UAB
Universitat Autònoma de Barcelona

Internet of Things

Code: 104421
ECTS Credits: 6

2024/2025

Degree	Type	Year
2503740 Computational Mathematics and Data Analytics	OT	4

Contact

Name: Jordi Carrabina Bordoll

Email: jordi.carrabina@uab.cat

Teachers

Marc Codina Barbera

Teaching groups languages

You can view this information at the end of this document.

Prerequisites

The course is self-contained and therefore there are no specific pre-requisites.

Objectives and Contextualisation

The ICT world is being structured on various concepts. One of them is the Internet of Things, which is based on expanding the computing domain to connected objects (devices) of small size and energy consumption that interact with the real world via sensors and actuators in different areas: personal / wearables, health, home automation, environment, energy and water distribution, automotive, etc. These connect through various protocols to a fixed or mobile intermediate platform (edge) that manages, filters and processes part of the data locally. In turn, it is connected to the cloud where the data is stored, processed and displayed. The implementation of these systems requires integrating the various concepts, acquired in previous courses, in this new device-edge-cloud paradigm associated with different types of computing platforms (single-, multi-, many-core processors) with different requirements of functionality, power, latency, bandwidth and cost; different programming and communication models; and different cloud options for back-end and front-end, so a higher level of abstraction is required at the interface level (APIs and Middleware) and virtualization (computing and communications).

Goals:
Establish the fundamentals of the internet of things (IOT): device, periphery (edge) and cloud (cloud).
Learn to classify embedded processors, sensors, actuators, and systems, and select communications protocols and cloud options.
Evaluate the functional requirements and the performance in terms of cost, real time comnditio and energy efficiency.

Evaluate the cost of data structures based on sensors, computing, communication, storage and visualization at each level.

Select embedded and mobile platforms for the edge and cloud solutions for back-end and front-end.

Manage the virtualization of computing and communications.

Design a theoretical and practical example case of the entire IoT chain for a specific application.

Learning Outcomes

1. CM46 (Competence) Efficiently integrate heterogeneous data from various interconnected devices and systems.
2. CM46 (Competence) Efficiently integrate heterogeneous data from various interconnected devices and systems.
3. KM36 (Knowledge) Select the most appropriate components, technologies, platforms and datasets to develop environmentally friendly solutions to Internet of Things problems.
4. KM36 (Knowledge) Select the most appropriate components, technologies, platforms and datasets to develop environmentally friendly solutions to Internet of Things problems.

Content

Lectures

1. Global View of the Internet of Things and Virtualization

- IoT Systems: Functionality & Architecture. Device, edge,cloud
- Cloud back-end & front-end
- Virtual platforms for embedded systems
- Virtual platforms for cloud systems: IaaS, PaaS, SaaS
- Communications Virtualization

2. Introduction to Wired & Wireless Communications

- Communications standardization
- Wired Protocols for device, edge & cloud
- Wireless Networks for device to edge: WBAN, WPAN, WLAN, LPWAN
- Wireless Networks for edge to cloud: WLAN, WAN, LPWAN, 5G
- Communications data frames

3. Embedded and mobile platforms

- Embedded platforms: open & industrial
- Platform examples
- Mobile platforms

4. IoT Devices

- Examples and Use Cases
- HW Components: processors, sensors, actuators, batteries
- Performance: cost, real-time (latency, throughput), and energy efficiency
- Standards and Intellectual property

Guided project: Design of an (original) IoT system

P1. Original ideas for the design of an IoT system and preliminary market study

P2. Functional and performance specifications of the project

P3. Block and communications architecture of the IoT system and implementation alternatives

P4. System implementation. Selection of components and platforms

P5. Estimation of planning, costs and business model
P6. Document, presentation and defense of the project
Labs: Prototyping the (original) IoT system
L1. Introduction to programming on a SoC MCU-BLE
L2. Sensor +MCU + Bluetooth dataflow emulation.
L3. Android APP Programming I: Bluetooth Low energy Data Acquisition.
L4. Android Programming II: Computation and JSON application to a server.
L5. Cloud application: back-end & front-end
L6. Final presentation

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lessons and Seminars	30	1.2	
Study & Homework	90	3.6	
Type: Supervised			
Laboratories & Design Project	28	1.12	

The learning methodology will combine: master classes, activities in tutored sessions, project based-learning and use cases, debates and other collaborative activities; and laboratory sessions.

Attendance will be mandatory for the design of the IoT project and laboratory sessions tha will be done in groups of 2 or 3 people.

The laboratory sessions will use a supervised format (not guided) to offer greater autonomy to students and a more personalized support.

