Assignments 1 + 2 + 3 + 4

Assignment 1: There are many large and small scale IoT projects being rolled out globally, from smart farms to smart cities, in healthcare monitoring, transport, and for the use of public spaces.

Search the web for details of a project that interests you, ideally one close to where you live. Explain the upsides and the downsides of the project, such as what benefit comes from it, any problems it causes and how privacy is taken into consideration.

⇒"In Bến Cát, where industrial activity and urban development are increasing, an IoT-based air quality and temperature monitoring system could provide valuable insights for residents and local authorities. Such a system utilize sensors deployed across the city to measure particulate matter (PM2.5 and PM10), nitrogen dioxide (NO2), ozone (O3), and temperature, transmitting data wirelessly to a central platform. Upsides include real-time monitoring of air pollution levels, enabling timely alerts for vulnerable populations and informing public health initiatives. This data can also help identify pollution hotspots and inform urban planning decisions. Furthermore, temperature monitoring can aid in understanding urban heat island effects and optimizing energy consumption. However, downsides include the initial cost of sensor deployment and maintenance, the need for reliable internet connectivity, and ensuring data accuracy in varying weather conditions. Privacy considerations are paramount, as the system must protect the location data of sensors and ensure that air quality data is anonymized when shared with the public. Data security protocols are essential to prevent unauthorized access and misuse of sensitive information."

Assignment 2: This lesson covered microcontrollers and single-board computers. Create a table comparing and contrasting them, and note at least 2 reasons why you would use a microcontroller over a single-board computer, and at least 2 reasons why you would use a single-board computer over a microcontroller.

Feature	Microcontroller	Single-Board Computer (SBC)
Processing Power	Limited, often single-core, lower clock speeds	More powerful, multi-core processors, higher clock speeds
Operating System	Typically no OS or a Real-Time Operating System (RTOS)	Full-fledged OS (Linux, Windows IoT)
Memory	Limited RAM and Flash memory	Larger RAM and storage (SD card, SSD)
Peripherals	Built-in peripherals (GPIO, ADC, timers)	Requires external peripherals via USB, HDMI, etc.
Power Consumption	Very low	Higher
Cost	Lower	Higher
Complexity	Simpler to program (C, assembly)	More complex software development (Python, Java, etc.)
Purpose	Dedicated control applications	General-purpose computing, prototyping, complex IoT applications
Connectivity	Limited (UART, SPI, I2C)	More versatile (Ethernet, Wi-Fi, Bluetooth, USB)

Reasons to Use a Microcontroller Over a Single-Board Computer:

1. Low Power Consumption: Microcontrollers are designed for applications where power efficiency is critical, such as battery-powered devices or remote sensors. This is particularly important in IoT deployments in areas where power supply is limited or unreliable.
2. Real-Time Responsiveness: Microcontrollers excel at real-time applications where precise timing and immediate responses are necessary, like controlling

motors or reading sensor data at high speeds. This is crucial for applications that require deterministic behavior.

Reasons to Use a Single-Board Computer Over a Microcontroller:

1. Complex Processing Requirements: For applications requiring significant processing power, such as image processing, machine learning, or running complex algorithms, an SBC is essential. This is common in advanced IoT projects that involve data analysis and decision-making at the edge.
2. Rich Operating System and Software Libraries: SBCs run full-fledged operating systems, providing access to extensive software libraries, frameworks, and tools. This simplifies development and allows for more complex applications to be built quickly, especially when networking and connectivity are involved.

Assignment 3: Research and describe one sensor and one actuator that can be used with an IoT dev kit, including:

- **What it does**
- **The electronics/hardware used inside**
- **Is it analog or digital**
- **What the units and range of inputs or measurements is**

Sensor: JXCT NPK Sensor

What it does:

The JXCT NPK sensor measures the concentration of three essential nutrients in the soil: Nitrogen (N), Phosphorus (P), and Potassium (K). These nutrients are crucial for plant growth, and the sensor helps farmers optimize fertilizer use.

Electronics/Hardware Used Inside:

- Electrochemical sensing elements to detect ion concentrations in the soil.
- Incoperated with microcontroller and signal processing circuit to convert readings into digital values.

- RS-485 tranciever for data transmission from RS485 to to a microcontroller.

Analog or Digital:

- Digital (Uses RS-485 Modbus protocol for communication).

Units & Range of Inputs/Measurements:

- Nitrogen (N): 0–1999 mg/kg
- Phosphorus (P): 0–1999 mg/kg
- Potassium (K): 0–1999 mg/kg
- Operating voltage: 12V–24V DC

Actuator: Electric Pump Connected to Arduino

What it does:

An electric pump is used for irrigation, nutrient delivery, or liquid movement in IoT-based agriculture. The Arduino controls the pump based on sensor inputs (e.g., soil moisture level).

Electronics/Hardware Used Inside:

- DC motor or solenoid-based pumping mechanism to move fluids.
- MOSFET or relay module to switch power on/off using the Arduino.
- Power supply (battery or DC adapter) to drive the pump.

Analog or Digital:

- Digital (controlled via a relay or MOSFET switch).

Units & Range of Inputs/Measurements:

- Voltage: 5V–24V DC (depending on the pump type).
- Flow rate: 0.1–5 liters per minute (varies by model).
- Current draw: 100mA to several amps (depends on pump power).

Assignment 4: Research these both and compare/contract them with MQTT. Think about power usage, security, and message persistence if connections are lost.

1. AMQP (Advanced Message Queuing Protocol)

AMQP is a more feature-rich protocol than MQTT, supporting message queuing, transactions, and routing. It is widely used in banking and enterprise systems.

Power Usage:

- Higher power consumption due to its complex message-handling capabilities.

Security:

- Supports TLS/SSL encryption and SASL (Simple Authentication and Security Layer) for enhanced security.

Message Persistence:

- Guaranteed message delivery – Supports message acknowledgment, persistence, and transactions.
- More robust than MQTT in ensuring message integrity.

Comparison with MQTT:

- MQTT is lighter and better for low-power IoT devices, whereas AMQP is more feature-rich but power-hungry.
- AMQP is better for enterprise applications needing message queuing and reliability.
- MQTT is better for simple IoT telemetry where low bandwidth is key.

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2. HTTP/HTTPS (HyperText Transfer Protocol / Secure)

HTTP/HTTPS are request-response protocols commonly used for web applications and REST APIs. They are not optimized for IoT but are still widely used.

Power Usage:

- High power consumption – Every request requires a new connection setup, leading to higher overhead.

Security:

- HTTPS uses SSL/TLS encryption, making it more secure than unencrypted MQTT.
- Supports OAuth, API keys, and JWT authentication.

Message Persistence:

- No built-in message persistence – If a device disconnects, it must manually retry sending data.

Comparison with MQTT:

- MQTT is better for real-time, low-bandwidth applications, while HTTP/HTTPS is better for structured REST API communication.
- HTTP/HTTPS is stateless (each request is independent), whereas MQTT maintains persistent connections.
- MQTT supports QoS levels for reliable delivery, while HTTP has no built-in message persistence.