University of Ruhuna- Faculty of Technology

Bachelor of Information and Communication Technology Honours Degree
Level 2 (Semester II) Examination, November/December 2025
Academic year 2023/2024

Course Unit: ICT2223 Internet of Things (Written) **Duration: 2 hours**

IMPORTANT INSTRUCTIONS:

1. The medium of this examination is English.
2. This is a closed book examination.
3. This question paper contains **eight (08) pages** including this instruction page.
4. This examination consists of **four (04) questions** that are given equal marks.
5. You must answer **all four (04) questions** in this examination.

1)

a) Assume that a hospital implements an IoT-enabled patient monitoring system. Patients wear smart wristbands that can continuously measure heart rate, blood oxygen (SpO_2), and temperature, and transmit that data via Bluetooth Low Energy (BLE) towards gateways. The gateways securely transmit data to the hospital's cloud platform for analysis. This uses AI algorithms to detect anomalies and automatically alert doctors.
Identify three (03) ***key features of IoT*** evident in this healthcare system. For each feature, provide a clear example from the scenario.

[21 marks]

b) Given that, a smart agriculture company collects soil moisture, temperature, and crop health data from 5,000 IoT sensors across multiple farms. The sensors generate 1 GB of data per day. Farmers require real-time irrigation alerts and predictive analytics for crop yields.

i. Considering the above given scenario, design a ***data processing pipeline*** which is aimed to deliver real-time irrigation alerts.

[16 marks]

ii. Review ***offline vs. real-time analytics*** for this system in terms of ***decision-making, accuracy*** and ***latency***.

[20 marks]

c) The IoT applications are useful but critical in many industries as people are moving towards an advanced automation future.

i. Consider a real-world scenario which a developing city plans to implement an IoT-based Smart Surveillance and Traffic Control System (SSTCS) to reduce accidents and improve response times during emergencies. However, there are growing public concerns about citizen privacy and data misuse.
Hence, state how this IoT initiative could balance ***public safety*** and ***privacy protection***, suggesting at least two (02) design or policy-level measures that address both concerns.

[12 marks]

ii. Malithi enters her office, and IoT systems adjust lighting, temperature, and notifications based on her preferences. Similar smart home setups adjust energy usage and provide security alerts automatically.
Recognize two (02) ***potential risks*** of ***over-reliance on automation*** in homes and offices. Propose one (01) solution for each risk to balance automation with user control.

[16 marks]

iii. ***"The overall benefits of IoT in all sectors outweigh its risks, so organizations should prioritize IoT adoption over traditional methods".***

Do you agree with the above statement? Justify your answer by weighing technological advantages against risks with two (02) key points.

[15 marks]

2)

a) Read each scenario given below carefully. Express ***which IoT design principle*** addresses the given design challenge. Justify your answer with one (01) logical reasoning per each.

A. A startup creates a "smart wardrobe" that chooses daily outfits with AI. During testing, users find the idea uncomfortable and "too intrusive." Only after designers reframe it as a "digital stylist" that suggests clothes instead of deciding, do users start to accept it.

B. A hospital's IoT system for patient monitoring uses multiple proprietary devices from different brands. When the main server fails, all systems stop functioning, no local fallback or interoperability exists, delaying emergency care.

C. A connected home security system includes a panic button. However, the design team made the panic button flat, gray, and unlabeled to match aesthetics. During an emergency, users hesitate, unsure which surface to press.

[21 marks]

b) Study the given scenario below and answer the following questions.

A city's smart water management system continuously monitors water levels, pressure, and water quality using embedded IoT sensor devices. The system must transmit data to a centralized cloud dashboard for real-time analytics and automated valve control. The deployment uses a hybrid communication infrastructure, and some zones use Ethernet, others rely on Wi-Fi, and remote sites connect via GSM, which is similar to the architecture shown in Figure 01: Things are always connected to the Cloud/Internet.

