2023-24 Trimester B - Internet of Things MMI126818-21-B (15 Credits)

Coursework 1: Combined Specification and Submission Template

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| Student ID |  |
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| Date |  |

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| I declare that this coursework is an original piece of work that has been created only by me. The work is not based on previous coursework that has been submitted as part of another module or submitted to another academic programme of study.   |  | | --- | | **Enter your name below as confirmation of this declaration.** | | Name: YOUR NAME | |

**Notes**

* This document delivers the following:
  + The CW1 specification
  + The details of each response that is expected for each part of the CW.
* You must deliver the CW submission within a copy of this current document, using the entries provided.
* Before submission you must update the index on the page above. Right-click on the index, select ‘update field’ and then ‘update entire table’ and click OK.
* **Do NOT change the structure of this document. Do not remove any content.**
* You are required to use your own words in responses to each question. Do not use direct quotations from external sources. Marks will **not** be provided for copied narrative or narrative where you have obviously copied and then altered the text slightly.
* Feel free to state any assumptions that you make in responding to any section.
* Unless specifically stated otherwise, you are required to provide only your own diagrams/screenshots as part of your responses.
* For snippets of JavaScript code or JSON, do **not** use screenshots; copy the textual code content.
* Use bullet-points when you need to highlight several aspects related to a response you are making within any part of the report.
* Do not copy diagrams/figures/images from external sources. All such elements must be originated by you, unless explicitly indicated within the coursework specification. Copied diagrams will not gain any marks.
* There is an expectation that your report will:
  + have consistent layout,
  + be spell-checked,
  + be grammatically correct,
  + have a clear narrative structure,
  + have been proof-read to ensure that it meets each of the aspects listed above.
* There is a marking scheme provided. You MUST examine this so that you understand how marks are allocated to each part of the assessment.
* The report must be submitted via Turnitin and must be in .docx format only; PDF files will NOT be accepted.
* Writing Skills
  + <https://www.gcu.ac.uk/aboutgcu/academicschools/cebe/study/ldc>
  + <http://www.sussex.ac.uk/ei/internal/forstudents/engineeringdesign/studyguides/techreportwriting>
  + <https://www.eecs.qmul.ac.uk/~norman/papers/good_writing/Technical%20writing.pdf>
  + The following is a very detailed reference guide. Use this if you are in doubt over structural aspects of writing:
    - <https://www.researchgate.net/publication/240701960_Scientific_Writing_for_Computer_Science_Students>

# IoT Application Specification and Proposal

An IoT application has a specification, provided below. You are required to undertake analysis and propose an appropriate architecture and technology that can deliver a suitable solution. There is a set of requirements provided and then a detailed list of aspects that you must decide upon and discuss in your answer.

## Terminology

Central Computing Service: CCS

Vehicle Computing Device: VCD

## Background

There is a *fleet of delivery vehicles* which is required to have a new set of monitoring equipment added to it.

A *subset* of the equipment has already been selected to be within each vehicle, and this is listed here:

* A temperature/humidity monitor that has a Bluetooth interface and a messaging capability to deliver regular sensor readings.
* A driver-quality monitoring unit that provides messages from time-to-time about the quality of the driver performance (braking, steering, gear-changing, speed, etc). This has a Bluetooth interface with an appropriate messaging capability.
* A Vehicle Computing Device (VCD) that can have additional interface modules connected to it.

Constraint: All vehicles will be driven in towns/cities.

## Requirements

For *each vehicle*, the following requirements must be met and there will be a need for you to propose additional hardware and the software elements to match these:

* There will be a Central Computing Service (CCS) that all vehicles communicate with.
* A data network solution must be designed and must be an add-on to the VCD.
* A vehicle must report its geographical location to the CCS every 20 seconds.
* Driving quality data must be sent to the CCS every 30 minutes.
* Vehicle temperature/humidity readings must be processed as they arrive from the sensor module.
  + The values must be processed locally (on the vehicle) and if the values fall outside of normal limits, then an appropriate alert message must be sent to the CCS.
  + The average value of temperature and humidity must be sent to the CCS every minute.
* Messages can be received from a CCS application from time-to-time, and these must be displayed on an LCD Screen (with USB interface) in the driver area.
* The vehicles will transport packages, and these must be registered to a CCS application when: (a) the packages are loaded onto the vehicle, and (b) as they are delivered.

An outline of the tasks that you must complete within your proposed solution is provided below. Before you undertake that, here are some notes to help you:

* You can add appropriate extra hardware elements to meet the requirements.
* The vehicle central computer is a modular system that allows add-on interface modules.
* You will have to provide descriptions for the main software activities. *You are not asked to design/implement any of the software.*

## Your Proposal

You must carefully read the specification, analyse the various requirements, and then deliver the following elements of your proposal:

1. List any *VCD hardware modules/interfaces* and any *additional product* that you will require to be added, as part of the architecture on the vehicle. Perhaps you might indicate that a standard type of interface is already provided in the VCD, but you must still list all interfaces.  
   For each of the items, provide a descriptive name, briefly describe its functionality, and briefly justify why you need this as part of the architecture. Complete one row for each item that you include, within the table below.   
   Note: Add or remove rows as necessary. The size of the table supplied does not infer anything about the number of items.

