Unit 18: The Internet of Things

Delivery guidance

This is an optional Pearson Set Assignment assessed unit that gives an opportunity for learners to consider the wider implications of IT and how it impacts on the world.

The Internet of Things (IoT) has become a market-changing tool for retailers, service providers, consumer electronics OEMs (Original Equipment Manufacturer) and system integrators, enabling new products and services, delivering new revenue streams, operational efficiencies and improved customer engagement models by providing a new method of interconnectivity between people, and the devices and services they use.

Conservative estimates claim that in the 2020s there will be:

- 4 billion connected people
- $4 trillion revenue opportunities
- 25+ million apps
- 26+ billion embedded and intelligent systems
- 50 trillion GBs of data.

This unit allows learners to investigate the applications of different IoT systems and services in various sectors. They will develop a design for an IoT system (or device) to solve a problem, as well as a prototype of an integrated IoT system (or device) to solve a problem.

There will be many opportunities for research and for learners to explore how the IoT is relevant to their everyday lives and to areas of personal interest.

Approaching the unit

This unit has an element of theoretical content, highlighting the underpinning purpose, principles and characteristics of this new IoT technology, as well as how and why it reaches so many different industries and sectors. Learners should have the opportunity to explore the Internet to consider what is currently available, and some of the emerging IoT technologies (e.g. nanotechnology (nanosensors and the Internet of Nanothings), autonomous vehicles, optogenics) and, further forward, systems to improve customer interactions and the customer experience, as well as further developments for augmented reality.

Having considered the “how” and “why” of the IoT, learners will then design and prototype for the IoT.

The approach to this unit should be:

- as practical as possible, to give learners an opportunity to gain a range of IoT-related design and development skills
- varied in terms of context and demonstrating usage
- mindful of security and ethical issues.

Learners should have plenty of opportunities to engage with IoT technologies. This could include security technologies, such as surveillance cameras, where live streaming can be accessed remotely on both a PC and a smartphone or tablet, or the use of Amazon's Alexa or Google's Home device to control a range of home technologies. Whilst practical, hands-on experience is desirable, this can be supported by very good videos on YouTube that not only look at existing IoT technologies, but also some emerging ones as well. Search IoT device examples. Learners should research practical logic skills on sites such as IFTTT, which teaches the basic principles of IoT development.

You should use the Internet to gather a good range of contexts against which to pitch the learning. Demonstrations are key here to show how the IoT genuinely impacts on people's lives. For example, how can IoT devices be used for entertainment? Examples include music streaming and the use of IoT devices as online encyclopedias. Consider the impact on published materials. Look at how can they assist partially sighted or disabled users with medication alerts, weather information, etc.

Learners should carry out independent research into security and ethical considerations, and the impacts this technology has.

Delivering the learning aims

Learning aim A

This aim gives the underpinning content for the IoT and the benefits of this new technology in the real world. Learners will begin by developing an understanding of the purpose of systems, the services they give (such as device monitoring and management, security, tracking, remote maintenance and metering), as well as the contexts in which the IoT operates.

Learners will look at the principles of common IoT services, such as the collection and analysis of data that is triggered by actions. The common principles include product/service operations, the collection and analysis of data, and systems monitoring.

To complete this learning aim, learners will explore the regulatory and ethical characteristics of IoT systems and services (such as risks and security, ethical and privacy considerations, local law, sustainability and benefits), before examining the technical characteristics of IoT systems and services.

Learning aim B

As a practical learning aim, learners will need to develop a design for an IoT system or device to solve a problem. There are similarities here with aspects of systems analysis and program development, such as investigation, outlining requirements and developing initial designs and/or prototypes, with the usual diagramming and supporting text that learners may well have experienced before.

As the IoT frequently has no user/physical intervention and is made up of machines connecting to other machines and systems, learners explore the architectures and communications requirements, including sensors, wireless and wired communications, and actuators (used in controllers, motors and servos).

An appreciation of the concept that the IoT is built on three domains (device, network and application) will enable learners to find out how connected networks enable communications between machines, acting as gateways.

Technical standards are important and some of the organisations involved in setting standards

and monitoring activity are considered. One key question that would give a useful discussion could be: "What would happen if there were no standards and no gatekeepers?"

The final part of this learning aim is focused on the security of IoT systems and devices, and asks learners to examine not only the threats posed to unmanned and unguarded systems and devices, but the importance of remote management, and the implementation and use of security protection methods.

Having taken these factors into account, learners will draw on their knowledge and understanding to develop a design for a device or system with illustrations outlining the architecture, communication requirements, addresses and security protection methods, and they will demonstrate a consideration of alternative solutions.