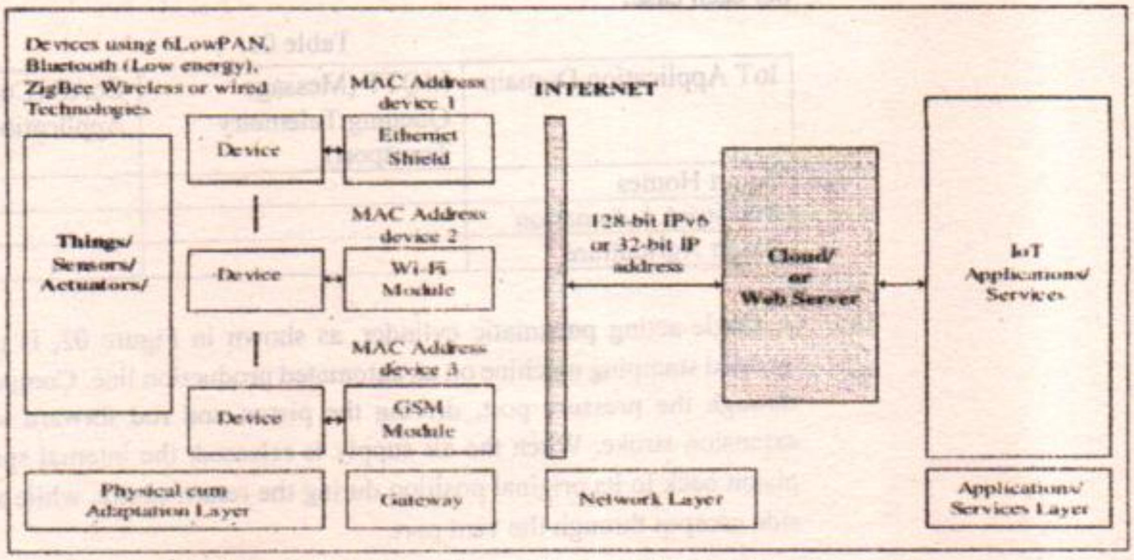

Figure 01: Things always connected to the Cloud/Internet

i. Using the layered architecture in Figure 01, show how ***Ethernet-, Wi-Fi-, and GSM-based devices*** establish connectivity from sensors to the cloud. In your answer, describe the role of each layer in Figure 01 in ensuring reliable data transmission.

[15 marks]

ii. Imagine there are 500 sensor nodes distributed across 20 city zones. Analyze the implications of using heterogeneous communication technologies, ***Ethernet, and Wi-Fi*** on system performance, considering factors such as latency, and cost.

[12 marks]

c) Sensors and actuators are transducers which operate functions in IoT systems.

i. Assume that RuhunaTech Industries (Pvt) Ltd is a manufacturing company producing automotive components using automated assembly lines. To reduce unexpected conveyor motor failures caused by bearing wear, overheating, and belt slippage, the company is introducing an IoT-based predictive maintenance system. They plan to use vibration, temperature, and speed sensors to monitor motor conditions and send data to a cloud dashboard for fault prediction. During testing, the system generates inconsistent alerts and some faults go undetected while others trigger false alarms. The team suspects issues with the linearity and repeatability of the sensors.

Discover how sensor ***linearity*** and ***repeatability*** impact the reliability of predictive maintenance alerts. Provide examples from this scenario.

[16 marks]

ii. Differentiate between ***MQTT (Message Queuing Telemetry Transport)***, and ***CoAP (Constrained Application Protocol)*** in terms of their suitability for actuator control in the following IoT domains in Table 01 given below. Give one (01) point per each case.

Table 01

IoT Application Domain	MQTT (Message Queuing Telemetry Transport)	CoAP (Constrained Application Protocol)
Smart Homes		
Industrial Automation		
Smart Agriculture		

[18 marks]

iii. A single-acting pneumatic cylinder, as shown in Figure 02, is used in an IoT-enabled stamping machine on an automated production line. Compressed air enters through the pressure port, driving the piston and rod forward to complete the extension stroke. When the air supply is released, the internal spring pushes the piston back to its original position during the return stroke, while air from the rod side escapes through the vent port.

