H9FEC: Fog and Edge Computing

Module Code:	H9FEC
Long Title	Fog and Edge Computing APPROVED
Title	Fog and Edge Computing
Module Level:	LEVEL 9
EQF Level:	7
EHEA Level:	Second Cycle
Credits:	10
Module Coordinator:	Horacio Gonzalez-Velez
Module Author:	DAVID TRACEY
Departments:	School of Computing
Specifications of the qualifications and experience required of staff	PhD or MSc degree in Computer Science, Computing or Electronic Engineering with experience of Cloud technologies, distributed systems and Internet of Things.

Learning Outcomes

On successful completion of this module the learner will be able to:

#	Learning Outcome Description
LO1	Describe the key architectures and concepts in the Internet of Things and in Fog and Edge Computing
LO2	Describe the key architectures and applications in cloud computing, big data and how they relate to edge computing
LO3	Critically evaluate research publications on cloud services and edge computing and deliver oral presentations on selected ones.
LO4	Implement software using standard open-source cloud and edge computing software for data analytics.
LO5	Demonstrate in-depth knowledge of different types of hardware and software systems used in fog and edge computing

Dependencies

Module Recommendations

No recommendations listed

Co-requisite Modules

No Co-requisite modules listed

Entry requirements	Bachelor's degree in Computer Science, Computing or Electronic Engineering.

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Module Content & Assessment

Indicative Content
Introduction to the Internet of Things Overview of issues in IoT and Architectural approaches to IoT and Edge Computing, RESTFul Architectural Style, P2P systems
Wireless and Mobile technologies Introduction to wireless fundamentals to understand the importance of power, Role of a MAC layer, Routing techniques such as RPL, NB-IoT and 5G
Big Data Systems and IoT Overview of Big Data systems, Use of NoSQL databases in IoT and Fog, Focus on time-series databases for IoT and Fog
Services for Distributed Systems Redis and the role of caching, Kafka, Zookeeper, Kubernetes
Embedded Systems and Constrained Devices Introduction to programming on IoT devices and constrained environments, Use of embedded OS such as Contiki or RIOT, Review of CoAP and MQTT
Data models for IoT OMA LWM2M, IETF WoT Architecture
Cloud IoT Services Review of IoT services from Amazon, Google and Microsoft
Fog and Edge Architectures Fog and Edge Architectures, e.g. OpenFog Reference Architecture, Network Function Virtualization (NFV) and SDN (Software Defined Networking), Recommendations of the National Institute of Standards and Technology (NIST)
Middleware for Fog and Edge Focus on data aggregation
Security Issues for IoT, Fog and Edge NIST recommendations, Typical security attacks and relevance to IoT devices
Introduction to Data Analytics Introduction to Data Analytics approaches for Edge, e.g Amazon Sagemaker for Anomaly Detection

Assessment Breakdown	%
Coursework	40.00%
End of Module Assessment	60.00%

Assessments

Full Time

Coursework

Assessment Type:	Project	**% of total:**	40
Assessment Date:	n/a	**Outcome addressed:**	1,2,3,4
Non-Marked:	No		

Assessment Description:
This will include a review of selected research papers and an implementation of a small example of a system using this research, using open-source software as required. This will be demonstrated to the lecturer, with marks awarded for the implementation, demonstration and understanding shown of the research performed.

End of Module Assessment

Assessment Type:	Terminal Exam	**% of total:**	60
Assessment Date:	End-of-Semester	**Outcome addressed:**	1,2
Non-Marked:	No		

Assessment Description:
Questions covering a range of content to ensure the fundamental aspects of the course have been understood

No Workplace Assessment

Reassessment Requirement

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

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Module Workload

Module Target Workload Hours 0 Hours

Workload: Full Time

Workload Type	*Workload Description*	*Hours*	*Frequency*	*Average Weekly Learner Workload*
Lecture	Attendance at lecture	24	Every Week	24.00
Tutorial	Review of lecture content and work for assessment	24	Every Week	24.00
Independent Learning Time	Study and work on assessment	202	Per Semester	16.83
			Total Weekly Contact Hours	48.00

Module Resources

This module does not have any book resources

Recommended Article/Paper Resources

Mark Weiser. (1991), The Computer for the Twenty-First Century, Scientific American, September,
https://www.ics.uci.edu/~corps/phaseii/W eiser-Computer21stCentury-SciAm.pdf

F. Bonomi et al. (2013), Fog Computing and Its Role in the Internet of Things, Proceedings of the first edition of the MCC Workshop on Mobile Cloud Computing, August,
https://conferences.sigcomm.org/sigcomm/ 2012/paper/mcc/p13.pdf

Mahadev Satyanarayanan. (2017), The Emergence of Edge Computing, IEEE Computer, January,
https://ieeexplore.ieee.org/abstract/doc ument/7807196

NIST. Fog Computing Conceptual Model: Recommendations of the National Institute of Standards and Technology,
<a shape="rect" class="external-wrap" href="https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-325.pdf"" target="_blank">
https://nvlpubs.nist.gov/nistpubs/Specia lPublications/NIST.SP.500-325.pdf"

M. Armbrust et al. (2009), Above the clouds: A Berkeley View of Cloud Computing,
https://www2.eecs.berkeley.edu/Pubs/Tech Rpts/2009/EECS-2009-28.pdf

P. Mell and T. Grance. The NIST Definition of Cloud Computing,
https://csrc.nist.gov/publications/nistp ubs/800-145/SP800-145.pdf

M. Kovatsch et al. (2019), Web of Things (WoT) Architecture (W3C Candidate Recommendation),
https://www.w3.org/TR/2019/CR-wot-archit ecture-20190516/

Supplementary Article/Paper Resources

R. Fielding. (2000), R. Fielding, Architectural Styles and the Design of Network-based Software Architectures, Doctoral Thesis,
https://www.ics.uci.edu/~fielding/pubs/d issertation/fielding_dissertation.pdf

Z. Shelby et al. RFC 7252, The Constrained Application Protocol (CoAP),
https://datatracker.ietf.org/doc/rfc7252 /

M. Stonebraker. (2007), The End of an Architectural Era (It's Time for a Complete Rewrite), Proceedings of the 33rd International Conference on Very Large Data Bases,
http://nms.csail.mit.edu/~stavros/pubs/h store.pdf

Open Mobile Alliance. Lightweight Machine-to-Machine Technical Specification v1.0.1,
http://www.openmobilealliance.org/releas e/LightweightM2M/V1_0_1-20170704-A/OMA-T S-LightweightM2M-V1_0_1-20170704-A.pdf

Industrial Internet Consortium. (2017), OpenFog Reference Architecture,
https://www.iiconsortium.org/pdf/OpenFog _Reference_Architecture_2_09_17.pdf

This module does not have any other resources

Discussion Note:	