Module 34 Internet of Things & Sensor Systems

Module title	Internet of Things & Sensor Systems
Module NFQ level (only if an NFQ level can be demonstrated)	8
Module number/reference	BSCH-ITSS
Parent programme(s)	Bachelor of Science (Honours) in Computing Science
Stage of parent programme	Award stage
Semester (semester1/semester2 if applicable)	Semester 2
Module credit units (FET/HET/ECTS)	ECTS
Module credit number of units	5
List the teaching and learning modes	Direct, Blended
Entry requirements (statement of knowledge, skill and competence)	Learners must have achieved programme entry requirements.
Pre-requisite module titles	BSCH-CSWD, BSCH-SSWD
Co-requisite module titles	None
Is this a capstone module? (Yes or No)	No
Specification of the qualifications (academic, pedagogical and professional/occupational) and experience required of staff (staff includes workplace personnel who are responsible for learners such as apprentices, trainees and learners in clinical placements)	Qualified to as least a Bachelor of Science (Honours) level in Computer Science or equivalent and with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.
Maximum number of learners per centre (or instance of the module)	60
Duration of the module	One Academic Semester, 12 weeks teaching
Average (over the duration of the module) of the contact hours per week	3
Module-specific physical resources and support required per centre (or instance of the module)	One class room with capacity for 60 learners along with one computer lab with capacity for 25 learners for each group of 25 learners

Analysis of required learning effort		
	Minimum ratio teacher / learner	**Hours**
Effort while in contact with staff		
Classroom and demonstrations	1:60	18
Monitoring and small-group teaching	1:25	18
Other (specify)		
Independent Learning		
Directed e-learning		
Independent Learning		54
Other hours (worksheets and assignments)		35
Work-based learning – learning effort		
Total Effort		125

Allocation of marks (within the module)					
	Continuous assessment	**Supervised project**	**Proctored practical examination**	**Proctored written examination**	**Total**
Percentage contribution	50%			50%	100%

Module aims and objectives

The module aims to introduce the learner to the Internet of Things. The Internet of Things (IoT) is an area that has received significant attention from both industry and academia in the recent years. This module is an introductory level which provides an overview of developing and deploying solutions for the Internet of Things. It focusses on key concepts of data retrieval from IoT devices and sending the data to a cloud platform where it can be used to develop smart applications. Learners learn all the steps that are required to develop a basic IoT oriented solution.

Minimum intended module learning outcomes

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

1. Explain the building blocks and underlying technologies that support IoT.
2. Describe the hardware components and interaction between software and hardware in an IoT device.
3. Critique the role of an operating system in IoT devices.
4. Demonstrate how IoT services can be deployed on the web.
5. Compare the differences between various IoT communication protocols.
6. Explore the security and privacy developments and challenges in IoT.
7. Develop and deploy basic IoT applications.

Rationale for inclusion of the module in the programme and its contribution to the overall MIPLOs

The module enables learners to understand concepts which form the basis of Internet of Things technologies. It enables the learners to develop and deploy IoT-powered applications.

Appendix 1 of the programme document maps MIPLOs to the modules through which they are delivered.

Information provided to learners about the module

Learners receive a programme handbook to include module descriptor, module learning outcomes (MIMLO), class plan, assignment briefs, assessment strategy, and reading materials.

Module content, organisation and structure

Basics of Internet of Things

- Introduction to Internet of Things and History
    - From Internet to Internet of Things,
    - Overview of IoT enabling technologies,
    - Opportunities and challenges.
- IoT principles and fundamentals
    - Communication and Networking (Zigbee, Bluetooth, GSM, WiFi, etc.)
    - Hardware - boards, sensors and actuators
    - Software – IoT software stack
- Applications of IoT
    - Smart Traffic,
    - Smart Health,
    - Smart Agriculture,
    - Smart Mobility, etc.

Internet of Things Technology Stack

- IoT Operating Systems
    - TinyOS,
    - ContikiOS,
    - Embedded Linux, etc.
- Data and Communication Protocols
    - CoAP,
    - MQTT,
    - XMPP, AMQP, etc.

- IoT Cloud-based Platforms
    - Commercial (IBM Watson, Google Cloud IoT, Microsoft Azure IoT Suite, etc.)
    - Open Source (Kaa, ThingSpeak, OpenIoT, etc.)

- IoT Security
    - IoT security challenges,
    - Privacy implications,
    - Existing solutions.
- IoT Architectures
    - IoT Architectural Reference Model (ARM),
    - Comparison with other architectures.

IoT Programming – Running parallel

- IoT Device Programming Techniques
    - Data acquisition from sensors,
    - Actuations and Controls.
- IoT platform and applications
    - Acquire the sensor data at various frequency rate and store it on a chosen IoT cloud platform,
    - Process and visualize the data.

Module teaching and learning (including formative assessment) strategy

The module is taught using a combination of lectures, demonstrations, and tutorials. The demonstrations and tutorials focus on getting learners up to standard in practical application development. The lectures supply the necessary theoretical background. In a fast-changing technology field, learners are expected under guidance to engage in research in relation to the different technologies and products available.

The module has both a continuous assessment element and a final examination. It requires the learner to show an understanding of the emerging technologies in the area of Internet of Things and develop applications. The group project allows the learners to gain practical hands-on experience of building and deploying an IoT application. The final examination assesses their understanding to the theoretical concepts involved.

Timetabling, learner effort and credit

The module is timetabled as one 1.5-hour lecture and one 1.5-hour labs per week.