Recently, the IoT monitoring system has detected that the return stroke time of this cylinder has gradually increased over several production cycles. Sensor data indicate higher back pressure at the vent during retraction and reduced spring tension compared to baseline readings. In addition, vibration sensors show slight frictional resistance along the piston rod movement.

Using Figure 02 and the given case study as a reference, report two (02) possible ***mechanical or pneumatic causes*** that could lead to a slow return stroke in this single-acting cylinder.

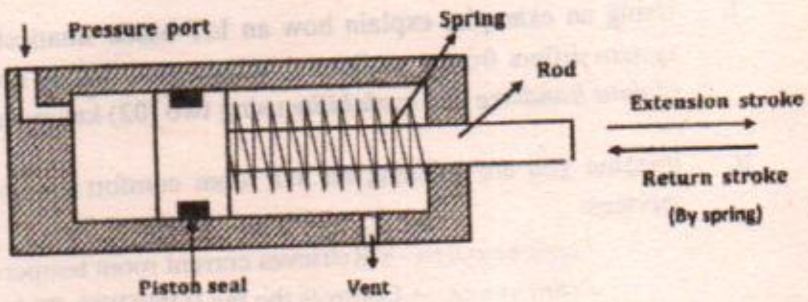

Figure 02: Construction features of single acting cylinder

[18 marks]

3)

a) Hardware EcoTrack Innovations has deployed an IoT-based wildlife tracking system using smart object collars on leopards to monitor their location, movement, and body temperature.
The devices send data wirelessly to nearby base stations through a low-power mesh network. After several months, the team observes that:

Some collars lose connection or show delayed data transmission.
A few collars stop working early due to battery depletion.
Certain devices crash when multiple sensors operate together.
Some collars cannot store full temperature data logs during continuous tracking.

In this case study, identify four (04) ***design constraints*** affecting the smart object collars and explain how each constraint is reflected in the system with a suitable example.

[20 marks]

b) Your research team is making a proposal to design a wearable IoT patch for hospital patients that continuously monitors heart rate, skin temperature, and oxygen saturation. The patch must transmit data securely to hospital servers, last 10 days on a single charge, and be comfortable for long-term wear.
In your proposal:

i. Propose a hardware system design using a suitable block diagram for the wearable IoT patch that addresses the ***five foundational roles*** of IoT hardware, including your hardware choices in each role.

[15 marks]

ii. Write how your design achieves high ***efficiency, reliability and scalability*** (ERS mandate) while maintaining patient safety and comfort using two (02) points per each.

[18 marks]

c) Machine to Machine (M2M) is a technology that helps devices to connect between devices without using internet.

i. Using an example, explain how an IoT-based smart city air-quality monitoring system differs from a traditional M2M-based factory monitoring system in terms of ***data handling*** and ***scalability*** using two (02) key points.

[16 marks]

ii. Imagine you are building an IoT room comfort controller with these RESTful services:

`/temperature` → Retrieves current room temperature (GET)

`/fan/state` → Controls the fan (ON/OFF) (PUT/GET)

`/controller/auto` → Adjusts the fan automatically based on temperature (native service)

Given code:

```
@app.route("/controller/auto", methods=["POST"])
def auto_control():
temperature = read_temperature()
if temperature > 30:
set_fan_state("ON")
else:
set_fan_state("OFF")
return jsonify({"fan": fan["state"], "temp": temperature})
```

Report two (02) improvements that would make this service fault-tolerant and safe for repeated automatic invocations.

[12 marks]

iii. A city council plans to implement an IoT-based smart waste management system to improve garbage collection efficiency.

Each bin is equipped with an ultrasonic sensor that measures the waste fill level and a LoRa or LTE communication module that sends data to a cloud-based monitoring dashboard. When a bin becomes nearly full, the system should automatically notify the waste management center so that a garbage truck route can be scheduled.

