ELEC0032 - Setting the scene

This module (previously known as ELEC310P) is part of the 3-module Connected Systems Minor.

ELEC0017 (previously referred to as ELEC210P)

In the first module, ELEC0017, we learned how to connect a simple edge device (such as the Texas Instruments CC3200) to the Internet over a communications medium (in this case, WiFi). We used this device to send and receive data using a lightweight protocol (in this case, MQTT). Subsequently, a cloud platform (in this case, IBM Bluemix), was used to register the device, store the data and run applications and services in the cloud that made use of this data.

ELEC0032 (previously referred to as ELEC310P)

In this module, ELEC0032, we will build upon this knowledge and delve deeper into the different technologies making up an Internet of Things (IoT) system looking at all layers of the so-called *IoT stack*.

ELEC0033 (previously referred to as ELEC311P)

In the final module, ELEC0033, we will combine the skills acquired in ELEC0017 with the advanced theory and knowledge acquired in ELEC0032 to devise and implement a complete, end-to-end IoT system.

Topics in ELEC0032

The topics that will be studied during this module (ELEC0032) include the following:

- **Topic 1 (JM)**: Physical (PHY) Layer - Wireless Technologies, Topologies and Networks.
- **Topic 2 (LT)**: Media Access Control (MAC) Layer - MAC Designs and Protocols.
- **Topic 3 (MR)**: Network and Transport Layer - IP and Transport Protocols.
- **Topic 4 (RG)**: Application Layer - Data Analytics.

The lecturers who will be teaching these topics are:

- Prof John Mitchell (JM).
- Dr Laura Toni (LT).
- Prof Miguel Rio (MR).
- Dr Ryan Grammenos (RG).

The IoT Stack

Conventionally, we use the Open Systems (or Standards) Interconnect (OSI) model to break down a communications or networked system into seven abstract layers. Similarly, an IoT system can be partitioned into multiple layers though a standardised model does not exist to date. We can, however, link the OSI model to different conceptual models of an IoT system, as shown in Figure 1 below.

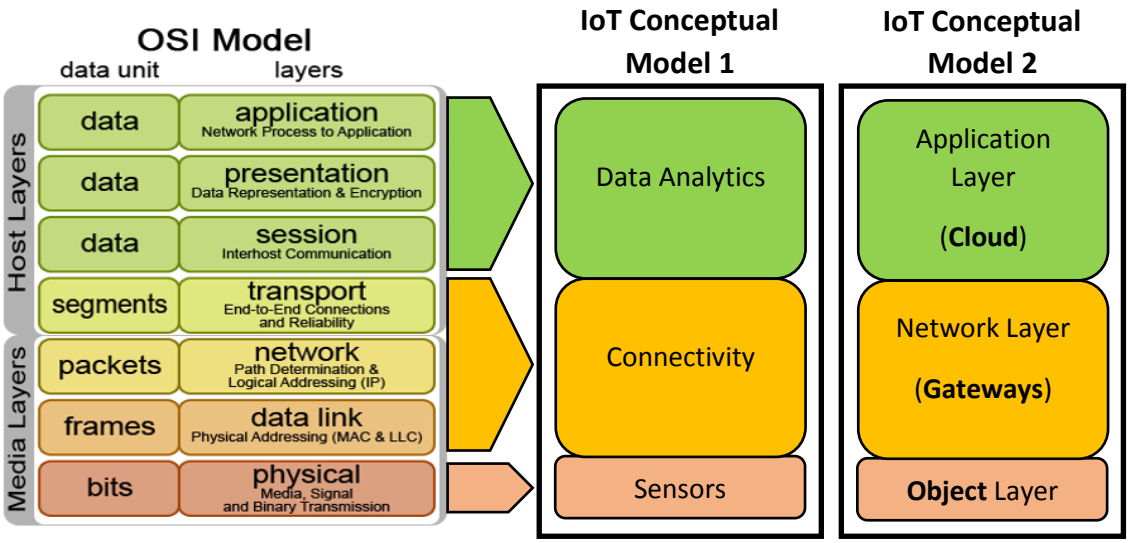

Figure 1: The OSI model with reference to different conceptual models of the IoT stack [1]

From Figure 1, it should be evident how the different topics to be examined in this module relate to both the conventional OSI model, as well as the conceptual IoT stack.

