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ArtFlow - Room Presence in a Museum

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System Analysis

1. Introduction of the system and the Reference Scenario

The way that are art pieces are organized in a Musem influences heavingly the enjoyment and overall procession and evaluation of visiting patrons. Which can also be a detriment to a curator that wishes to prolonge the visitors’ stay and engagement.

In this project we provide an IoT solution to monitor the presence of the visitors, track their numbers and the pathways taken by the crowd from one artwork to another. This will aid in tailoring the experience to the users’ preference.

This IoT solution is mainly aimed at curators with small to medium sized exihibition venues. Despite the fact that it is aimed mainly at art museums, it still functions and scales perfectly for historical museusms as well.

2. Analysis of current state of the art solutions

When looking at the existing state of the art solutions to the problems of crowd flow monitoring, generally and more specifically in the context of museums, we find that that we can detect 4 system technologies. These technologies enable anonymous tracking of visitors' movements, allowing curators to optimize space utilization and enhance the visitor experience. We will present the 4 most relevant technologies used for crowd flow monitoring in museums, in addition to their advantages and disadvantages, with a brief analysis.

2.1. RFID-based systems

RFID (Radio-Frequency Identification) systems are widely used for tracking and monitoring the movement of objects or people within a defined space. In a museum setting, RFID tags can be provided to visitors, allowing their movements to be tracked as they explore different exhibits.

Advantages	**Disadvantages**
Accurate Tracking: RFID systems provide precise data on the location and movement of visitors, allowing curators to understand which exhibits are most popular and how visitors navigate through the space	**Privacy Concerns**: Although the tracking is anonymous, some visitors may be uncomfortable with the idea of being tracked, which could affect their experience
Real-Time Data: The ability to track visitors in real-time enables immediate adjustments to crowd management strategies and exhibit placement	**Initial Setup Cost**: The installation of RFID readers and the distribution of tags can be costly, particularly for smaller museums with limited budgets
Low Maintenance: Once installed, RFID systems require minimal maintenance, making them cost-effective over time	**Limited Range**: RFID systems may have a limited range, requiring a higher density of readers in large venues to ensure comprehensive coverage

2.2. Camera-based systems

Camera-based systems are another prevalent technology used for crowd flow monitoring. These systems employ video cameras to capture visual data, which is then processed using image recognition algorithms to track the movement of visitors.

Advantages	Disadvantages
Visual Data: Provides rich visual data that can be used to analyze visitor behavior, including which exhibits attract the most attention and how long visitors spend at each one	**Privacy Issues**: Camera-based systems can raise significant privacy concerns, especially if not implemented with appropriate safeguards to ensure anonymity
Integration with AI: Advanced image processing and AI techniques can be used to enhance the accuracy of visitor tracking and even predict future crowd flows	**Environmental Sensitivity**: These systems can be affected by lighting conditions, obstructions, and the overall layout of the museum, potentially reducing their effectiveness
Non-Intrusive: Unlike RFID, there is no need to distribute tags or devices to visitors, which can make the experience feel more seamless and natural	**High Computational Demand**: Processing large volumes of video data in real-time requires significant computational resources, which can be expensive

2.3. Wi-Fi and Bluetooth-based Systems

Wi-Fi and Bluetooth-based tracking systems are increasingly used for indoor positioning and crowd flow monitoring. By detecting signals from visitors' mobile devices, these systems can estimate the location and movement of individuals within the museum.

Advantages	Disadvantages
Widespread Adoption: Since most visitors carry mobile devices, this method allows for easy and widespread tracking without the need for additional hardware	**Accuracy**: The accuracy of Wi-Fi and Bluetooth tracking can be lower compared to RFID or camera-based systems, particularly in crowded environments where signals may overlap or interfere with each other
Scalability: Wi-Fi and Bluetooth systems can easily scale to cover large areas, making them suitable for museums of all sizes	**Battery Drain**: Continuous tracking can drain the battery life of visitors' mobile devices, which may negatively impact their experience
Cost-Effective: Leveraging existing Wi-Fi infrastructure reduces the need for significant additional investment, particularly in venues that already have robust network coverage	**Privacy and Consent**: Using visitors' devices for tracking requires clear consent and transparency, which can complicate the implementation process

2.4. Sensor-based IoT Systems

Our proposed IoT solution employs a combination of sensors, such as ultrasonic distance sensors and infrared motion detectors, to monitor crowd flow and visitor movements. These sensors are strategically placed throughout the museum to gather data on the number of visitors, their movements, and the time spent at each exhibit.