|  |  |
| --- | --- |
| **Descriptive name of Interface or Additional Product.** | * **Describe the functionality provided by the VCD interface or additional product that is required.** * **Justify why it is required.** |
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1. Draw a clearly labelled block-diagram that shows how all parts interconnect within the vehicle, including the provision of an Internet connection. The block diagram *style* can be taken from the range of examples in the Week 1 documents: “Using your PC as an IoT Device OVERVIEW SLIDES V2.pdf” and “Using your PC as an IoT Device OVERVIEW SLIDES V2.pdf”.

|  |
| --- |
| Provide the diagram below, with a *Figure number* and *Caption* using the MS Word facilities. |

1. By carefully reading the specification and analysing the activities, list the main software activities that will be required within the applications on the VCD and on the CCS. One sentence is sufficient to describe each activity.

Note: Add or remove rows as necessary. The size of the table supplied does not infer anything about the number of items.

|  |
| --- |
| **Descriptions of activities for the Vehicle software** |
|  |
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| --- |
| **Descriptions of activities for the Cloud software** |
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1. MQTT messaging will be used to send data between the VCD and CCS. You are required to provide pairs of MQTT topics and example data-payloads (in JSON format) to cover the following scenarios. Your solutions should imagine one *specific vehicle* that works within one *specific organisational subdivision* of the company. It is entirely left to you as how to structure the payloads and construct the topics.

|  |  |
| --- | --- |
| 1. Vehicle Sending an alert message when a temperature or humidity value is outside required limits. | |
| Topic |  |
| Example payload |  |
| 1. Cloud application sending a message to be displayed on the LCD screen on the vehicle. | |
| Topic |  |
| Example payload |  |
| 1. A vehicle reports its geographical location. | |
| Topic |  |
| Example payload |  |
| 1. A package has been delivered. Report this to the CCS. | |
| Topic |  |
| Example payload |  |

1. During the development phase for this system, you are tasked with reviewing another engineer’s prototype MQTT implementation and you immediately note that the MQTT port number is 1883. Without examining anything else about the implementation you should be able to make a comment about this and make some recommendations.

|  |
| --- |
| Comment about the current implementation: |
|  |
| General recommendations: |
|  |
| Detail how you would configure an MQTT node within a Node-RED implementation to support your recommendations. Provide narrative and screenshots as appropriate. |
|  |

# Node-RED Deployment on Google Cloud

In Week 3 you should have deployed Node-RED on a Google Cloud VM as part of your laboratory exercises, using Docker. You were supplied with Lab instructions, and for reference the online Node-RED documentation describes key aspects of running under Docker.

Here is an example command for somebody deploying Node-RED:

**docker run -d --restart=always -it -p 1880:1880 -v /home/john/.node-red:/data --name john\_nodered nodered/node-red**

All questions below refer to aspects of this command and its related behaviour.

|  |
| --- |
| 1. Name the user’s Home directory. |
|  |
| 1. The very first time that this command is executed, describe what will be downloaded. Explain which part of the command identifies the item to be downloaded. |
|  |
| 1. When this command is executed there will be a transformation from one type of Docker representation to another runtime Docker representation. Name both these representations. |
|  |
| 1. When the virtual machine is stopped, and the virtual machine is restarted, explain what will happen to your Node-RED instance and indicate exactly why this occurs, referring to an appropriate section of the command above. You can assume that no commands are entered on the virtual machine terminal at any point – just the VM restart. |
|  |
| 1. Provide details of where the Node-RED flows and configurations are being stored. Explain what determines where they are stored. |
|  |
| 1. Provide the Docker ‘Name’ of the Node-RED executable. |
|  |
| 1. Identify *which command* you would use to confirm that the Node-RED deployment is correctly executing. The command provides a column-view of the metadata for the running instance. *Identify which column* provides assurance that the instance is correctly executing and explain *what information is provided by that column*. |
|  |
| 1. Identify a single command that will stop and then start the Node-RED instance. |
|  |

# MQTT subscriptions

Below are some example MQTT publishing topics for energy-metering application. These are a subset of all the possible topics within this application.

edinburgh/north2/telemetry/meter-type-3/meter-23246123778

edinburgh/north2/telemetry/meter-type-3/meter-23246127649

edinburgh/north1/state/meter-type-3/meter-23247775432

edinburgh/north1/telemetry/meter-type-3/meter-23247775432

edinburgh/north1/telemetry/meter-type-2/meter-21167543783

glasgow/east4/telemetry/meter-type-2/meter-2324634762

glasgow/east4/state/meter-type-2/meter-2324634762

glasgow/east1/telemetry/meter-type-3/meter-2324688763

Provide MQTT subscriptions for the following scenarios:

|  |
| --- |
| 1. All *telemetry* messages in the *north1 area* of Edinburgh. |
|  |
| 1. All *telemetry* messages in *all areas* of Glasgow. |
|  |
| 1. *State* messages for meter: *meter-2377777777* |
|  |
| 1. *State* messages for type-2 meters across the whole of Scotland. |
|  |