GENERAL INFORMATION

Course information	
Name	IIoT-Cloud Communications
Code	DEA-MIC-513
Degree	Máster en Industria Conectada (MIC)
Year	1st (2nd if pursuing a joint Master's degree)
Semester	1st (Spring)
ECTS credits	6 ECTS
Type	Compulsory
Department	Electronics, Control and Communications
Area	
Coordinator	José Javier Ruiz Cobo

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DETAILED INFORMATION

Contextualization of the course
Contribution to the professional profile of the degree

With economies of scale for sensors and other devices and the steady improvement in communication infrastructure, in the new industrial operation practice, a large number of connected devices (IIoT) report information from ubiquitous locations. The collected data are stored in databases and data warehouses which are more and more commonly hosted in the Cloud, where the information they contain is extracted and used to improve companies' efficiency.

This new context requires a fast, reliable and secure communication concept. In this course, we will thoroughly review the most important concepts, protocols and frameworks so that students are able to understand and implement the technology that supports the operation of a growing number of companies today.

By the end of the course, students will:
- Understand the main structures of systems communicating connected devices and the Cloud.
- Know the most important communication protocols and frameworks.
- Know the way security is ensured all along the communication stack.
- Know today's reference Cloud platforms.

Prerequisites

Students wishing to take this course should be very familiar with the fundamentals of networking and computer systems.

CONTENTS

Contents
Theory
Unit 1. Virtualization and Cloud
1.1 Concept, purpose and historical evolution. 1.2 Techniques: application-based, hypervisors and operating-based virtualization. 1.3 Advantages and disadvantages 1.4 Security and virtualization. Standardization. 1.5 Cloud computing concept and motivation. 1.6 Main cloud types: IaaS, PaaS and SaaS. 1.7 Cloud computing: advanced features.
Unit 2. Communication protocols
2.1 Low-power Networks 2.2 HTTP RESTful APIs. 2.3 GraphQL. MQTT. 2.4 CoAP. 2.5 OPC-UA.
Unit 3. Communication frameworks.
3.1 Message brokering. 3.2 Event aggregation. 3.3 Massive event capture in IoT platforms. 3.4 Semantic technologies.
Unit 4. Security
4.1 Security in IoT platforms. Physical, application and communication security. 4.2 Credential management. Encryption. PEP/PDP.
Unit 5. Reference platforms
5.1 Amazon 5.2 Microsoft 5.3 Google 5.4 ThingWorx 5.5 FIWARE
Laboratory
Lab 1. Virtual Private Cloud Network & Virtual Platforms (AWS)
Configuration of networks and virtual platforms, on Amazon Cloud platform
Lab 2. AWS IAM & Simple Storage Service
Authorization, authentication and management of access and permissions; Virtual Storage Solution, on Amazon Cloud platform
Lab 3. AWS Lambda & API Gateway
Software execution in SaaS mode and ways of remote management of platform, on Amazon Cloud platform
Lab 4. AWS DynamoDB & Key Management Service
cloud relational databases, security key management, on Amazon Cloud platform
Lab 5. AWS E2E IoT Application
Development of an end-to-end solution for an IoT service on a cloud platform
Competences and learning outcomes
Competences[1]
General competences

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[1] Competences in English are a free translation of the official Spanish version.

