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TECHNOLOGICAL UNIVERSITY DUBLIN

CITY CAMPUS - GRANGEGORMAN

TU856 – Computer Science
TU857 – Computer Science (Infrastructure)
TU858 – Computer Science (International)

Year 4

SEMESTER 1 EXAMINATIONS 2024/25

CMPU4100 – Fundamentals of IoT

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Instructions To Candidates: Attempt **all** questions

Exam Duration: 2 hours

Special Instructions /Handouts/ Materials Required: n/a

1. a) A commonly used architectural pattern in IoT devices is the *device-to-gateway* architecture. Describe this architecture in your own words, using a diagram to illustrate your answer.

(8 marks)

b) Briefly name and describe ***two (2)*** other architectural patterns commonly used when building IoT systems.

(2 × 3 = 6 marks)

c) List ***three (3) advantages*** and ***three (3) disadvantages*** of the device-to-gateway architecture.

(6 marks)

2. a) Modern Raspberry Pi models have 40 GPIO pins. Each pin has ***two (2)*** names, depending on which of ***two (2)*** *naming schemes* are being used. What are these two naming schemes, and explain briefly why the device has two naming schemes?

(6 marks)

b) Explain the purpose of the following electronic components:

i. Capacitor
ii. System-on-Chip (SoC)
iii. Motor controller
iv. Light-emitting diode (LED)

(4 × 2 = 8 marks)

c) The Raspberry Pi and Arduino do not have analogue output pins, instead relying on a trick called *pulse width modulation* (PWM). Explain how PWM works in your own words, making reference to the terms *frequency* and *duty cycle*.

(6 marks)

3. a) Generally, the Internet Protocol (IP) is combined with the Transmission Control Protocol (TCP) to form the TCP/IP stack. Name and briefly describe ***three (3)*** services provided by TCP that are not supported by IP alone.

(3 × 3 = 9 marks)

b) Below is a list of three common technologies used to allow IoT devices to communicate. Give an ***advantage*** and a ***disadvantage*** of each of the technologies:

i. Ethernet
ii. Bluetooth
iii. Wi-Fi

(3 × 2 = 6 marks)

c) IoT devices often have a poor security record. Suppose an IoT vendor is aiming to produce a device with encrypted communications: what encryption setup would you advise them to use?

(5 marks)

4. a) Name and briefly define the ***four (4)*** *Big Vs of Big Data*.

(4 × 2 = 8 marks)

b) Name ***three (3)*** dimensionality reduction algorithms.

(3 × 2 = 6 marks)

c) Define *statistical correlation analysis* and explain why it might be useful in your own words.

(6 marks)

5. A startup company is developing an IoT device to allow users to read and compose emails via a voice interface. The system consists of an IoT device they set up in their home, a cloud server, and a web app which allows users to connect their email provider to the system. When the user receives an email, the device plays an alert sound through its built-in speaker, and lights up an LED. The user can then ask the device to play their emails with an audio command, which causes the server to run a speech synthesis engine and stream the audio back to the device. Users can also tell the device that they want to send an email to a particular person, and compose the email by speaking it. The server uses a speech-to-text AI model to convert this to an email. To minimise power consumption on the end device, most processing occurs on the servers. The server also serves the web interface to the end user.

a) Draw a high-level architectural diagram of the system the company will build. Show one of the IoT devices, the servers, the email provider servers, and the web app running on the user's browser.

(10 marks)

b) The company has to make a decision about whether to buy their own hardware or use a cloud provider. Briefly describe ***two (2) advantages*** and ***two (2) disadvantages*** of using such a service.

(4 marks)

c) Supposing that the product is successful, and the company decides to expand the scope of the project to something like a smart speaker (similar to an Amazon Echo, Google Nest, etc.). As a first step in this process, they decide to add integration with Spotify, where users can ask the device to play a song, and it does so via their Spotify account. With reference to components of the system shown in the diagram from part (a), explain what changes would need to be made to the system to implement this new functionality?

(6 marks)