

# Introduction to Internet of Things (IO4041)

Date: February 29<sup>th</sup> 2024

**Course Instructor**

Dr. Ammar Haider

## Sessional-I Exam

**Total Time: 1 Hours**

**Total Marks: 35**

**Total Questions: 05**

**Semester: SP-2024**

**Campus: Lahore**

**Deptt: Computer Science**

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Student Name

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Roll No

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Section

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Student Signature

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Vetted by

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### Instructions:

1. Write all answers on the question booklet. Rough pages may be used but won't be collected.
2. If you think some information is missing then make an assumption and state it clearly.

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### ***CLO 1: understand the basic ecosystem and architecture of the Internet of Things (IoT) systems***

#### **Q1: MCQs**

**[7 marks]**

1. \_\_\_\_\_ systems include the concept of creating a digital twin.
  - a. WoT
  - b. M2M
  - c. Cyber physical
  - d. All of the above.
2. A piezo-mechanical actuator produces power of around 20 watts.
  - a. True
  - b. False

3. A sensor board is powered by 300mAh battery. If the board constantly draws a current of \_\_\_\_\_ mA, it can last for 20 hours before the battery dies.
  - a. 30
  - b. 20
  - c. 15
  - d. None of the above
4. How many bytes are sent by Arduino when the statement `Serial.println(13)` executes.
  - a. 1
  - b. 2
  - c. 3
  - d. 4
5. Duty cycle of a PWM signal is defined as
  - a. ratio of on-time to cycle time
  - b. ratio of on-time to off-time
  - c. ratio of off-time to cycle-time
  - d. inverse of signal frequency
6. In MQTT QoS-2, how many times will the sender transmit the message?
  - a. Exactly one time
  - b. At least one time
  - c. Exactly two times
  - d. None of the above
7. Which of the following is not a request method supported by CoAP?
  - a. GET
  - b. PUT
  - c. HEAD
  - d. DELETE

***CLO 2: explain the key enabling technologies for developing IoT applications.***

**Q2: Short answer questions**

**[2 + 2 + 1 + 2 marks]**

- a. Elaborate on the pros and cons of using analog versus digital sensors.

Digital sensors provide an output that is ready to be processed by microcontroller.

Analog sensors need a separate conversion step, but output has a higher resolution.

b. Why is it a problem for sensors to have non-linear output?

Linear output means output signal changes in direct proportion to input physical quantity. Non linear output makes it much harder to correlate the output changes to input changes.

c. What happens when you press the Reset button on Arduino board?

Microcontroller RAM is cleared and jumps to beginning of the program.

d. Why do we need a pull-down resistor when connecting a push button to Arduino?

Without pull-down, the input pin will be in a floating state when the push button is open (not pressed). PD resistor forces it at zero level.

**CLO 3: provide overview of wireless connectivity standards and underlying protocols for IoT applications.**

**Q3: Short answer questions**

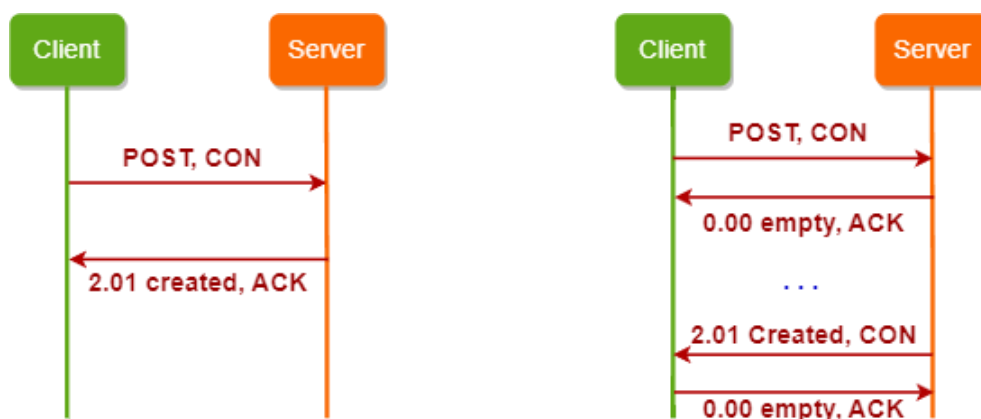
**[3 + 3 marks]**

a. Discuss the fundamental difference between CoAP and MQTT protocols.

MQTT follows a pubsub model, where clients connect to a broker only. Clients can publish data on some topics or subscribe to specific topics. Broker ensures all subscribed clients receive the data they are interested in. There is no direct interaction between publishers and subscribers.

CoAP on the other hand follows client-server mode. Server is in charge of a resource, client sends request to create, get, update or delete the resources.

