



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

**"Edge Computing technologies and standards toward 5G-Advanced systems:
focus on automotive use cases"**

Teacher: Dario Sabella

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Short Abstract: The course will cover the main aspects of Edge Computing, from a both system level and practical perspective and with the aim to provide useful tool for engineers, research scientists and application developers. An initial technology overview will provide the description of MEC and related standards and industry associations working in the field, together with various open-source frameworks available. A particular emphasis will be given to the ETSI MEC standard (Multi-access Edge Computing), by mentioning as well other SDOs and the relationship with 3GPP for the definition of 5G systems. In particular, this course will introduce also innovative concepts like MEC Federation, and heterogeneous environments in multi-MNO domains, that are critical in many vertical market domains. A special focus will be given to automotive segment, and related MEC relevance from 5GAA (5G Automotive Association). The federation requirements, defined by GSMA OPG, will be presented together with the latest findings from impacted SDOs (ETSI, 3GPP) and open-source projects (LF). Additionally, an introduction of 5G-Advanced and their impacts on future MEC systems will be provided. A classroom exercitation will complete the course, where students will be asked to build their own application example exploiting MEC and based on the open-source software introduced during the course.

Course Contents in brief:

- Edge Computing, Fog computing, Cloud computing
- ETSI MEC Framework and Reference Architecture
- MEC in 4G, MEC in 5G, MEC in WiFi networks
- GSMA OPG and OPAG; LF CNCF Camara
- 5GAA MEC4AUTO and global MEC deployments
- MEC Federation (aspects from ETSI, 3GPP, GSMA, LF)
- MCE Phase 3 and 3GPP Release 18
- MEC Services, MEC Management, MEC Mobility
- MEC APIs (Radio Network Information API, Location API, BW API, ...)
- Open-Source frameworks: OpenNESS, OpenAPI MEC APIs representations, ETSI Forge, MEC Sandbox, tools and MEC Ecosystem
- Classroom exercise

Total # of hours of lecture: 20

References:

- [MEC001] ETSI GS MEC 001 V1.1.1 (2016-03) Mobile Edge Computing (MEC) Terminology - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/001/01.01.01_60/gs_MEC001v010101p.pdf
- [MEC002] ETSI GS MEC 002 V1.1.1 (2016-03) Mobile Edge Computing (MEC); Technical Requirements - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/002/01.01.01_60/gs_MEC002v010101p.pdf
- [MEC003] ETSI GS MEC 003 V1.1.1 (2016-03) Mobile Edge Computing (MEC); Framework and Reference Architecture - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/003/01.01.01_60/gs_MEC003v010101p.pdf
- [IEG004] ETSI GS MEC-IEG 004 V1.1.1 (2015-11) Mobile-Edge Computing (MEC); Service Scenarios - http://www.etsi.org/deliver/etsi_gs/MEC-IEG/001_099/004/01.01.01_60/gs_MEC-IEG004v010101p.pdf
- [IEG005] ETSI GS MEC-IEG 005 V1.1.1 (2015-08) Mobile-Edge Computing (MEC); Proof of Concept Framework - http://www.etsi.org/deliver/etsi_gs/MEC-IEG/001_099/005/01.01.01_60/gs_MEC-IEG005v010101p.pdf
- [IEG006] ETSI GS MEC-IEG 006 V1.1.1 (2017-01) Mobile Edge Computing; Market Acceleration; MEC Metrics Best Practice and Guidelines - http://www.etsi.org/deliver/etsi_gs/MEC-IEG/001_099/006/01.01.01_60/gs_MEC-IEG006v010101p.pdf
- [MEC009] ETSI MEC 009 "General principles for Mobile Edge Service APIs" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/009/01.01.01_60/gs_MEC009v010101p.pdf
- [MEC010-1] ETSI MEC 010-2 "Mobile Edge Management; Part 2: Application lifecycle, rules and requirements management" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/01002/01.01.01_60/gs_MEC01002v010101p.pdf
- [MEC010-2] ETSI MEC 010-2 "Mobile Edge Management; Part 2: Application lifecycle, rules and requirements management" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/01002/01.01.01_60/gs_MEC01002v010101p.pdf
- [MEC011] ETSI MEC 011 "Mobile Edge Platform Application Enablement" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/011/01.01.01_60/gs_MEC011v010101p.pdf
- [MEC012] ETSI MEC 012 "Radio Network Information API" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/012/01.01.01_60/gs_MEC012v010101p.pdf
- [MEC013] ETSI MEC 013 "Location API" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/013/01.01.01_60/gs_MEC013v010101p.pdf
- [MEC015] ETSI MEC 015 "Bandwidth management API" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/015/01.01.01_60/gs_MEC015v010101p.pdf
- [MEC016] ETSI MEC 016 "UE application interface" - http://www.etsi.org/deliver/etsi_gs/MEC/001_099/016/01.01.01_60/gs_MEC016v010101p.pdf
- [MEC018] ETSI MEC 018 "End to End Mobility Aspects" - http://www.etsi.org/deliver/etsi_gr/MEC/001_099/018/01.01.01_60/gr_MEC018v010101p.pdf
- [MEC035] ETSI GR MEC 035, "Multi-access Edge Computing (MEC); Study on Inter-MEC systems and MEC-Cloud systems coordination" - https://www.etsi.org/deliver/etsi_gr/MEC/001_099/035/03.01.01_60/gr_mec035v030101p.pdf
- [MEC040] ETSI GS MEC 040, "Multi-access Edge Computing (MEC); Federation enablement APIs" - <https://docbox.etsi.org/isg/mec/open/MEC040%20FederationAPI%20drafts>

