

## Edge Computing

Code: 44025  
ECTS Credits: 6

Degree	Type	Year	Semester
4316624 Internet of Things for e-Health	OT	0	2

### Contact

Name: Remo Suppi Boldrito

Email: Remo.Suppi@uab.cat

### Use of Languages

Principal working language: english (eng)

### Prerequisites

It is recommended to have basic knowledge on Linux and Cloud Computing (concepts & practice).

### Objectives and Contextualisation

This course will explore research, frameworks, and applications in Edge Computing. The course will begin with a review of the problems of current big data at Cloud Computing and the student will then explore frameworks for computing over edge devices and cloud. Students will also create a lab project to test edge and cloud computing technologies.

### Competences

- Apply basic research tools in the area of IoT in health.
- Communicate and justify conclusions clearly and unambiguously to both specialist and non-specialist audiences.
- Continue the learning process, to a large extent autonomously.
- Design, develop, manage and evaluation mechanisms of certification, compression and security guarantees in the processing of and access to information in a local or distributed processing system.
- Develop and adapt geo-distributed services and apps on mobile devices aimed at the Cloud and Edge computing infrastructures.
- Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.
- Use and implement methods, techniques, specific use programmes, norms and standards in the development of mobile apps/wearables and social networks in the area of health.

### Learning Outcomes

1. Analyse and plan an optimal distributed solution in a mixed Clouds/Edge infrastructure according to the devices available in eHealth environments, taking advantage of geo-distributed system capabilities.
2. Apply basic research tools in the area of IoT in health.
3. Communicate and justify conclusions clearly and unambiguously to both specialist and non-specialist audiences.
4. Continue the learning process, to a large extent autonomously.
5. Design and evaluate an Edge Computing application prototype regarding its necessary infrastructure and costs.
6. Implement energy-efficient mobile-computing solutions through apps and services.

7. Implement secure solutions in Edge environments.
8. Solve problems in new or little-known situations within broader (or multidisciplinary) contexts related to the field of study.

## Content

Outline of course topics:

Unit 1: Introduction to Edge Computing

Unit 2: The Cloud Computing: problems & solutions

Unit 4: Edge Architectures & frameworks. Simulation.

Unit 5: Edge Computing Applications & Case Study (service data provider + mobile app + backend).

## Methodology

The course will be developed in classes, lab sessions and seminars with discussion groups & students presentations.

## Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Lab	12	0.48	2, 5, 6, 7
Lectures	27	1.08	1, 2, 5, 6, 7, 4
Type: Autonomous			
Collaborative work	20	0.8	1, 2, 8, 3, 4
Individual (personal work)	40	1.6	1, 2, 5, 7, 8, 4
Preparation and study	40	1.6	1, 2, 5, 8, 3, 4

## Assessment

The evaluation will be made by developing the proposed case studies using the tools presented in the lectures sessions and laboratory. Group work and interaction will also be assessed. Finally, the student will perform a conceptual test to evaluate the main aspects of the subject.

### Academic Integrity

If the student use someone work (code, figures, research publications, etc.) to produce any work for this course, the student must:

- indicate how this work was used,
- include this work in a bibliography section.

Violation of these policies will be considered a breach of academic integrity, and the student will be subject to penalties outlined by the MsC studies coordination at the School of Engineering. The student is subject to the rights and responsibilities that includes an academic (grade) penalty administered by the professor and/or disciplinary action by plagiarism in relation to internal rules of the UAB.

## Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Cases Studies: Analysis & Development	48	4	0.16	1, 2, 5, 6, 7, 8, 3, 4
Discussion in the forums	17	3	0.12	1, 2, 5, 6, 7
Quiz	35	4	0.16	1, 5, 6, 7, 8, 3