Learning aim C

In this final learning aim, the learners will develop a prototype to solve a problem identified for an integrated IoT system or device.

To do this, they need to understand how the machines work together, how to manage the interconnected devices, ensuring that these are kept up-to-date, and how rule-based event triggers enable the execution of smart actions based on sensor events.

Programming techniques and constructs will be lightly relevant here, although this learning aim focuses more directly on the development of a simplistic prototype for an IoT solution. There will also be a requirement for working with basic logic, which is a fundamental component of the IoT, for example, "*If This Then That*" design solutions (if a user approaches a shop, a shopping list is pinged). This would be achieved by using geo data. An alternative would be an IoT system that could ping places of interest with prices and booking links in a holiday location, or travel information such as train times when a user is near a bus or train station (based on personal preferences).

The learning aim completes with an investigation into IoT analytics how IoT data is used in various contexts.

Learners will be able to develop a prototype IoT system or device, evidencing their activity with screen grabs, videos, photos and reports for the raw data collected, and for the results of processing and analysing the data.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Examine systems and services that form part of the Internet of Things	**A1** Purpose and applications of systems and services that make up the IoT **A2** Principles that underpin IoT systems and services **A3** Characteristics of systems and services that make up the IoT	A written or video report investigating the systems and services that make up the IoT. Learners will cover the purpose, applications, principles and characteristics of systems and service that make up the IoT.
B Develop a design for an Internet of Things system or device to solve a problem	**B1** IoT system or device design process and documentation **B2** Machine-to-machine (M2M) system and device architecture **B3** Technical standards for IoT systems and devices **B4** M2M system and device communication requirements **B5** Security of IoT systems and devices	A system or device design portfolio containing the annotation and illustration of the architecture, communication requirements, addresses and security protection measures, including a comparison of alternative solutions. The development of a prototype IoT system or device with screen grabs, videos, photos and reports for the raw data collected and the results of processing and analysis of the data.
C Carry out the prototyping of an integrated Internet of Things system or device to solve a problem	**C1** M2M integrated system or device operations **C2** Programming techniques and constructs **C3** IoT analytics	

Assessment guidance

The assessment for this unit would benefit from being divided into two assignments as shown above.

Learning aim A

Developed as a written or video report, learners investigate the systems and services that make up the IoT. They should describe the purpose and applications of IoT systems in different sectors, going on to explain the principles and characteristics of systems and services in at least two sectors.

Learners should compare the purpose and applications of at least four devices from at least two different sectors. The comparisons should focus on the principles and characteristics from both a

technical and general perspective.

Evaluation is required to meet the distinction criteria, which should consider a range of factors. For example, the evaluation should cover the benefits and risks of each system and/or service, making a supported judgement. It should also cover the benefits, and possibly even the risks, of using health apps and technologies (monitoring heart rate, distance run, calories burned, etc).

Learning aims B and C

Learners should create a design for a system or device ensuring that it meets principles and standards as studied. Designs should be annotated with feedback sought from others, outlining improvements that could be made during the implementation stage. The prototype can be created using any appropriate off-the-shelf hardware and a suitable language. For example, this could be an app on an Android Smartphone that uses the phone's resources (such as its camera or gyroscope), created using the Android Studio IDE.

With partial functionality, the learners should be able to explain how the solution would solve the problem. Learners will also be expected to use appropriate technical language. For the higher grades, they will need to justify their design decisions and show how they have incorporated feedback. The prototype should be functional, at least in part.

The distinction criteria require learners to evaluate an optimised IoT system (or device) by reflecting on how well a client's requirements have been met, and how feedback from others was used (or not used) to influence the design and implementation of the system or device.

In addition, learners must be able to demonstrate how they optimised the prototype to meet the users' needs and evidence how they demonstrated individual responsibility and effective self-management.

Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 18: The Internet of Things

Introduction

This unit is highly practical because learners design and create a prototype for an IoT system or service. To do this, they have to develop an appreciation of IoT as a concept and be able to identify sectors where IoT already exists, extrapolating to potential new opportunities.

As a current area of growth, there will be increasing opportunities for jobs in this area.

Learning aim A – Examine systems and services that form part of the Internet of Things

A1: Purpose and applications of systems and services that make up the IoT

- Lead a discussion that draws out learners' own knowledge and experience of IoT and how it affects their lives (in their place of education or in the home). There are four areas in the specification that you can use as a focus for the discussion: 1. productivity; 2. safety and security; 3. efficiency and effectiveness and 4. the experience and satisfaction of users. Learners should be able to give real examples of where they have come into contact with the IoT. There are also many examples on the Internet that you could use to illustrate these four areas.
- Present examples of IoT systems and services in different sector contexts. A number of the videos listed in the **Resources** section at the end of this guide give examples that will be useful and that could be hyperlinked into a presentation.