Advantages	**Disadvantages**
Anonymous Tracking: Unlike camera-based or RFID systems, our sensor-based solution tracks visitors without collecting personally identifiable information, ensuring complete anonymity	**Limited Data Granularity**: While effective in counting visitors and tracking general movement patterns, sensor-based systems may not provide the detailed behavioral insights
Cost-Effective: The sensors used in our solution are relatively inexpensive, making it accessible for small to medium-sized museums with limited budgets	**Environmental Sensitivity**: Sensors can be affected by environmental factors such as lighting, temperature, and obstructions, which may impact their accuracy
Scalable and Flexible: The system can be easily scaled to cover more areas of the museum or adjusted to focus on specific exhibits, providing curators with the flexibility to tailor the monitoring to their needs	**Maintenance**: Regular maintenance and calibration of sensors are required to ensure accurate data collection, which can be labor-intensive
Real-Time Data: Our system provides real-time data on visitor movements, allowing curators to make immediate adjustments to enhance the visitor experience	

2.5. Summary

We can summarize the advantages and the disadvantages of the technologies mentioned above as follows:

Category	**Advantage**	**Disadvantage**
RFID-based Systems	Accurate Tracking	Privacy Concerns
	Real-time Data	High initial setup cost
	Low Maintenance	Limited Range
Camera-based Systems	Rich visual data	Privacy Issues
	AI integration for advanced analytics	Sensitivity to enviromental conditions
	Non-intrusive	High computational demand
WiFi/Bluetooth Systems	Widespread adoption	Lower accuracy
	Scalability	Battery drain
	Cost-effective	Privacy concerns
Sensor-based IoT systems	Anonymous Tracking and Real-time Data	Limited data granularity
	Cost-effective	Enviromental sensitivity
	Scalable and flexbile	Maintenance requirements

3. System Requirements

The analysis of the current state-of-the-art allows us to define the requirements that the system needs to satisfy to compete and perform well in our reference scenario.

Functional Requirements

Functional requirement	Description	Input	Output
FR1: Presence Monitoring	The system is able to monitor the presence of a visitors in museum premises	Data from the IoT system on visitor presence	Status of visitors in the museum
FR2: Real-time Presence Monitoring	The system is able to monitor the presence of a visitors in museum premises in Real-time	Continous data from the IoT system on visitor presence	Real-time status of visitors in the museum
FR3: Visitor Entry and Exit Detection	The system is able to detect when visitors enter and exit a museum room and track their movements throughout the museum	Entrance and Exit monitoring data from the IoT system	Records of visitor movements
FR4: Real-time Visitor Number Monitoring	The system is able to keep track of the number of visitors present in different rooms and areas of the museum	Data on room occupancy by the IoT system	Records of visitor counts
FR5: Visitor Number Monitoring	The system is able to keep track of the number of visitors present in different rooms and areas of the museum in real-time	Continous data on room occupancy by the IoT system	Real-time visitor count
FR6: Crowd Movement and Pathway Monitoring	The system is able to keep track of the crowd movement and pathways taken from one artwork to another	Sensor data on crowd flow by the IoT system	Analysis of crowd movement and visitor routes

FR7: Data Logging	The system is able to collects data and keep logs in order to provide insights to the museum curators to enhance the overall user experience	Recorded continous visitor movement data from the IoT system	Logged data for analysis
FR8: Real-time Data Access	The system is able provide the museum curator with Real-time updated data from the museum IoT sensors	Curator login credetials	Real-Time access to museum data and analytics via a suitable user interface
FR9: Collected and Logged Data Access	The system is able provide the museum curator with access to the collected and logged data from the museum IoT sensors	Curator login credetials	Access to collected and logged museum data and analytics via a suitable user interface

Non Functional Requirements

Functional requirement	Description
NFR1	The system is scalable to different museum sizes and is able to handle large traffic
NFR2	The system is reliable and accurate and is able to keep track of visitors under different circumstances and in an accurate manner
NFR3	The system is robust, secure and prioritizes the privacy of the visitors and data collected
NFR4	The system is user friendly and is able to be used easily by curators to gain access to the data collected

4. System Features

Based on the requirements analysis gathered previously, several features can be identified to ensure that the proposed IoT solution effectively monitors and enhances the visitor experience in museums. The following sections detail these features in relation to the functional and non-functional requirements.