CG1.	Have acquired advanced knowledge and demonstrated, in a research and technological or highly specialized context, a detailed and well-founded understanding of the theoretical and practical aspects, as well as of the work methodology in one or more fields of study. *Haber adquirido conocimientos avanzados y demostrado, en un contexto de investigación científica y tecnológica o altamente especializado, una comprensión detallada y fundamentada de los aspectos teóricos y prácticos y de la metodología de trabajo en uno o más campos de estudio.*
CG2.	Know how to apply and integrate their knowledge, understanding, scientific rationale, and problem-solving skills to new and imprecisely defined environments, including highly specialized multidisciplinary research and professional contexts. *Saber aplicar e integrar sus conocimientos, la comprensión de estos, su fundamentación científica y sus capacidades de resolución de problemas en entornos nuevos y definidos de forma imprecisa, incluyendo contextos de carácter multidisciplinar tanto investigadores como profesionales altamente especializados.*
CG5.	Be able to transmit in a clear and unambiguous manner, to specialist and non-specialist audiences, results from scientific and technological research or state-of-the-art innovation, as well as the most relevant foundations that support them. *Saber transmitir de un modo claro y sin ambigüedades, a un público especializado o no, resultados procedentes de la investigación científica y tecnológica o del ámbito de la innovación más avanzada, así como los fundamentos más relevantes sobre los que se sustentan.*
CG6.	Have developed sufficient autonomy to participate in research projects and scientific or technological collaborations within their thematic area, in interdisciplinary contexts and, where appropriate, with a high knowledge transfer component. *Haber desarrollado la autonomía suficiente para participar en proyectos de investigación y colaboraciones científicas o tecnológicas dentro de su ámbito temático, en contextos interdisciplinares y, en su caso, con una alta componente de transferencia del conocimiento.*
CG7.	Being able to take responsibility for their own professional development and their specialization in one or more fields of study. *Ser capaces de asumir la responsabilidad de su propio desarrollo profesional y de su especialización en uno o más campos de estudio.*
Specific competences	
CEx.	Have an overview of the characteristics of the IIoT service platforms, as well as the ability to design a data aggregation and processing system, having the ability to select among the different available technological solutions the most suitable for a particular application. *Tener una visión general de las características de las plataformas de servicio IIoT, así como la capacidad de diseñar un sistema de agregación y tratamiento de datos, teniendo la capacidad de seleccionar entre las diferentes soluciones tecnológicas disponibles la más idónea para una aplicación en particular.*

Learning outcomes
By the end of the course students should:
RA1. Understand the benefits of platform virtualization, and the technical evolution that has led to the development of cloud computing platforms
RA2. Understand the different cloud services that can be offered, and have the ability to design an information management solution for these services
RA3. Design an IIoT solution using a cloud computing platform
RA4. Analyze and understand the different options of low power communication protocols
RA5. Understand and distinguish between different options for using transport communication protocols and consolidating data generated by IoT devices
RA6. Understand the different blocks and processes that make up a framework for communication and information processing IoT
RA7. To know the existing risks in terms of information security on an IoT platform, and the use of good practices and mechanisms that help to minimize them.
RA8. Compare and be able to decide on the choice of IIoT trading platforms

TEACHING METHODOLOGY

General methodological aspects	
Theory and practice will be combined along the course. The teacher will explain the basics of the subject and will go in depth in the more important issues with illustrative examples. The students will be grouped in pairs in order to put in practice the proposed methods and techniques in a collaborative way.	
In-class activities	**Competences**
▪ **Lectures (28 hours)**: The lecturer will introduce the fundamental concepts of each chapter, along with some practical recommendations, and will go through worked examples to support the explanation. Active participation will be encouraged by raising open questions to foster discussion and by proposing short application exercises to be solved in class either on paper or using a software package.	CG1, CG2, CG3, CG4, CG5, CG6, CG7, CEx
▪ **Lab sessions (28 hours):** Under the instructor's supervision, students, divided in small groups, will apply the concepts and techniques covered in the lectures to real problems and will become familiar with technologies used in development of smart solutions in the context of Industry 4.0.	CG1, CG2, CG3, CG4, CG6, CEx
▪ **Assessment (4 hours)**	–
Out-of-class activities	**Competences**
▪ Personal study of the course material and resolution of the proposed exercises (30 hours).	CG1, CG2, CEx
▪ Lab session preparation, programming and reporting (30 hours).	CG1, CG2, CEx
▪ Development of the final project (60 hours)	CG1, CG2, CEx

ASSESSMENT AND GRADING CRITERIA

Assessment activities	Grading criteria	Weight
Continuous evaluation	▪ Understanding of the theoretical concepts. ▪ Ability to search, analyze, sort and structure information ▪ Oral communication skills	20%
Final exam	▪ Understanding of the theoretical concepts. ▪ Application of these concepts to problem-solving.	30%
Lab assignments	▪ Application of theoretical concepts to real problem-solving. ▪ Ability to use and develop lab software. ▪ Written communication skills. There will be an intra-group evaluation method to differentiate among team members.	10%
Final project development	▪ Quality of the project implementation.	40%

GRADING AND COURSE RULES

Grading

Regular assessment

- **Theory** will account for 50%, of which:
  - Continuous evaluation: 20%
  - Final exam: 30%

- **Lab** will account for the remaining 50%, of which:
  - In-class labs report: 10%
  - Final project development: 40%

In order to pass the course, the mark of the Lab must be greater or equal to 5 out of 10 points and the mark of the Theory must be greater or equal to 5 out of 10 points. Otherwise, the final grade will be the lower of the two marks.