A2: Principles that underpin IoT systems and services

- Learners research how the IoT collects and analyses data that triggers actions to meet a particular need or solve a problem, e.g. climatically controlled greenhouses: using sensors to gather data on a range of variables and making rule-based decisions on actions that will be taken. Data are then stored and outputs (growth yields/harvest) measured in relation to the controls in the environment to improve efficiency and effectiveness of the environment. Learners should be able to give examples of other situations during a class discussion (in transport, health, entertainment and retail, among others).
- Present on how the existing Internet and telecommunications infrastructure plays a part in supporting IoT systems and services, with examples, along with the access to, and/or analysis of, both real-time data and analogue data from the physical and natural world.
- Lead a discussion on the “always-on” connectivity that allows continuous monitoring of data from the physical world; this can be developed into a discussion about the general principles of 24/7 availability.
- Present on “*The Spectrum of Insight*” (see the websites listed in the **Resources** section of

this guide).

A3: Characteristics of systems and services that make up the IoT

Examine the general and technical characteristics of IoT systems and services.

- Split the class into two halves and then sub-divide the learners into small groups of three or four. Allocate each group of learners either 'general' or 'technical' and then one of the following:
    A. Presentation
    B. Web page
    C. Quiz
    D. Animation/video
    E. Technical 250/300-word article.
- Learners need to be given a list of the sub-items in the “general” or “technical” category and should work in their groups to create whichever artefact they have been given. You can change the items in the artefact list to include some of your own if you wish.
- Learners should be encouraged to evaluate the purpose and characteristics of these different devices (assessment criteria A3).

All learners take part in reviewing each other's artefacts.

Learning aim B – Develop a design for an Internet of Things system or device to solve a problem

B1: IoT system or device design process and documentation

Examine the steps involved in developing a design for an IoT system or device to solve a problem.

- Deliver a presentation that covers the steps involved in investigating for the design of an IoT system, including:
    - problem definition statement
    - purpose requirements
    - initial design ideas.

  Learners should consider areas of a business model, such as the problem, existing alternatives, solutions, key metrics, unique value propositions and high-level concept, unfair advantage, channels, customer segment and early adopters, as well as cost structure and revenue streams.

  It is highly likely that this will need to be a session used to prepare for assessment, and based on the fact that learners will have met the same concepts in different contexts/units.
- Issue a scenario for learners to work with, or create an outline for the tasks, and allow them to choose their own context. When learners undertake the assignment, they will be working on a potential innovation (or new way of doing something). For this activity, they can replicate something that exists already; it is the process that is important here, not

the product.

- Learners should work in small groups to go through an investigation and initial design. They will use the same context in the next topic.

B2: Machine-to-machine (M2M) system and device architecture

Examine the architecture of M2M communications in IoT systems and devices.

- Learners should work in pairs to explore the components and domains described in the unit content, e.g. sensors, connectivity, platform, analytics, user interface. In groups, learners could be given a range of IoT scenarios with different architecture and communication requirements. Each group can come up with a design solution and present to the class; this will give the class a broad overview of the implementation possibilities for different scenarios. This activity could also incorporate features from **learning aims B3 and B4**.
- Working with the design created for the previous topic, learners should now work in the same groups to establish which architecture they would use to implement their IoT system or service.
- Learners should create a technical specification/outline of their system or service and present it informally to a member of the technical staff in the department to check it for appropriateness.

B3: Technical standards for IoT systems and devices

Examine the current and relevant industry and internet standards that are set out by standards organisations.

- The specification lists three organisations (ISO, LoRa Alliance and IEEE), with a number of standards and reference frameworks relevant to the IoT. Give learners a table to capture research they will undertake individually or in pairs. The three homepages for these organisations are included in the websites in the **Resources** section at the back of this guide. The column headings should read:
  - Organisation
  - Purpose
  - Standard or Reference framework
  - Description and scope of standard.
- Deliver a presentation to learners that covers these topics, which will enable them to add anything they missed.
- Working with the design and technical specification created with the previous topic, learners should check their design and specification for adherence to the listed standards.
- Lead a class discussion to check and explore any anomalies.

B4: M2M system and device communication requirements

- Learners should work together in small groups to investigate the content for a series of three linked webpages; one for each of the following:
  - system and device communication principles
  - system and device capabilities

- the identification and network location of secure connected components to support the design of a scalable and efficient system and devices.