This course will use UAB's virtual campus at https://cv.uab.cat.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Evaluation of activities developed in tutored sessions (laboratories)	40%	0	0	CM46, KM36
Individual activities (i.e. exercices)	20%	0	0	KM36
Report and defence of the design project	40%	2	0.08	CM46, KM36

The evaluation of the course will follow the rules of the continuous evaluation and the final grade for the course, is calculated in the following way:
A - 20% from the mark obtained by the student through the evaluation of activities (i.e. exercises). When an evaluation activity is scheduled, the evaluation indicators will be reported and its weight in this qualification.
B - 40% from the mark obtained through the evaluation of the IoT design project.
C - 40% from the mark obtained by the student of the laboratory work and reports. It is necessary to exceed 5 (out of 10) in this item to pass the subject.

To obtain MH it will be necessary that the students have an overall qualification higher than 9 with the limitations of the UAB (1MH/20students). As a reference criterion, they will be assigned in descending order.

All activities will require delivering report through the virtual campus.
- Type A activities will be proposed along the course for groups of lectures.
- Type B activities, will require delivering partial reports of a global IoT project document every 2 weeks.
- Type C activities, will require delivering two partial reports (one by mid semester and a 2nd one at the end).

A final weighted average mark not lower than 50% is sufficient to pass the course, provided that a score over one third of the range is attained in every one of the Marks for first 2 items (A and B). If not reached, the mark will be 4.0.

Plagiarism will not be tolerated. All students involved in a plagiarism activity will be failed automatically. A final mark no higher than 30% will be assigned.

Open source code or available libraries can be used but they must be referred in the corresponding reports.

An student not having achieved a sufficient final weighted average mark, may opt to apply for remedial activities (individual work or additional synthesis examination) the subject under the following conditions:
- the student must have participated in the laboratory activities and design project, and
- the student must have a final weighted average higher than 30%, and
- the student must not have failed any activity due to plagiarism.

The student will receive a grade of "Not Evaluable" if:
- the student has not been able to be evaluated in the laboratory activities due to notattendance or not deliver the corresponding reports without justified cause.
- the student has not carriedout a minimum of 50% of the activities proposed.
- the student has not done the design project.

For each assessment activity, the student or the group will be given the corresponding comments. Students can make complaints about the grade of the activity, which will be evaluated by the teaching staff responsible for the subject.

Repeating students will be able to "save" their grade in laboratory activity.

Bibliography

C. Pfister. Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud (Make: Projects) . O'Really. 2011.

A. McEwen, H. Cassimally. Designing the Internet of Things.2014. Willey.

A. Bahga, V. Madisetti. Internet of Things: A Hands-on Approach. VTP. 2015.

S. Greengard, The Internet of Things. The MIT Press Essential Knowledge series.

V. Zimmer. Development Best Practices for the Internet of Things.

A. Bassi, M. Bauer, M. Fiedler, T. Kramp, R. van Kranenburg, S. Lange, S. Meissner. (Eds) Enabling Things to Talk - Designing IoT solutions with the IoT Architectural Reference Model. Springer.

J. Olenewa, Guide to Wireless Communications, 3rd Edition, Course Technology, 2014.

P. Raj and A. C. Raman, The Internet of Things: Enabling Technologies, Platforms and Use Cases, CRC Press 2017.

H. Geng (Ed.), Internet of the Things and Data Analytics Handbook, Wiley 2017.

Y. Noergaard, "Embedded Systems Architecture" 2nd Edition, 2012, Elsevier

K. Benzekki, Softwaredefined networking (SDN): a survey, 2017, https://doi.org/10.1002/sec.1737

https://blogs.cisco.com/innovation/barcelona-fog-computing-poc

https://aws.amazon.com/

A.K. Bourke et al. Evaluation of waist-mounted tri-axial accelerometer based fall-detection algorithms during scripted and continuous unscripted activities, Journal of Biomechanics, Volume 43, Issue 15, 2010, pp. 3051-3057

N. Jia. Detecting Human Falls with a 3-Axis Digital Accelerometer. Analog Devices. http://www.analog.com/en/analog-dialogue/articles/detecting-falls-3-axis-digital-accelerometer.html

Software

Students will use the SoC-BLE from Nordic Semiconductors as a device; the Android smartphone as Edge; and an server cloud option (selected by the students) with front-end i back-end.

Improvementets are expected in this whole chain (that will keep the same structure).

Language list

Name	Group	Language	Semester	Turn
(PLAB) Practical laboratories	418	English	first semester	morning-mixed
(PLAB) Practical laboratories	419	English	first semester	morning-mixed
(TE) Theory	418	English	first semester	morning-mixed