Introduction to IoT End Sem Exam (Spring 2022)

Duration: 3 hours **Total Marks: 100**

1. Help Ayu with his research!

   Ayu is an IoT researcher looking for a feasible IoT solution for his research. He is conducting a research experiment on conditional decision-making through multiple devices. He plans to build a Home Automation system that can operate remotely and efficiently. **(15 marks)**

(1) → reliable → responsible in correctly transmitting data / acknowledgement.

a) Suggest a suitable QoS level for a Home Automation application and explain the reason for it. **(5 marks)**

b) Concerning the MQTT protocol, design a block diagram to exchange data between multiple devices within the Home Automation system and explain it briefly. **(5 marks)**

c) Ayu uses the below-naming convention for his MQTT channels.

"/HomeAutomation/Room_Number/Device_ID"

   a. How does Ayu get the data of all the devices within a room? **(2.5 marks)** → By going room no → Device ids

   b. How does Ayu get data from all the devices with a unique device id? **(2.5 marks)**

↳ going to specific device ids.

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2. Anu is working on a project to develop an IoT-based water quality measurement system using various analog sensors to measure parameters like TDS, pH, and Turbidity. The sensed parameters are posted to OM2M server through Wi-Fi at defined periodic interval T. **(13 marks)**

(Slope Gradient is the rate of Change of Slope)

a) With a brief explanation, suggest an appropriate sensing interval for the above-mentioned application. Also suggest various improvements to enhance the overall power efficiency of the system. **(3 marks)**

b) Consider the below table for slope gradient parameters of each sensor. Briefly elaborate on the sensor calibration approach required for pH and Turbidity. **(4 marks)**

Slope of calibration is the slope of linear graph.

S.No	Sensor Name	Slope Gradient (α)
1	pH	10^{-6}
2	Turbidity	5^4

c) It has been observed that the TDS sensor (TDS value is measured in parts per million) uses a threshold-based sensor characteristic. When the TDS value is below 100 ppm, the slope gradient is observed to be 10^{-4}. When the TDS range is between 100 to 300 ppm, the slope gradient was observed to be 10^{-1} . When the TDS range is between 300 ppm to 700 ppm, the slope gradient was 10^3 and anything beyond 700 ppm has a gradient of 0. Briefly explain the sensor calibration strategy to be followed. **(6 marks)**

3. Mars is the new Earth, which creates a huge requirement to understand the feasibility of life. To assess the feasibility, environmental parameters like temperature (float), humidity (float), NO2 (float), CO (double), and CO2 (double) are collected. This information must be sent to the Earth in a data packet (where a packet contains the parameter values as a set) in a bandwidth constrained environment. Once the data storage of the controller reaches 90%, the data is published back to Earth. **(15 marks)**

These are the deployment requirement that needs to be satisfied.

a) Calculate the memory required in bytes for each data packet. **(1 mark)**

b) Assuming the controller has 512 KB of memory, calculate the number of data packets that can be stored before the data gets published. **(2 marks)**

c) Write a pseudo-code that can store the data packets inside the device memory as a buffer of the size that you get in question B. Initialize a variable called "publish" to zero. When data publishing is required, set the publish variable to 1. **(buffer is an array)** (consider Question 3(d) while answering this). **(6 marks)**

d) Briefly summarize the computation cost for the pseudo-code in question 3 (c). The I/O operations consume **5 us**, arithmetic/logical/bit-wise operation takes **10 us**, each iteration consumes **3 us**, each variable initialization takes **1 us**, and each variable storage, retrieval takes **0.5 us** and any other operation takes **2 us**. (us stands for microseconds) **(6 marks)**

4. Building an interoperable system is a crucial requirement for building deployable IoT systems. The idea is to create a health monitoring system in which specific ECG sensors, pulse oximetry, and temperature sensors are used to monitor the dynamic health state of the patient who needs continuous monitoring and alert in case of emergency. **(15 marks)**

a) Explain in brief the choice of application layer protocol. **(3 marks)**

b) Briefly compare the pros and cons of cloud-based and edge-based computing for this scenario. **(6 marks)**

c) Draw an OM2M resource tree that contains five hospital rooms with 4 beds each. **(6 marks)**

5. *Build one IoT project which can reduce the energy wastage in any home automation application.* **(12 marks)**

a) Explain the hardware implementation for this scenario. **(6 marks)**

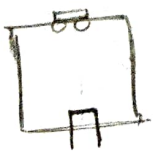
b) Explain the suitable protocols to be used for implementing the proposed system. **(6 marks)**

6. Please describe what communication protocol is suitable for the following scenarios and why. **(15 marks)**

a) communication between multiple nodes in an IoT system deployed in mountains to monitor the glacier movement. **(5 marks)**

b) communication between a sensor node on a delivery bike and a control room for a logistics company. **(5 marks)**

c) communication between a vehicle multimedia system and the cloud to download video data. **(5 marks)**



7. A camera-based edge device is installed in an intersection in Gachibowli, Hyderabad which is monitoring the traffic flow data. The cameras are used to collect video streams of the traffic data, which is then processed using image/video processing algorithms to perform vehicle detection. The detected vehicles can be counted to determine the flow of traffic. **(15 marks)**

a) Given the above system and a normal flow of traffic being 60 vehicles passing in one direction over 10 minutes, please describe a simple analytics algorithm that can be executed on the edge to detect if there is an abnormal traffic flow. **(6 marks)**

b) Instead of the above image/video processing-based system, if traffic flow in one direction on one side of the intersection (denoted as **Dir**) can be analytically computed based on the traffic flow values from the other 3 sides in a 4-way intersection, please describe a simple analytics algorithm that will enable traffic flow prediction in **Dir**. **(6 marks)**

c) What are the issues in the above image/video processing-based system if analytics is entirely performed in the cloud? Please explain specifically in the context of this system. **(3 marks)**