- Working together, learners design the content for these pages and storyboard their plans. They can find suitable web content or YouTube videos, news articles or any other relevant data that will help them fill the space.
- Once the designs are completed, learners informally present their ideas to the class for feedback.
- Continuing the earlier group work, learners should identify the system and device communication requirements for the scenario they have been working on.

B5: Security of IoT systems and devices

- Drawing on security content from other units, learners should carry out research in pairs that will enable them to create a briefing document as if they were advising a small business client on the security of IoT systems and devices. The briefing document could be a short report, slide presentation or a leaflet.
- Given a scenario, learners should develop a suitable design solution and measure these against the scenario to give a basis for justification.
- Learners should share their documents with an IoT specialist who will review them from a technical perspective and give them feedback.
- Continuing the earlier group work, learners should explore their design from a security perspective. Has security been considered? What should be done to make their design secure?

Learning aim C – Carry out the prototyping of an integrated Internet of Things system or device to solve a problem

C1: M2M integrated system or device operations

- Prior to carrying out any formal prototyping, a guest speaker could be invited who has experience of M2M integrated systems or device operations, and who can introduce learners to M2M in a range of contexts. If possible, learners should be able to see some of these systems in action.
- Initiate a Q&A session to give learners the chance to ask questions and seek clarification. They should also use this as an opportunity to talk to a specialist about the system or service they have designed, specifically asking about any pitfalls they may fall into.
- Depending on the context of the scenario they have been working on as a group, learners should begin the prototyping process, including: connectivity and normalisation, device management, database use, processing and action management and visualisation.
- Given a scenario, learners should develop a suitable design solution and measure this against the scenario to give a basis for justification.

C2: Programming techniques and constructs

- Deliver a presentation about programming techniques and constructs. It should include:
  - using a software development environment

- off-the-shelf hardware devices
- visual and non-visual programming constructs.

It is highly likely that this will be a session to prepare for assessment, only based on the fact that learners will have met the same concepts in different contexts/units.

- Learners work in their groups to program/develop their prototype and present the prototype to the class once completed. It is likely that this activity will occur over a number of sessions.

C3: IoT analytics

- Split the class into three, six or nine groups. Each group should be given one of the following to investigate:
  - extrapolation and prediction
  - metering and billing
  - activation of actuators.
- Learners collaborate to explore how analytics are used in IoT and create the content for a blog for the class. The content should be uploaded so that it can be shared by the learners.
- Learners should then reflect on which analytics have been used in their prototype and should be able to explain them and justify the approach taken.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- *Unit 4: Programming*
- *Unit 6: Website Development*
- *Unit 7: Mobile Apps Development*
- *Unit 8: Computer Games Development*
- *Unit 9: IT Project Management*
- *Unit 11: Cyber Security and Incident Management*
- *Unit 13: Software Testing*
- *Unit 14: Customising and Integrating Applications*
- *Unit 15: Cloud Storage and Collaboration Tools*

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International Level 3 Qualifications in Information Technology. Check the Pearson website at http://qualifications.pearson.com/endorsed-resources for more information as titles achieve endorsement.

Videos

YouTube:

- *The Internet of Things: Dr. John Barrett at TEDxCIT*
- *Internet of Things [1/5]: Devices and Local Networks*
- *Internet of Things [2/5]: Embedded Devices*
- *Internet of Things [3/5]: Network Protocols and the Internet*
- *Internet of Things [4/5]: The Cloud*
- *Internet of Things [5/5]: The IoT and the RTOS*
- *Internet of Things (IoT) Architecture for Beginners*
- *The Internet of Things – An Architectural Foundation and its Protocols*
- *Top 5 Facts about the Internet of Things*

Websites

- Go to the Computer Weekly website and search "*Internet of Things will drive forward lifestyle innovations*".
- Go to the Computer World website and search "*17 most powerful Internet of Things companies 2016: AWS, Microsoft IBM and more*".
- Go to the European Commission website and search "The Internet of Things: Digital Single Market – Europe's IoT Policy".
- Institute of Electrical and Electronics Engineers.
- Search "*Industrial Internet Consortium 7 Principles of the IoT – A Personal Perspective*".
- Go to the TechTarget IoT Agenda website and search "*IoT Security (Internet of Things Security)*".
- Go to the Internet Society website and search "*The Internet of Things (IoT): An overview*".
- International Organisation for Standardisation.
- LoRa Alliance.
- Search "*Wired The Internet of Things is far bigger than anyone realises*".

Pearson is not responsible for the content of any external internet sites. It is essential for teachers to preview each website before using it in class to ensure that the URL is still accurate, relevant and appropriate. We suggest that teachers bookmark useful websites and consider enabling learners to access them through the school/college intranet.