## Bibliography

### General

- [The Emergence of Edge Computing](#)  
M. Satyanarayanan. Computer, vol. 50, no. 1, Jan. 2017
- [Edge-centric Computing: Vision and Challenges](#)  
P. Lopez, A. Montresor, D. Epema, A. Datta, T. Higashino, A. Iamnitchi, M. Barcellos, P. Felber, and E. Rivore. Computer Communication Review 45 (5): 37-42 (2015)
- [Computing on the Edge: A Platform for Replicating Internet Applications](#)  
Rabinovich, Michael, and Xiao, Zhen, and Aggarwal, Amit. Web Content Caching and Distribution: Proceedings of the 8th International Workshop, 2004
- [Above the Clouds: A Berkeley View of Cloud Computing](#)  
Michael Armbrust Armando Fox, Rean Griffith, Anthony D. Joseph, Randy H. Katz, Andrew Konwinski, Gunho Lee, David A. Patterson, Ariel Rabkin, Ion Stoica, Matei Zaharia. Tech. Rep. UCB/EECS-2009-28, Feb 10, 2009.
- [NIST definition of cloud computing](#)  
P. Mell and T. Grance. Special Publication 800-145
- [Gearing resource-poor mobile devices with powerful clouds: architectures, challenges, and applications](#)  
Fangming Liu, Peng Shu, Hai Jin, Linjie Ding, Jie Yu, Di Niu, and Bo Li. IEEE Wireless Communications June 2013
- [Cloud-Based Augmentation for Mobile Devices: Motivation, Taxonomies, and Open Challenges](#)  
Saeid Abolfazli, Zohreh Sanaei, Ejaz Ahmed, Abdullah Gani, Rajkumar Buyya. IEEE Communications Surveys & Tutorials, 16(1), Feb. 2014
- [Mobile cloud computing: A survey](#)  
Niroshinie Fernando, Seng W. Loke, Wenny Rahayu. Future Generation Computer Systems 29 (2013)
- [Edge Computing Complete Self-Assessment guide](#). Gerardus Blokdyk. 2017.
- [Fog Computing in the Internet of Things: Intelligence at the Edge](#) 2018.
- [Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security](#) Paperback. Perry Lea. 2018

### Specific:

- [CloneCloud: elastic execution between mobile device and cloud](#)  
Chun, Byung-Gon and Ihm, Sunghwan and Maniatis, Petros and Naik, Mayur and Patti, Ashwin. Eurosys 2011
- [ThinkAir: Dynamic resource allocation and parallel execution in cloud for mobile code offloading](#)  
S. Kosta, A. Aucinas, P. Hui, R. Mortier, and X. Zhang. INFOCOMM 2012
- [Just-in-time provisioning for cyber foraging](#)  
Ha, Kiryong and Pillai, Padmanabhan and Richter, Wolfgang and Abe, Yoshihisa and Satyanarayanan, Mahadev. ACM MobiSys 2013
- [Tactical Cloudlets: Moving Cloud Computing to the Tactical Edge](#)  
Grace Lewis, James Root, Dan J. Klinedinst, Keegan M. Williams, Ben W. Bradshaw, Sebastian Echeverra. SEI CMU Publication, November 2015
- [OpenStack++ for Cloudlet Deployment](#)  
Kiryong Ha, Mahadev Satyanarayanan. CS Techreport CMU-CS-15-123, August 2015
- [The role of cloudlets in hostile environments](#).  
Mahadev Satyanarayanan et al. Proceeding of the fourth ACM workshop on Mobile cloud computing and services (MCS '13)

- [A Survey of Computation Offloading for Mobile Systems](#)  
Kumar, Karthik and Liu, Jibang and Lu, Yung-Hsiang and Bhargava, Bharat. Journal Mobile Networks and Applications Volume 18 Issue 1, February 2013

#### Edge Architecture, Services

- [ECC: Edge Cloud Composites](#)  
Bhardwaj, Ketan and Sreepathy, Sreenidhy and Gavrilovska, Ada and Schwan, Karsten. MobileCloud 2014
- [Cloud4Home. Enhancing Data Services with @Home Clouds](#)  
Sudarsun Kannan, Ada Gavrilovska, Karsten Schwan. CDCS 2011
- [ParaDrop: Enabling Lightweight Multi-tenancy at the Network's Extreme Edge](#)  
P. Liu, D. Willis and S. Banerjee. IEEE/ACM Symposium on Edge Computing (SEC), 2016
- [AppSachet: Distributed app delivery from the edge cloud](#)  
Bhardwaj, Ketan and Agarwal, Pragya, Gavrilovska, Ada and Schwan, Karsten. EAI International Conference on Mobile Computing, Applications and Services, 2015
- [Databox](#) Project
- [Apache Edgent](#)
- [Cloudy](#) Project
- [Microservices](#)
- [IOTracks](#)
- [EdgeFoundry](#)
- [DC/OS](#)
- [StreamSets](#)
- [OpenFog Consortium](#)
- [OpenEdge Computing](#)