The Internet of Things in a nutshell

An excellent poster presenting the different elements of an IoT ecosystem is available from Keysight Technologies at the link below:
https://www.keysight.com/main/editorial.jspx?cc=DJ&lc=eng&ckey=2670326&nid=-11143&id=2670326

The figures presented in the following paragraphs have been extracted from the above Keysight poster with some additional annotations.

Exploring the IoT stack in more detail, Figure 2 shows the different technologies used to communicate data between the lowest level (the object layer) and the highest level (the application layer).

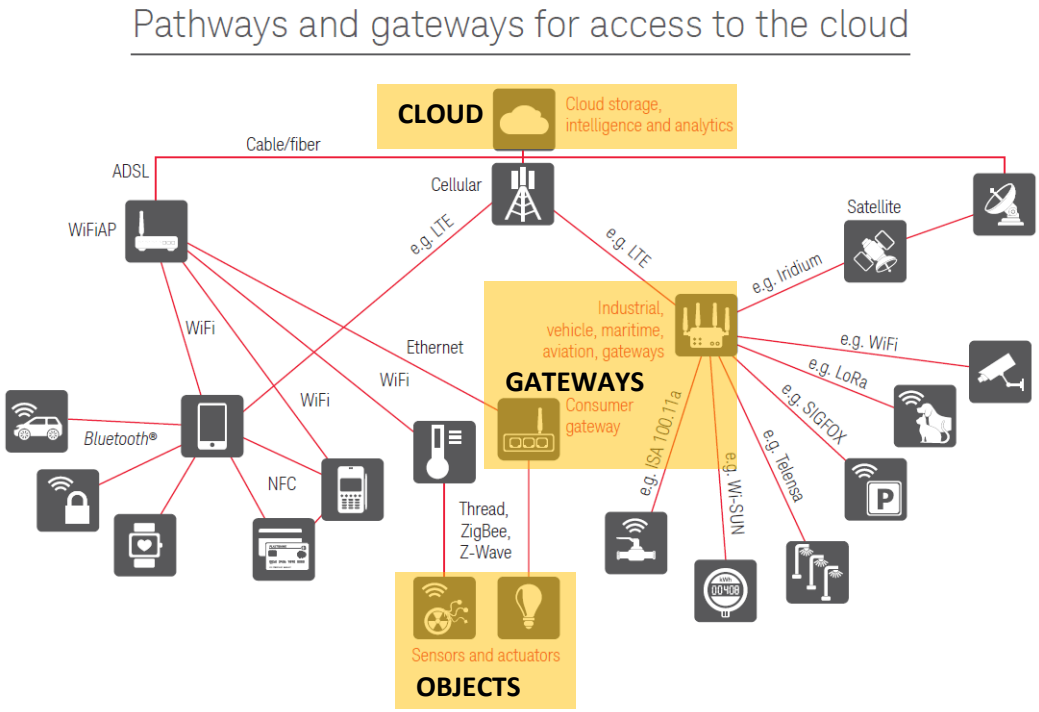

Figure 2: Communication avenues between the object layer and the application (cloud) layer [2]

Interconnection between the different topics in ELEC310P

The layers in the OSI model and the IoT stack offer different levels of abstraction depending on the technology and application under consideration. Some technologies, for example, may span more than one layers in these conceptual models.

The PHY and MAC layers usually go hand-in-hand. Notable examples include the IEEE 802.11 standard (WiFi and its variants) and the IEEE 802.15.4 standard (Low Rate wireless and its variants). On the contrary, ZigBee is a technology considered at higher abstraction layers from the network layer upwards. Figure 3 gives an example of how different standards and technologies correspond to different layers in the OSI model.