4.1. User-Friendly Interface

As identified in the previous sections, analyzing complex data patterns can be a challenging and time-consuming task, particularly when the system needs to operate under varying conditions. To ensure the requirements FR8, FR9, and NFR4, it is essential to implement a modern and user-friendly interface that provides a comprehensive overview of the system.

This interface will make it easier for curators to comprehend the data presented, facilitating better decision-making. The interface will also be secure, ensuring that only authorized personnel can access sensitive information.

4.2. Real-Time Presence Monitoring and Analysis

To meet the requirements of FR2, FR4, and FR5, the system must be capable of real-time monitoring of visitor presence across museum premises. Leveraging data from IoT sensors, the system will continuously track the number of visitors in different rooms and areas, providing real-time updates on visitor status and movement.

The inclusion of real-time data processing ensures that the museum curator can respond immediately to changes in crowd dynamics, such as adjusting the flow to prevent overcrowding or identifying which exhibits attract the most attention. The use of real-time analytics will also enhance the overall visitor experience by enabling curators to optimize the layout and arrangement of exhibits based on current data.

4.3. Enhanced Visitor Tracking

According to FR3 and FR6, the system must accurately detect when visitors enter and exit different museum rooms and track their pathways throughout the museum. The system will employ a network of sensors to monitor visitor movement, collecting data that details how visitors navigate the space and interact with the exhibits.

This data will allow curators to understand visitor behavior patterns, such as which exhibits are most popular or where visitors tend to spend the most time. By analyzing these movement patterns, the system can help optimize the placement of exhibits and improve crowd management strategies.

4.4. Data Logging and Access

To fulfill the requirements FR7, FR8, and FR9, the system must provide robust data logging capabilities, recording all visitor movement and occupancy data for later analysis. This logged data will be crucial for curators aiming to gain insights into visitor behavior and improve the museum experience over time.

The system will also allow curators to access both real-time and historical data through a secure interface, enabling them to make data-driven decisions about exhibit placement, crowd flow management, and overall museum operations. Access to logged data will be particularly valuable for long-term planning and optimization of the museum layout.

4.5. Cost Efficiency and Scalability

The "as-is" analysis highlighted the high costs associated with implementing effective visitor monitoring systems, often making them inaccessible to smaller museums. To address this, the new system will be designed using cost-effective components, significantly reducing implementation expenses without compromising on functionality (NFR1).

Despite its lower cost, the system will be scalable, allowing it to adapt to museums of various sizes and accommodate different levels of visitor traffic. This scalability ensures that the system remains relevant and effective as museum needs evolve, making it a viable solution for both small and large institutions.

4.6. Reliability and Privacy

Ensuring the reliability and accuracy of the system is critical, as outlined in NFR2 and NFR3. The system will be designed to operate under various conditions, accurately tracking visitor movements even in challenging environments. Additionally, the system will prioritize the privacy of visitors, using anonymized data collection methods and implementing robust security measures to protect both the data and the users.

The system's reliability will be further enhanced by its modular design, allowing for easy maintenance and upgrades. This modularity ensures that any potential issues can be quickly addressed, minimizing downtime and maintaining the integrity of the visitor monitoring process.

4.7. Summary

The proposed system will offer a comprehensive solution for monitoring and enhancing the visitor experience in museums, combining real-time data analysis, enhanced visitor tracking, and user-friendly interfaces with cost-effective and scalable technology. By prioritizing reliability, privacy, and ease of use, the system will empower curators to make informed decisions that optimize museum operations and improve visitor satisfaction.

5. Analysis of available hardware

The project at hand requires the use of several parts in order to analyze and capture the input data taken from the museum, process it, and store it appropriately. In order to adequately choose the correct and suitable hardware for our system, we will conduct a detailed analysis of the available hardware parts and conclude on which ones are the best fit for our case.

5.1. Development Boards

Several development boards can be used to implement our propsed museum crowd flow monitoring system, but we must take into account the cost, computational resources, maintenance, and the specific requirements of this project. As such, we provide below a comparison between the available boards:

Arduino Uno: The Arduino Uno is a popular and open-source development board commonly used for building electronic projects. It features digital and analog input/output pins, USB connectivity for programming, and various power and communication protocols. The Arduino Uno is known for its ease of use, versatility, and extensive community support. However, it lacks built-in wireless connectivity, which would require additional modules to achieve network capabilities essential for this project.