#### IoT

- [An Operating System for the Home](#)  
Colin Dixon (IBM Research) Ratul Mahajan Sharad Agarwal A.J. Brush Bongshin Lee Stefan Saroiu Paramvir Bahl. NSDI 2012
- [IoT-MAP: IoT mashup application platform for the flexible IoT ecosystem](#)  
S. Heo, S. Woo, J. Im and D. Kim. 5th International Conference on the Internet of Things (IOT), 2015
- [Smart LaBLEs: Proximity, Autoconfiguration, and a Constant Supply of Gatorade](#)  
A. F. Harris, V. Khanna, G. S. Tuncay and R. H. Kravets. IEEE/ACM Symposium on Edge Computing (SEC), 2016
- [The Cloud is Not Enough: Saving IoT from the Cloud](#)  
Zhang, Ben and Mor, Nitesh and Kolb, John and Chan, Douglas S. and Goyal, Nikhil and Lutz, Ken and Allman, Eric and Wawrzyniec, John and Lee, Edward and Kubiatowicz, John. Proceedings of the 7th USENIX Conference on Hot Topics in Cloud Computing, 2015
- [The Internet of Things Has a Gateway Problem](#)  
Zachariah, Thomas and Klugman, Noah and Campbell, Bradford and Adkins, Joshua and Jackson, Neal and Dutta, Prabal  
HotMobile '15

#### Device Clouds, Edge Sensor Systems

- [STRATUS: Assembling Virtual Platforms from Device Clouds](#)  
Minsung Jang, Karsten Schwan. IEEE Cloud 2011
- [Vision: mClouds . Computing on Clouds of Mobile Devices](#)  
Emiliano Miluzzo, Ramon Caceres, Yih-Farn Chen. MCS 2012
- [The Swarm at the Edge of the Cloud.](#)
- E. A. Lee et al. IEEE Design Test, 2014
- [OUL: An Edge-Cloud System for Mobile Applications in a Sensor-Rich World](#)  
M. Jang, H. Lee, K. Schwan and K. Bhardwaj. IEEE/ACM Symposium on Edge Computing (SEC), 2016
- [The Design and Implementation of a Wireless Video Surveillance System](#)  
Zhang, Tan and Chowdhery, Aakanksha and Bahl, Paramvir (Victor) and Jamieson, Kyle and Banerjee, Suman

Proceedings of the 21st Annual International Conference on Mobile Computing and Networking, MobiCom 2015

- [Nebula: Distributed Edge Cloud for Data Intensive Computing](#)
- [A Hybrid Edge-cloud Architecture for Reducing On-demand Gaming Latency](#)  
Choy, Sharon and Wong, Bernard and Simon, Gwendal and Rosenberg, Catherine. Multimedia Syst. 20(5), 2014
- [Scalable Crowd-Sourcing of Video from Mobile Devices](#)  
Simoens, Pieter and Xiao, Yu and Pillai, Padmanabhan and Chen, Zhuo and Ha, Kiryong and Satyanarayanan, Mahadev. Mobisys 2013
- [Medusa: A Programming Framework for Crowd-Sensing Applications](#)  
Ra, Moo-Ryong and Liu, Bin and La Porta, Tom F. and Govindan, Ramesh  
Mobisys 2012
- [Odessa: Enabling Interactive Perception Applications on Mobile Devices](#)  
Ra, Moo-Ryong and Sheth, Anmol and Mummert, Lily and Pillai, Padmanabhan and Wetherall, David and Govindan, Ramesh  
Mobisys 2011.