Retake

There will be only a final exam which will be the 100% of the grade. It will include both practical questions and theoretical concepts.

Course rules

- Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences:
  - Students who fail to attend more than 15% of the lectures may be denied the right to take the final exam during the regular assessment period.
  - Regarding laboratory, absence to more than 15% of the sessions can result in losing the right to take the final exam of the regular assessment period and the retake. Missed sessions must be made up for credit.
- Students who commit an irregularity in any graded activity will receive a mark of zero in the activity and disciplinary procedure will follow (cf. Article 168 of the General Regulations (Reglamento General) of Comillas Pontifical University).

WORK PLAN AND SCHEDULE[2]

In and out-of-class activities	Date/Periodicity	Deadline
Continuous evaluation activities to review and self-study of the concepts covered in the lectures	Periodically on demand	–
Final exam	Last week	-
Lab sessions	Weekly	–
Review and self-study of the concepts covered in the lectures	Weekly	–
Project preparation	Weekly	Last week

STUDENT WORK-TIME SUMMARY		
IN-CLASS HOURS		
Lectures	Lab sessions	Assessment
28	28	4
OUT-OF-CLASS HOURS		
Self-study	Lab preparation and reporting	Project Development
30	30	60
	ECTS credits:	6 (180 hours)

BIBLIOGRAPHY

Basic bibliography
▪ Slides prepared by the lecturer (available in Moodle).
▪ Geoff S. *IoT System and Device Architecture and Implementation*, EA Books
▪ Buyya R. Dastjerdi A. (2016) *Internet of Things*. Morgan Kaufmann. ISBN-13: 978-0128053959
▪ AWS – Centro de recursos iniciales (https://aws.amazon.com/es/getting-started/labs/)
▪ AWS – Training (https://www.aws.training/Training)

Complementary bibliography
▪ Practical Industrial Internet of Things Security: https://www.packtpub.com/business/practical-industrial-internet-things-security.
▪ Internet of Things – from research and innovation to market deployment: http://www.internet-of-things-research.eu/pdf/IoT-from%20Research%20and%20Innovation%20to%20Market%20Deployment_IERC_Cluster_eBook_978-87-93102-95-8_P.pdf

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[2] A detailed work plan of the subject can be found in the course summary sheet (see following page). Nevertheless, this schedule is tentative and may vary to accommodate the rhythm of the class.

Week	Date	Time [h]	Module	Lecture	Laboratory	Assessment
			In-class activities			
1	4-sep	2	INTRODUCTION	Course introduction (2h)		
2	6-sep	2	VIRTUALIZATION & CLOUD	Virtualization I (2h)		
3	11-sep	2		Virtualization II (2h)		
4	13-sep	2			Virtual Private Cloud Network & Virtual Platforms (AWS) (1,5h)	Quizz (0,5h)
5	18-sep	2		Cloud computing (I) (2h)		
6	20-sep	2		Cloud computing (II) (2h)		
7	25-sep	2			AWS IAM & Simple Storage Service (1,5h)	Quizz (0,5h)
8	27-sep	2	COMMUNICATION PROTOCOLS	Low-power Networks (2h)		
9	2-oct	2		HTTP RESTful APIs. (2h)		
10	4-oct	2		GraphQL. MQTT. (2h)		
11	2-oct	2		CoAP, OPC-UA (2h)		
12	9-oct	2			AWS Lambda & API Gateway (1,5h)	Quizz (0,5h)
13	11-oct	2	COMMUNICATION FRAMEWORKS	Message brokering (2h)		
14	16-oct	2		Event aggregation (2h)		
15	18-oct	2		Massive event capture in IoT platforms (2h)		
16	23-oct	2		Semantic technologies (2h)		
17	25-oct	2			AWS DynamoDB & Key Management Service (1,5h)	Quizz (0,5h)
18	30-oct	2	SECURITY	Security in IoT platforms (2h)		
19	6-nov	2		Credential management (2h)		
20	8-nov	2			AWS E2E IoT Application (1,5h)	Quizz (0,5h)
21	13-nov	2	REFERENCE PLATFORMS	Amazon (2h)		
22	15-nov	2		Microsoft (2h)		
23	20-nov	2		Google (2h)		
24	22-nov	2		ThingWorx (2h)		
25	27-nov	2		FIWARE (2h)		
26	29-nov	2		FIWARE (1,5h)		Quizz (0,5h)