ESP8266: The ESP8266 is a low-cost, compact Wi-Fi module with an integrated microcontroller, widely used in Internet of Things (IoT) applications. It is affordable and offers built-in wireless communication, making it ideal for real-time monitoring and data transmission. While it has fewer GPIO pins and limited memory compared to other boards, its wireless capabilities and cost-effectiveness make it a strong candidate for this project.

Raspberry Pi: The Raspberry Pi is a powerful single-board computer featuring USB ports, HDMI output, audio jacks, GPIO pins, and an SD card slot for storage. It offers higher computational capabilities and extensive customization options, making it versatile for various applications. However, its higher power consumption and the need for continuous power supply make it less ideal for low-power, small-scale IoT applications like the one proposed here.

We can summarize the above in the table below:

Board	**Advantages**	**Disadvantages**	**Cost**
Arduino Uno	• Large community support • Stable and reliable • Highly versatile	• Limited memory and processing power • No built-in wireless connectivity	20 - 30 EUR
ESP8266	• Compact form factor • Built-in wireless connectivity • Cost-effective	• Limited GPIO pins • Limited Memory	5 - 11 EUR
Raspberry Pi	• Power Processing • Built-in connectivity • Highly versatile	• High power consumption • Requires continous power supply	35 EUR

From the analysis and the table above, we will choose the **ESP8266** as the development board. Its built-in wireless connectivity, compact form factor, and low cost make it an optimal choice for implementing the museum's crowd flow monitoring system. Although, its limited computational resources and memory may pose challenges.

5.2. Sensors Selection and Analysis

In the proposed IoT-based crowd flow monitoring system for museums, sensors play a critical role in detecting and tracking visitor presence, movement, and behavior within the exhibition spaces. Below is an analysis of various sensors that could be used in this context.

HC-SR501 PIR Motion Sensor: The HC-SR501 Passive Infrared (PIR) Motion Sensor is widely used for detecting human presence based on body heat. It is highly sensitive to infrared radiation emitted by human bodies, making it suitable for detecting when a visitor is in front of an exhibit. This sensor is commonly employed in security and automation applications due to its reliability, low power consumption, and ease of use.

HC-SR04 Ultrasonic Sensor: The HC-SR04 Ultrasonic Sensor measures distance by emitting ultrasonic waves and calculating the time taken for the echo to return. This sensor is commonly used for distance measurement and object detection.

Infrared (IR) Sensors: Infrared sensors detect objects and measure distances based on the reflection of infrared light. These sensors are often used for proximity detection and basic motion sensing.

Pressure Sensors: Pressure sensors detect the force exerted on a surface, which can be used to measure foot traffic or detect when a visitor steps on a specific area.

Below is a table with details on each sensor:

Sensor	Purpose	Advantage	Disadvantage
HC-SR501 PIR Motion Sensor	Detecting presence in front of exhibits	Low power consumption, easy integration, cost-effective	Limited range, sensitive to temperature and sunlight
HC-SR04 Ultrasonic Sensor	Monitoring entry and exit points, room occupancy	Accurate distance measurement, works in various conditions	Limited field of view, affected by soft materials
Infrared (IR) Sensors	Basic proximity detection	Simple, cost-effective, reliable for short-range	Limited range and accuracy, affected by lighting conditions
Pressure Sensors	Measuring foot traffic and specific area presence	Detailed foot traffic patterns, non-intrusive	Expensive, complex installation, limited to specific areas

Based on the analysis of the available sensor options, the combination of the **HC-SR501 PIR Motion Sensor** and **HC-SR04 Ultrasonic Sensor** offers a robust, cost-effective, and scalable solution for monitoring visitor presence and movement within a museum. These sensors fulfill the key requirements of the system, providing accurate data on visitor engagement and crowd flow without imposing significant costs or complexity.

5.3. Chosen hardware detailed presentation

I. Development Board – NodeMCU ESP8266

Microcontroller	ESP8266
Operating Voltage	3.3V (Still provides a 5V output)
Digital I/O Pins	11 (all pins support PWM, I2C, and 1-wire)
Flash Memory	4 MB
SRAM	64 KB
Clock Speed	80 MHz
Power Source	Micro USB / Battery
Price	3-11 EUR
Datasheet	https://www.elegoo.com

The NodeMCU will be the main microcontroller used to manage the entire system with gathering and processing data from the sensors, to communication with the network. It is the perfect choice given its low cost as compared to other microcontroller like the Arduino Uno, and support for ample sensor connections.

