcome to Architecting Smart IoT Devices

What you'll learn and how you'll learn it! This course will teach you how to develop an embedded systems device. In order to reduce the time to market, many pre-made hardware and software components are available today. You'll discover all the available hardware and software components, such as processor families, operating systems, boards and networks. You'll also learn how to actually use and integrate these components. At the end of the course you will be ready to start architecting and implementing your own embedded device! You'll learn how to debug and finetune your device and how to make it run on a low power supply.

Topic 2. Hardware & Software for EmS

Welcome to Module 1! Processors. Boards. Networks. Software Components. IoT Components. What's a web tour and what does it have to do with quizzes? Study of a few Embedded Processor Families. MCU, SOC, FPGA. Cache, pipeline and coupling. Where do (development) boards come in? Explore examples of boards.

Self-study materials

Optional Resources. Network basics - for network newbies. Sensor Networks for IoT. Multi- what? Operating System types. Protocol stacks. Licenses. Integrated Development Environment. IoT today and tomorrow. IoT and big data (in the cloud). Complete solution market offerings. Application protocols. SensorTag Experiment.

Practical exercises
Processors. Boards. Networks. Software Components. IoT Components.

Topic 3. RTOS

Welcome to Module 2! From XXS to XXL. Real-time Scheduling. Synchronisation and Communication. Device Drivers. Five rules for architecting a multithreading design.

Self-study materials
Optional Resources. Silicon vendor - independent OS. Silicon vendor OS for IoT. XXS (RT) OS for IoT Evaluation reports on the embedded OS. Optional Resources. Arbitration in a hardware bus-based environment. Scheduling algorithms. Optional Resources. RTOS overview. Reading more about RTOS. What is priority inversion, inheritance and ceiling? What does an RTOS have to offer? Multitasking programming language. Investigate an RTOS of your choice. Optional Resources. VRTX vs Nucleus. Processor interrupt models. Device Driver model example. Driver certification programs. Optional Resources. Rules for tasking. Rate Monotonic Scheduling. Tools for schedulability analysis. Fault-Tolerance Design. Turn your smartphone into a BB. Gateway.

Practical exercises
XXS/XXL. Real-Time Scheduling. Synchronisation and Communication web tour. Device Drivers. Multithreading Design.

Topic 4. System Finalisation

Welcome to Module! Software development tools and environments. Debugging basics: Thread and Device Drivers. Debugging Specials and Code Tuning. Testing and Device Simulation. Hardware or Software Security?

Self-study materials
Optional Resources. Challenges in Embedded Systems Development. Connecting target and host. IDE examples. Languages for Embedded Systems. Remote debugginng (optional experiment). Cross-compiler practice. Optional Resources. Simulation on host. Logical remote debugging. Realtime debugging. Step by step (optional). Optional resources. MMU as debugging tool. Finetuning. Optional Resources. White- and black-box testing. Simulating input, capturing output. Sporadic bugs. System survival under failure. Hardware or Software Security? Security requirements. Security coding techniques. Cryptography. Security models. No reverse engineering. How vendors deal with security issues. Private Clouds.

Practical exercises
Development Tools and Environments. Debugging Basics. Debugging Specials.

Topic 5. Low Power

Welcome to Module 4! What is low power? Power Budget. Measuring Power Consumption. On-board communication. External Communication.

Self-study materials
How long will the battery last? Discussion prompt. Reading assignment.

Practical exercise
Graded Quiz Low Power.

III. Assessment

Current control of knowledge is not provided.

An exam at the end of the course involves practical work for all students enrolled in the course. Topics covered by the test embraces all course material. If a student misses the exam because of some valid reason, s/he receives «absence» grade. The exam is assessed on usual 10-point scale.

IV. Evaluation tools for student certification assessment

Oral exam at the end of the course includes a theoretical question and a practical task.

The topics covered cover all course materials.

V. Reading list

5.1 Required

1. Principles of Cyber-Physical Systems - Rajeev Alur, MIT Press, 2015
2. Internet of Things, 1st Edition - Rajkumar Buyya, Amir Vahid Dastjerdi, Morgan Kaufmann, 2016
3. Building the Web of Things With examples in Node.js and Raspberry Pi - Dominique D.
4. Guinard and Vlad M. Trifa, June 2016 ISBN 9781617292682, 344 pages
5. Internet of Things: A Hands-On Approach - Arshdeep Bahga, Vijay Madisetti, 2014
6. Internet veshchej / A.V. Roslyakov, S.V. Vanyashin, A.YU. Grebeshkov, M.YU. Samsonov; pod red. A.V. Roslyakova. – Samara: PGUTI, OOO «Izdatel'stvo As Gard», 2014. –340 s.
7. Industry 4.0: The Industrial Internet of Things 1st ed. Edition by Alasdair Gilchrist, 2016

5.2 Optional

8. Jeff C. Jensen, Edward A. Lee, and Sanjit A. Seshia, An Introductory Lab in Embedded and Cyber-Physical Systems, http://LeeSeshia.org/lab, First Edition v.1.00, 2013.
9. Hands-On Introduction to LabVIEW for Scientists and Engineers 3rd Edition – John Essick, 2015, ISBN: 9780190211899, 688 pages
10. Cloud Computing (The MIT Press Essential Knowledge series) by Nayan B. Ruparelia, 2016
11. Cloud Computing: Concepts, Technology & Architecture, Thomas Erl, 2013

12. Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, & IaaS), Michael J. Kavis, January 2014
13. IBM Bluemix Architecture Series: Web Application Hosting on IBM Containers, 2015
14. PTC Academic Programm [URL: http://www.ptc.com/academic-program]
8. Petrenko S. A., Smirnov M. B. Bezopasnost' ASUTP i kriticheskoj informacionnoj infrastruktury // SPb.: OOO «ID «Afina». – 2018. ISBN 978-5-
9. 9909868-1-7. Uchebno-metodicheskoe posobie [EHlektronnaya versiya]
10. Petrenko S. A., Stupin D. D. Nacional'naya sistema rannego preduprezhdeniya o komp'yuternom napadenii. (SPb.: OOO «ID «Afina». – 2017. ISBN 978-5- 9909868-0-0). [Dostupna ehlektronnaya versiya]
11. Petrenko, Sergei (2018) Big Data Technologies for Monitoring of Computer Security: A
12. Case Study of the Russian Federation.
13. M.B. Smirnov, A.YU. YUrshev. IB-audit ob"ektov KII i kriticheski vazhnyh
14. ob"ektov TEHK // Zashchita informacii. Insajd. - 2018. - №2 (80)

5.3 Software

№ п/п	Title	Access conditions
1.	NI LabView	*From the university's internal network (contract)*

5.2 Professional databases, information reference systems, Internet resources (electronic educational resources)

№ п/п	Title	Access conditions
	Professional databases, information reference systems	
1.	Consultant Plus	*From the university's internal network (contract)*
2.	Electronic library system Urayt	URL: https://biblio-online.ru/
	Internet resources (electronic educational resources)	
1.	Open education	URL: https://openedu.ru/
2.	Electronic encyclopedia of processor terms.	http://www.ixbt.com/cpu/cpupedia.shtml

5.3 Material and technical support of the discipline

Computer classroom with Internet.