CV of the Teacher

DARIO SABELLA works with INTEL as Senior Manager Standards and Research, driving new technologies and edge cloud innovation for advanced systems, involved in ecosystem engagement and coordinating internal alignment on edge computing across standards and industry groups. In February 2021 has been elected as Chairman of ETSI MEC (Multi-access Edge Computing), while from 2019 he was serving as vice-chairman, previously Lead of Industry Groups, and from 2015 vice-chair of IEG WG. Since 2017 he is also delegate of 5GAA (5G Automotive Association). Before 2017 he worked in TIM (Telecom Italia group), as responsible in various research, experimental and operational activities on OFDMA technologies (WiMAX, LTE, 5G). Author of several publications (40+) and patents (30+) in the field of wireless communications, energy efficiency and edge computing, Dario is IEEE senior member and has also organized several international workshops and conferences.

Final Exam: quiz with multiple-answers

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Aula Riunioni del Piano 6 del Dipartimento di Ingegneria dell'Informazione, Largo Lucio Lazzarino 1, Pisa

Aula Virtuale il 12/12/2022

Course Schedule:

Day1

05/12/2022: 11.00-18.00, Aula Riunioni Piano Terra, via Caruso

Topics:

- Edge Computing, Fog computing, Cloud computing
- MEC Framework and Reference Architecture [MEC003]
- General principles for Mobile Edge Service APIs [MEC 009]
- MEC Platform Application Enablement [MEC011]
- GSMA OPG and OPAG; LF CNCF Camara
- Classroom exercise – part 1

Day2

06/12/2022: 9.00-17.00, Aula Riunioni Piano Terra, via Caruso

Topics:

- MEC in 4G, MEC in 5G, MEC in WiFi networks
- MEC in NFV environment (MEC-017)
- MEC support for Network Slicing (MEC-024)
- MEC Management [MEC010-1][MEC010-2]
- MEC Application and E2E Mobility (MEC-018, MEC-021)
- Inter-MEC systems and MEC-Cloud systems coordination (MEC-035)
- 5GAA MEC4AUTO and global MEC deployments
- Software Development for MEC
- MEC-027 – MEC support for Containers
- Open Network Edge Services Software (OpenNESS)
- Classroom exercise – part 2

Day3

07/12/2022: 9.00-17.00, **Aula Riunioni Piano 6, Largo Lucio Lazzarino**

Topics:

- OpenAPI MEC APIs representations, ETSI Forge
- MEC Sandbox, tools and MEC Ecosystem
- MEC-012 – RNI API, MEC-013 – Location API, MEC-028 – WLAN Information API
- MEC-016 – UE Application Interface, MEC-014 – UE identity API
- MEC architecture variant for MEC Federation, inter-MEC system communication
- MEC Federation deployment options
- MEC Phase 3 and 3GPP Release 18
- MEC Testing Framework (MEC-025), MEC Conformance Test Suite
- Performance Assessment, Metrics Best Practices and Guidelines (IEG006)
- MEC-026 – MEC support for regulatory requirements
- Application Deployment, Application Walkthrough
- Classroom exercise – part 3

Day4

12/12/2022: 14:00 - 17:00, **Lezione da remoto**

Topics:

- Vertical segments: focus on automotive (MEC-022 “MEC support for V2X use cases”, and MEC-030 “MEC V2X API”)
- MEC-015 – Bandwidth management API
- MEC Federation enablement APIs (MEC 040)
- MEC toward 6G systems
- MEC in action: examples and trials
- OpenNESS and 5G: integration with SimuLTE/5G
- Classroom exercise – presentation of results