II. Sensors and wirings
HC-SR501 PIR Motion Sensor

Detection Range	Adjustable from 3m to 7m
Operating Voltage	5V
Delay Time	Adjustable from 5 seconds to 5 minutes
Detection Angle	120 degrees
Price	6 – 9 EUR
Datasheet	https://win.adrirobot.it/sensori/pir_sensor/pir_sensor_hc-sr501_arduino.htm

The HC-SR501 Passive Infrared (PIR) sensor detects the presence of visitors by sensing motion within its field of view. It is used to monitor visitor movement in specific areas, triggering data collection or logging entry and exit times. This sensor is also chosen mainly due to its low power consumption and adjustable and reliable sensitivity.

HC-SR04 Ultrasonic Sensor

Detection Range	2cm – 400cm
Operating Voltage	5V
Measuring Angle	15 degrees
Accuracy	3mm
Price	4.5 EUR
Datasheet	https://www.sparkfun.com/products/15569

The HC-SR04 Ultrasonic Sensor measures the distance between the sensor and the visitor. It is used to monitor how visitors move through the space and interact with exhibits, providing data on their pathways and information on the exact exhibits which are the most focused on points of interests. This sensor is chosen for its accuracy and detection range which fit the task required.

6. Analysis of communication technology and the application protocol

The choice of communication technologies and protocols is crucial for ensuring the reliability, efficiency, and security of the proposed IoT-based crowd flow monitoring system. This section provides an overview of the communication technologies and protocols that will be used in the system, focusing on their ability to meet the functional and non-functional requirements outlined earlier.

6.1. Communication technologies Analysis

The system will utilize wireless communication technologies to avoid intrusive infrastructure and facilitate easy installation. Given the requirements for real-time data transmission, accurate monitoring, and secure access, we analyse the the following technologies and protocols:

Wi-Fi: Wi-Fi is a wireless communication technology that allows devices to connect to a network and communicate over radio waves. It is well-suited for environments where devices need to transmit data over short to medium distances.

Bluetooth Low Energy: BLE is a wireless technology designed for short-range communication with low power consumption. It is often used for applications requiring intermittent data transfer and low energy usage.

Zigbee: Zigbee is a wireless communication protocol designed for low-power, low-data-rate applications. It is typically used in home automation and industrial applications.

LoRa: LoRa is a wireless communication technology designed for long-range, low-power applications. It is used for transmitting data over greater distances than Wi-Fi or BLE.

Below is a table with details on each of the communication technologies:

Technology	**Advantage**	**Disadvantage**	**Use Case**
Wi-Fi	High-data transfer rates, cost-effective, widely supported	Limited range, affected by interference	Communication between ESP8266 and central server
Bluetooth Low Energy	Low power usage, suitable for intermittent data transfer	Limited range, lower data transfer rate	Communication between ESP8266 and central server
Zigbee	Reliable for mesh networking, low power consumption	Lower data rate, requires additional infrastructure	Communication between ESP8266 and central server
LoRa	Long-range capabilities, low power consumption	Lower data transfer rate, additional infrastructure	Communication between ESP8266 and central server

We will choose **Wi-Fi** as the main communication technology and this is mainly due to the cost-effective nature of Wi-Fi, its high-data transfer rate compared to BLE and unlike alternatives such as Bluetooth Low Energy (BLE) and Zigbee, which have limitations in data transfer rates and range, Wi-Fi does not require additional infrastructure, making it both practical and economical for widespread deployment.

6.2. Application Protocols Analysis

The choice of application protocols ensures that data is transmitted securely and efficiently between the system, and central server. Given the requirements for real-time data transmission and communication, we analyse the the following protocols:

HTTP (HyperText Transfer Protocol): HTTP is a widely used protocol for transmitting data over the web. It is essential for web-based applications and provides secure communication channels.

MQTT(Message Queuing Telemetry Transport): MQTT is a lightweight, publish/subscribe messaging protocol designed for low-bandwidth, high-latency, or unreliable networks.