The number of 5 ECTS credits assigned to this module is our assessment of the amount of learner effort required. Continuous assessment spreads the learner

effort to focus on small steps before integrating all steps into the overall process of developing and deploying a IoT application/prototype.

There are 36 contact hours made up of 12 lectures delivered over 12 weeks with classes taking place in a classroom. There are also 12 lab sessions delivered over 12 weeks taking place in a fully equipped computer lab. The learner will need 54 hours of independent effort to further develop the skills and knowledge gained through the contact hours. An additional 35 hours are set aside for learners to work on worksheets and project that must be completed for the module as a part of the continuous assessment.

The team believes that 125 hours of learner effort are required by learners to achieve the MIMLOs and justify the award of 5 ECTS credits at this stage of the programme.

Work-based learning and practice-placement
There is no work based learning or practice placement involved in the module.

E-learning
The college VLE is used to disseminate notes, advice, and online resources to support the learners. The learners are also given access to Lynda.com as a resource for reference.

Module physical resource requirements
Requirements are for a classroom for 60 learners equipped with a projector, and a 25 seater computer lab for practical sessions with access to recommended IoT application development environment (this decision may be left on the lecturer to pick the current IoT software development platform).

IoT devices (Arduino, Raspberry PI, dragonboard, etc.) and basic sensors (temperature, light, humidity, etc.) are required for learners to work on group projects / prototype applications. Depending on the class size each group will need at least one IoT board and a set (3-4) of sensors.

Reading lists and other information resources
Recommended Text
Kellmereit, D. and Obodovski, D. (2013) *The Silent Intelligence: Internet of Things*. San Francisco: DnD Ventures.

Kranz, M. (2017) *Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry.* John Wiley & Sons.

Recent top quality journal papers on Internet of Things technological developments as well as documentation from IoT standards and platform providers.

Secondary Reading:

McEwen, A., Cassimally, H., (2014) *Designing the Internet of Things*, Hoboken: Wiley

Specifications for module staffing requirements

For each instance of the module, one lecturer qualified to at least Bachelor of Science (Honours) in Computer Science or equivalent, and with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.. Industry experience would be a benefit but is not a requirement.

Learners also benefit from the support of the programme director, programme administrator, learner representative and the Student Union and Counselling Service.

Module Assessment Strategy

The assignments constitute the overall grade achieved, and are based on each individual learner's work. The continuous assessments provide for ongoing feedback to the learner and relates to the module curriculum.

No.	Description	MIMLOs	Weighting
1	Group Project Students to work in a group of 3-4 to develop an IoT prototype based on a real-world scenario. The data must be stored in an IoT cloud-based platform and then processed and visualized.	1-7	50%
2	Written exam that tests the theoretical aspects of the module.	1-7	50%

All repeat work is capped at 40%.

Sample assessment materials

Note: All assignment briefs are subject to change in order to maintain current content.

Project Brief:

Overview:

In the prototype application powered by the Internet of Things, you will design and build your own system that uses at least 3 sensors, at least 1 actuator, at least 1 communication protocol and at least one cloud platform to store and visualize the sensor data. You will use the IoT application development technologies that we have studied throughout this module. You will need to program the IoT devices to acquire measurements from the sensors. You will then store these measurements in one of the cloud platform you have selected using an IoT communication protocol that you have studied. One the data is stored, you are required to process it and visualize intuitively. Thereafter, send a control code to the actuator for controlling a real-world object or implement a simulation scenario. You can come up with any scenario that sounds interesting, for example, setting HVAC temperature autonomously, switching lights on/off depending upon the room occupancy, or opening room windows when observing high CO_2 levels, etc.

Technologies to use:

Sensors & Actuator:

- Platform: Grove (Arduino compatible), Seed
- Sensing parameters: Temperature, humidity, light, presence, CO_2, sound, acceleration.

Programming Environment:

- Processing (Arduino) / ContikiOS

Communication Protocols:

- MQTT / CoAP

Cloud Platform:

- Xively / Amazon

Application Architecture:

- ARM

How to submit:

Demo:

Create and setup a working demo of your application. Demonstrate it to your classmates during lab slots in the last week of the semester.

Submission:

Create a word document to provide an overview of your application and its architecture. The technologies you have used. Submit the document along with the code you developed to program devices and the visualization tool.

Deadline:

See Moodle.

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QUALITY AND QUALIFICATIONS IRELAND
EXAMINATION

Internet of Things and Sensor Systems

Lecturer(s): …
External Examiner(s): …

Date: … **Time:** … – …

THIS PAPER CONSISTS OF FOUR QUESTIONS
ALL FOUR QUESTIONS TO BE ATTEMPTED
ALL QUESTIONS CARRY EQUAL MARKS

Question 1

a) What makes an embedded (WSNs) system different than other networked systems.

(5 marks)

b) Describe the difference between CoAP and MQTT protocols.

(10 marks)

c) What are the enabling technologies for IoT?

(10 marks)

Total (25 marks)

Question 2

d) Compare and contrast, under appropriate criteria, Bluetooth and ZigBee.

(10 marks)

e) List top 5 IoT related security and privacy challenges.

(15 marks)

Total (25 marks)

Question 3

a) Describe the ARM architecture and its components. Compare ARM with another reference model that you have studied.

(25 marks)

Total (25 marks)

Question 4

a) Provide 3 examples of IoT applications in the Context of Smart Cities and briefly discuss the technologies utilized therein.

(15 marks)

a) Discuss the differences between the UDP and TCP transport layer protocols. In doing so identify use cases for each, and their relative advantages and disadvantages.

(10 marks)

b) List the components of the IoT software stack.

(5 marks)

Total (25 marks)