Write a brief ***process specification*** for this Smart Waste Bin System, including two use cases *"Full-bin detection"* and *"Bin empty confirmation"* that clearly explains the sequence of operations and system behavior.

[19 marks]

4)

a) The driving philosophy behind Industrial Internet of Things (IIoT) is that smart machines are not only better than humans at capturing and analyzing data in real time, but they're also better at communicating important information that can be used to drive business decisions faster and more accurately.

i. According to the Table 02 below, calculate the ***Annual Savings***, ***Net Annual Benefit***, and ***NPV*** for both deployment options. Hence, indicate which architecture provides better long-term financial performance and reason for your choice.

Table 02

Parameter	Cloud-First Deployment	Hybrid (Edge + Cloud) Deployment
Initial Investment (LKR)	2,500,000	3,800,000
Annual OPEX (LKR)	1,800,000	1,200,000
Downtime Reduction	40%	55%
Average Downtime Cost per Year	LKR 60,000,000	LKR 60,000,000
System Lifetime	3 years	3 years
Discount Rate	8%	8%

Assume PV annuity factor for r=8%, n=3 and given that:

PV factor = $\frac{1-(1+r)^{-n}}{r}$

Annual Savings=Downtime Reduction (%)×Average Downtime Cost / year

Net Annual Benefit=Annual Savings−Annual OPEX

NPV=(Net Annual Benefit×PV factor)−Initial Investment

[15 marks]

ii. A robotics manufacturer has recently deployed an IIoT-enabled robotic assembly line using Azure IoT integrated with 5G connectivity for real-time control. However, during production peaks, the system experiences intermittent latency spikes, causing robot synchronization failures and temporary production halts. The project team has only two weeks to stabilize the system before a major client audit.

Thus, identify two (02) ***technical root causes*** of the ***latency issue*** in this IIoT plus 5G integration setup.

[08 marks]

b) Industrial Internet of Things (IIoT) is the use of smart sensors and actuators to enhance manufacturing and industrial processes.

i. A smart agriculture company uses thousands of IoT sensors deployed across multiple farms to monitor soil moisture, temperature, and humidity. The company needs to analyze this sensor data to predict irrigation needs, detect anomalies, and improve crop yield.

Explain how ***AWS IoT Analytics*** can be used to manage this workflow, describing its first three (03) key stages in the context of this application.

[15 marks]

ii. Identify which of the following is/are true? If ***False***, in each case, justify your answer.

A. AWS IoT Core automatically stores all incoming device data in Amazon S3 for long-term analysis.

B. In IIoT, data analytics and visualization are always performed only at the edge layer.

C. The Mirai Botnet in 2016 attack exploited IoT devices with weak or default passwords to launch DDoS attacks.

[09 marks]

c) IoT security is the practice of safeguarding internet-connected devices (IoT) and the networks they use from cyber threats.

i. A smart logistics company uses an IoT-based fleet monitoring system with GPS trackers, RFID sensors, and cloud dashboards to optimize deliveries. Last month, several delivery trucks were rerouted without authorization after attackers exploited unpatched firmware vulnerabilities in the IoT tracking devices. Determine the one (01) ***multi-layered security weakness*** in this system, referring to IoT security architecture layers.

[16 marks]

ii. A healthcare IoT application provides remote patient monitoring using wearable devices. Recently, the platform's APIs were exploited, exposing sensitive medical data.

Recommend ***an improved access control model*** to mitigate the above risks and justify why it is more suitable for healthcare IoT environments.

[17 marks]

iii. ***"Blockchain offers decentralization, but at the cost of scalability and efficiency, which are challenges that IoT systems can't afford."***

Support this statement with two (02) key points linking blockchain characteristics to IoT challenges. Include a real-world example of a blockchain-based IoT deployment to support your discussion.

[20 marks]

...............End of the paper...............