CoAP (Constrained Application Protocol): CoAP is a protocol designed for constrained devices and networks, providing a lightweight alternative to HTTP for RESTful communication.

AMQP (Advanced Message Queuing Protocol): AMQP is a messaging protocol designed for reliable communication between systems, supporting advanced messaging features.

XMPP (Extensible Messaging and Presence Protocol): XMPP is a protocol for real-time messaging and presence information, commonly used in chat applications.

Below is a table with details on each of the application protocols:

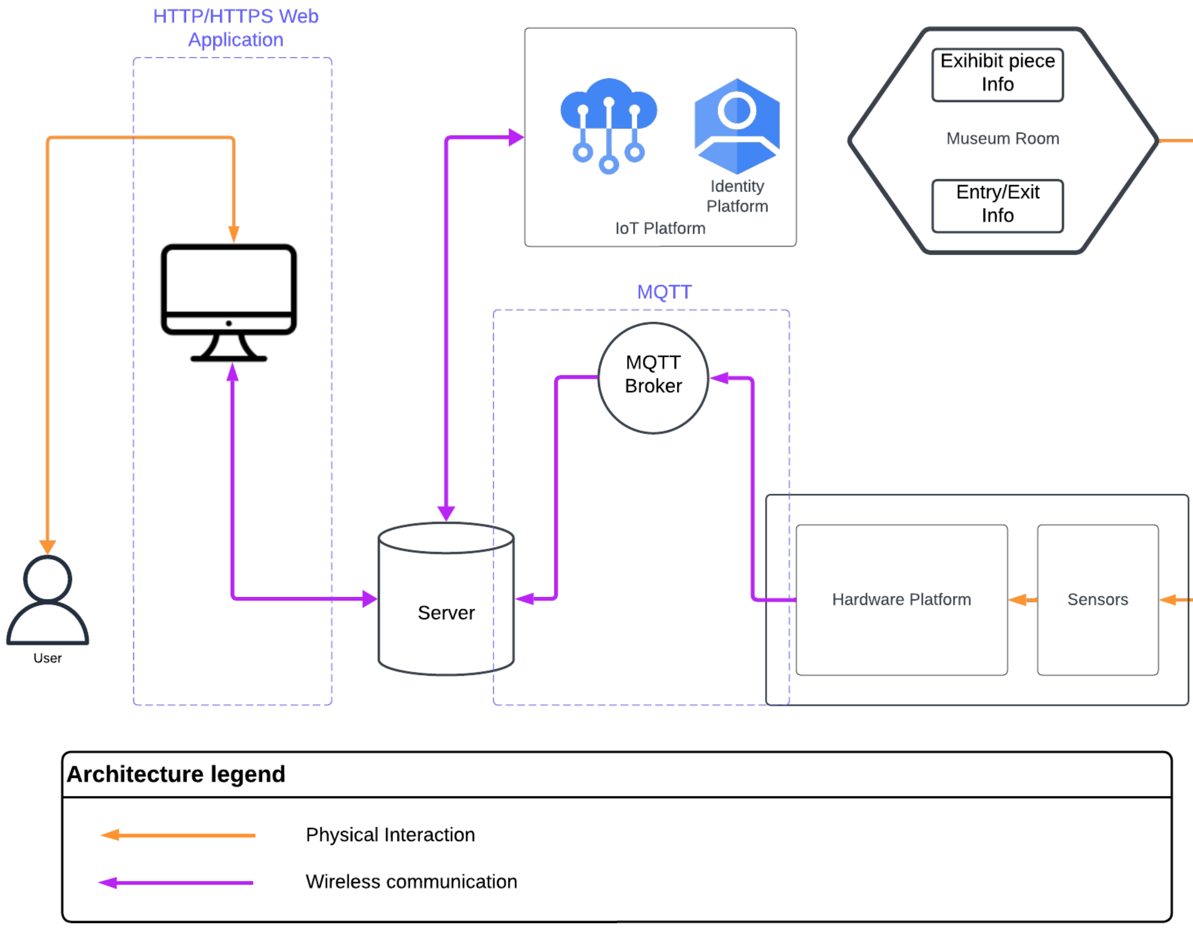
Technology	Advantage	Disadvantage	Use Case
HTTP	Standardized, supports secure communication via HTTPS	Higher overhead	Sending sensor data to central server, web-based interfaces
MQTT	Efficient for small data transfer, supports real-time communication	Less suited for high-throughput data transfer	Real-time communication for sensor data updates
CoAP	Low overhead, efficient for constrained environments	Less widely supported, potential complexity in securing communication	Real-time communication for sensor data updates
AMQP	Supports complex messaging patterns, reliable	More complex, higher resource requirements	Real-time communication for sensor data updates
XMPP	Supports real-time messaging, extensible	Higher overhead, complexity compared to MQTT	Real-time communication for sensor data updates