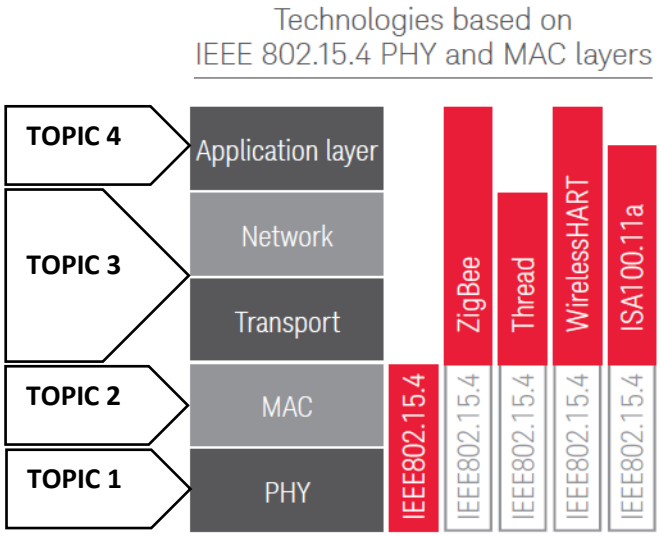

Figure 3: Matching technologies to different layers in the OSI model [2]

The MQTT protocol that we used in ELEC210P actually sits on top of TCP/IP and spans layers 5-7 of the OSI model, as illustrated in Figure 4.

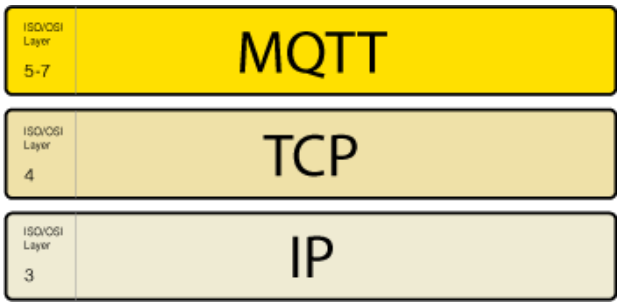

Figure 4: MQTT with reference to the OSI model [3]

The application layer in the IoT stack commonly refers to the cloud. This is where data is stored, processed and analysed with the goal of providing "smart(er) services and applications". Without loss of generality, the data typically defines the overarching domain of the application and/or service offered, as shown for example in Figure 5.

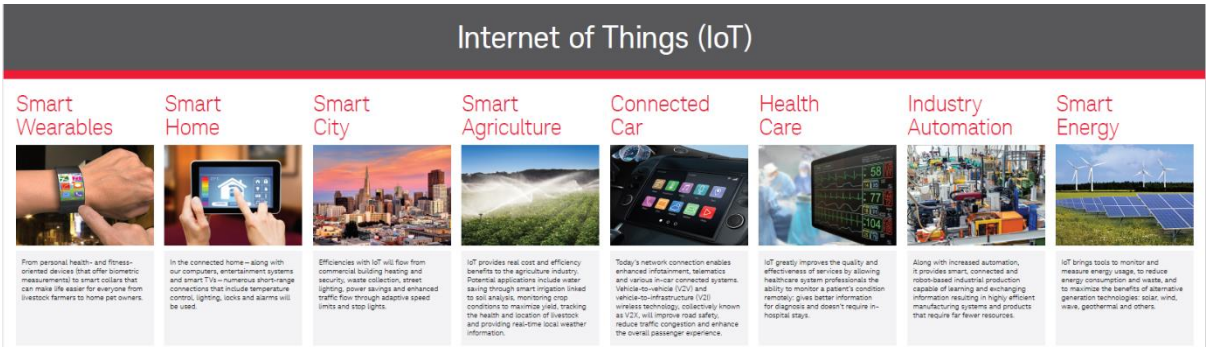

Figure 5: Smart services and applications enabled by the IoT [2]

Figure References

[1] OSI model reference: https://en.wikipedia.org/wiki/File:Osi-model.png
[2] Keysight technologies: https://www.keysight.com/main/editorial.jspx?cc=DJ&lc=eng&ckey=2670326&nid=-11143&id=2670326
[3] HiveMQ - MQTT Essentials: https://www.hivemq.com/blog/mqtt-essentials-part-3-client-broker-connection-establishment