

Course title: INTERNET OF THINGS SERVICES

Lecturers	Assoc. Prof. Darko Androćec, Ph.D. Asst. Prof. Nikola Ivković, Ph.D. Korhan Cengiz, Ph.D.
Language of instruction	Croatian and English
Study level	Bachelor
Study programme	Information and Business Systems
Semester	6 th (summer)
ECTS	4
Goal	The goal of the course is to introduce students to creation of thing as a service, connect and publish data from IoT devices to the cloud, and interoperability with other systems. The role of network protocols and standards for the Internet of Things, as well as the principles of service-oriented architecture in building an IoT system, will be also addressed. Students will be introduced to the architectures and platforms of the Internet of Things and the Web of Things.
General and specific learning outcomes	
Content	<p>1. Introduction to Internet of Things systems</p> <p>Definition of the Internet of Things (IoT). Sensors, actuators, microcontrollers, complex things. The most common use cases of the Internet of Things. (2 hours)</p> <p>2. Cloud computing</p> <p>The definition of cloud computing. Basic models of cloud services: infrastructure as a service, platform as a service, application as a service. Cloud classification into public, private and hybrid, and examples of each type. Basic use cases. Advantages and disadvantages of this computational paradigms. (2 hours)</p> <p>3. Cloud and fog topology</p> <p>Formal definition of cloud topology. Architectural overview of the OpenStack cloud. Basic architecture problems only in cloud and the need for fog computing. OpenFog reference architecture. Use cases for fog computing. (2 hours)</p> <p>4. Middleware and IoT</p> <p>The definition of middleware. Types of middleware for the Internet of Things. Communication middleware between things and the cloud. Types of IoT platforms. (2 hours)</p> <p>5. Protocol standardization for IoT</p> <p>Internet of Things standardization initiatives. M2N and WSN protocols. Problems in standardizing the Internet of Things. (2 hours)</p> <p>6. Service oriented architecture for the Internet of Things</p> <p>Fundamentals of service-oriented architecture and its use in the Internet of Things. Different types of services. SOAP, REST, WebSocket. Advantages and disadvantages of service-oriented architecture for IoT. (2 hours)</p>

	<p>7. The architecture of the Web of Things</p> <p>Using the web on IoT Devices. Sensor network frames. Overview of existing web property architectures and platforms. Portals for Web of Things. Different levels of architecture of the Web of Things (networked things, access, search, sharing, composition). (2 hours)</p> <p>8. Creating a Web API for things</p> <p>Designing an API for things based on REST principles. Implementing RESTful things with HTTP and WebSockets. Resource representation using JSON. Real-time communication between things. (2 hours)</p> <p>9. Protocols for connecting an IoT device to the cloud</p> <p>MQTT. COAP. Other protocols that can be used to connect an IoT device to the cloud. Using remote application programming interfaces of cloud service providers. (2 hours)</p> <p>10. Describing and searching the Web of Things</p> <p>Web-level detection methods and protocols. Models for describing web things and their capabilities. Extension of the basic model with additional Semantic Web formats. (2 hours)</p> <p>11. Platforms and software tools for collecting data from different sensors</p> <p>A way to collect data from different sensors. Examples of platforms and software tools that provide a unique way to store and retrieve data from different sensors. Configuration of these platforms. (2 hours)</p> <p>12. Cloud services interoperability</p> <p>Definition of interoperability. Different types of interoperability. The basics of the Semantic Web and how to use it to achieve interoperability. Interoperability services of different cloud computing providers. (2 hours)</p> <p>13. Interoperability of the Internet of Things and cloud services</p> <p>The specifics of the Internet of Things services and their interoperability with cloud services. JSON-LD protocol. Other useful semantic web recommendations and protocols. (2 hours)</p> <p>14. Security risks and the problems of the Web of Things</p> <p>The anatomy of attacking the Internet of Things. Examples of malware focused on the Internet of Things. Security basics</p> <p>The internet of things related to physical security, cryptography, network and application layer security. Blockchain and IoT security. (2 hours)</p> <p>15. Cloud and Fog IoT Data Analysis</p> <p>Cloud and fog storage specificities. NoSQL Database. The basics of data analysis for the Internet of Things. Fundamentals of machine learning for the Internet of Things. (2 hours)</p>
Exercises	Practical computer lab exercises related to content of lectures described above
Realization and examination	<p>Format of instructions: lectures, computer labs, partial e-learning.</p> <p>Student responsibilities: Passed laboratory exercises and passed theoretical part of the exam through continuous monitoring or through regular exam term.</p>
Related courses	Related courses on Carnegie Mellon and ETH Zurich

Literature	<p>Sudip Misra, Subhadeep Sarkar, Subarna Chatterjee: Sensors, Cloud, and Fog: The Enabling Technologies for the Internet of Things, CRC Press, 2019</p> <p>Dominique Guinard, Vlad Trifa: Building the Web of Things: With examples in Node.js and Raspberry Pi, Manning Publications, 2016</p> <p>Perry Lea: Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security, Packt Publishing, 2018</p>
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