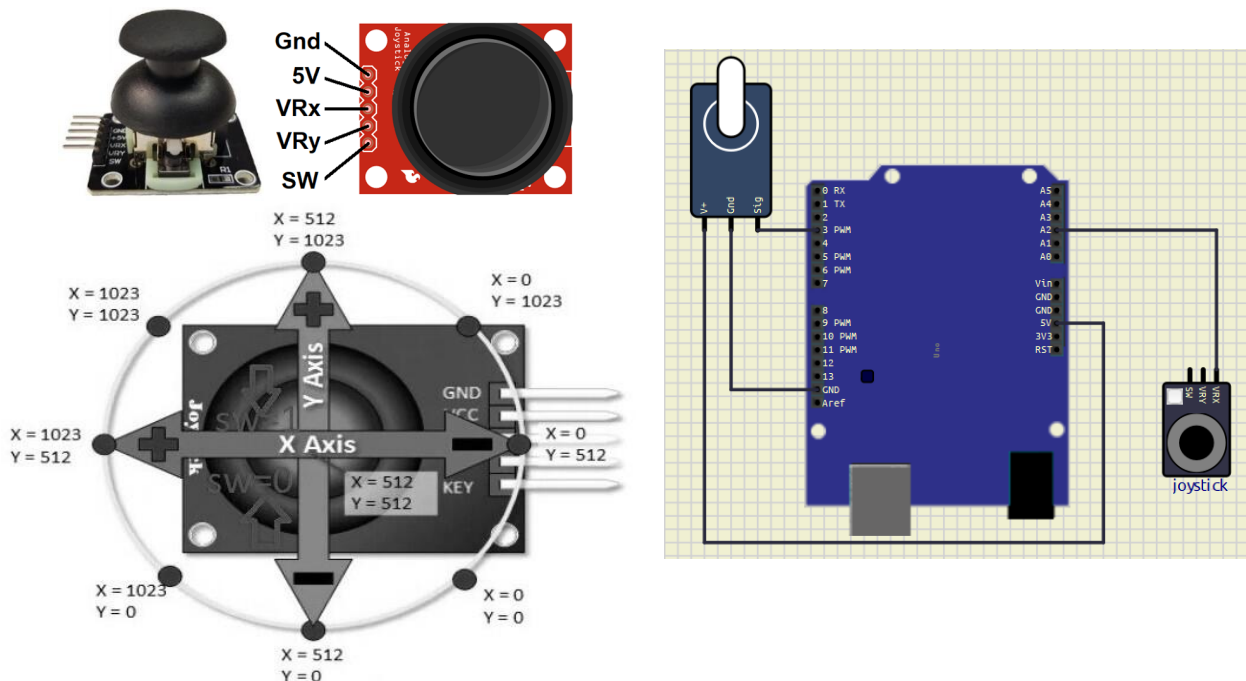
b. In CoAP, a response message can either be piggybacked or sent separately. Using a diagram, illustrate the difference between the two.



**CLO 4: introduce devices including sensors, low power processors, gateways, and cloud computing platforms.****Q4: Arduino Programming****[8 marks]**

**Background:** Joystick or thumbstick, commonly found on game controllers, is a device used for two-dimensional input. It consists of a small handle or knob that can be moved right, left, up and down from its neutral center position. Internally, joystick circuit is very simple, it consists of two potentiometers – one that tracks horizontal movement (X-axis), other for vertical movement (Y-axis). Output of both potentiometers is available as an analog value on VRX and VRY pins respectively. Joysticks handle can also be pressed down like a regular push-button. SW pin provides the push button output.

If we were to convert the analog readings on these potentiometers to digital data using a 10-bit ADC, we will get one X and one Y value, both in the range [0, 1023]. Figure on the right shows how to correlate these outputs with the handle position.



Now suppose we have a circuit as shown in the diagram below. VRX pin of joystick is connected to A2 pin on Arduino. The servo motor is to be controlled using joystick's horizontal position only. By default the servo arm is vertical (90°). Each right or left push on the joystick causes the motor arm to be pushed right (towards 180°) or left (towards 0°) **by 5°**. That means, if user keeps the handle pressed towards right, the motor arm will slowly move all the way to 180°. If user leaves the joystick handle at its neutral position, the servo will maintain its current angle, whatever it is.

Partial sketch is given below. Provide the missing code for locations marked with **//\*\***.

```
#include <Servo.h>

const int vrxPin = A2;
const int servoPin = 3;

int servoAngle = 90; // initial arm position
```

```
/** create servo object (1)
Servo xServo;

void setup() {
  /** setup code for servo (1)
  xServo.attach(servoPin);
}

void loop() {
  /** read joystick x-position (1)
  int xValue = analogRead(vrxPin);

  /** work out new servoAngle based on joystick x-position
  // angle should not go out of [0, 180] range (2 angle, 2 bounds)
  if (xValue < 512)
    servoAngle = min(servoAngle + 5, 180);
  else if (xValue > 512)
    servoAngle = max(servoAngle - 5, 0);

  /** turn servo to servoAngle (1)
  xServo.write(servoAngle);

  delay(300);
}
```

**Q5: MQTT Protocol****[7 marks]**

Consider an MQTT system, where there are two clients C1 and C2 in addition to broker. Below is a sequence of events performed by the clients. For each event, write down the immediate subsequent event, **if any**.

Assume that all subscriptions and data publishing is done with QoS-0.

RF stands for retain flag.

Event	Outcome	
C2 connects to broker.	Broker responds with connack.	.5
C1 connects to broker, providing LWT topic status/c1 and message 'offline'.	Broker responds with connack.	.5
C2 subscribes to status/c1.	(nothing for broker to do)	
C2 publishes '25' to home/gfloor/temp with RF=1.	(No subscriber, message retained)	
C2 publishes '300' to home/gfloor/light with RF=0.	(No subscriber, message discarded)	
C1 subscribes to home/+/+	Broker publishes '25' to C1.	1.5
C2 publishes '28' to home/gfloor/lounge/temp with RF=1	No subscriber, message retained	1
C1 sends a disconnect message.	No LWT published	1
C1 reconnects as a clean connection.	Broker responds with connack	.5
C1 subscribes to home/#	Broker publishes 25 for home/gfloor/temp and 28 for home/gfloor/lounge/temp to C1.	2