We will choose **HTTP** and **MQTT** as application protocols for their ability to provide reliable, high-speed data transmission and ease of integration with web-based systems. HTTP is selected for its simplicity, reliability, and integration with web-based applications. HTTP supports secure communication (via HTTPS) and is well-suited for web interfaces, making it ideal for real-time data access and management.

MQTT is chosen for its lightweight nature and efficient message distribution through a publisher/subscriber model. MQTT excels in scenarios involving frequent updates and multiple devices. Compared to AMQP, which offers more features but with greater complexity and overhead, MQTT is more straightforward and better suited for the needs of the system. As for the other discarded options, they are designed for constrained environments and low-bandwidth scenarios, but they lack the extensive support and simplicity of HTTP and MQTT. The chosen options provide a balanced approach, offering the necessary performance, cost-efficiency, and ease of integration to meet the system's requirements effectively.

System Design

1. System Architecture

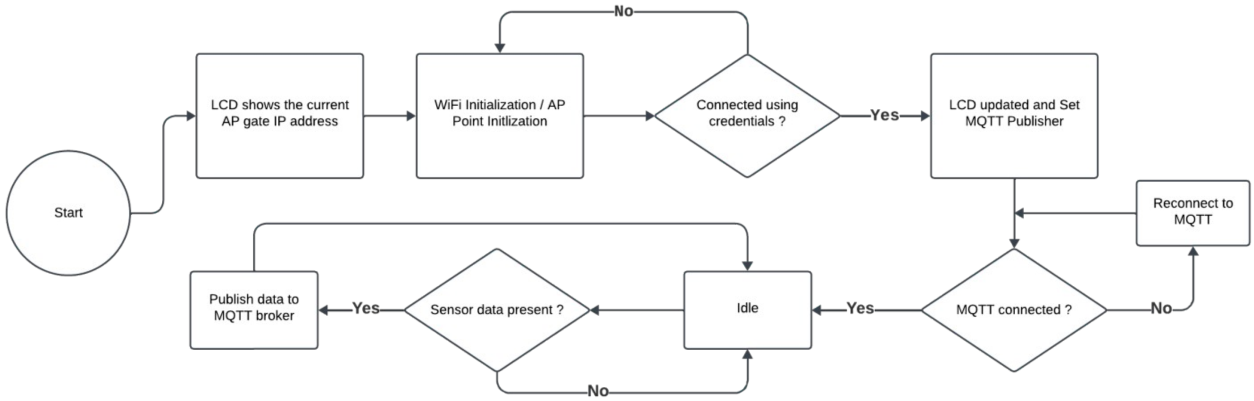


The system architecture provided shows that the system is composed of three main parts we can identify:

- The IoT subsystem installed in the museum room: This system is composed of the NodeMCU ESP8266 connected to the sensors for entry to the room and the sensors used for each exhibit piece. The system will account for user exit from one room by interpreting the entry into room 1 as exit from room 0 and so on.
- The Server: The server is composed of the MQTT broker to which the IoT system publishes to and from which the Flask server subscribes to using topics appropriate for each room and exhibit piece with specific Ids
- The Client: The client side of the whole system is composed of the web application to which the curator will be able to see the data captured by the

sensors and on which there will also be suggestions for rearranging the art museum tour.

1.1. IoT subsystem



In accordance with the system flowchart description above, we can encapsulate the system functioning. The IoT subsystem initially begins by providing the user with the Access Point to provide an ease of connecting to the museum’s network, whose IP address is shown on the lcd screen (purely for initial setup and can be deactivated after the installation). After, the subsystem connects to the MQTT publisher and upon detecting any new data on either the entry sensor or the exhibit piece sensors we publish a message with the appropriate JSON format as follows:

Room Entry Information message format	**Exhibit Piece**
{“id": <room_id>, "detected": 1}	{“r_id": <room_id>, "id": <exhibit_piece_id>, "detected": 1}

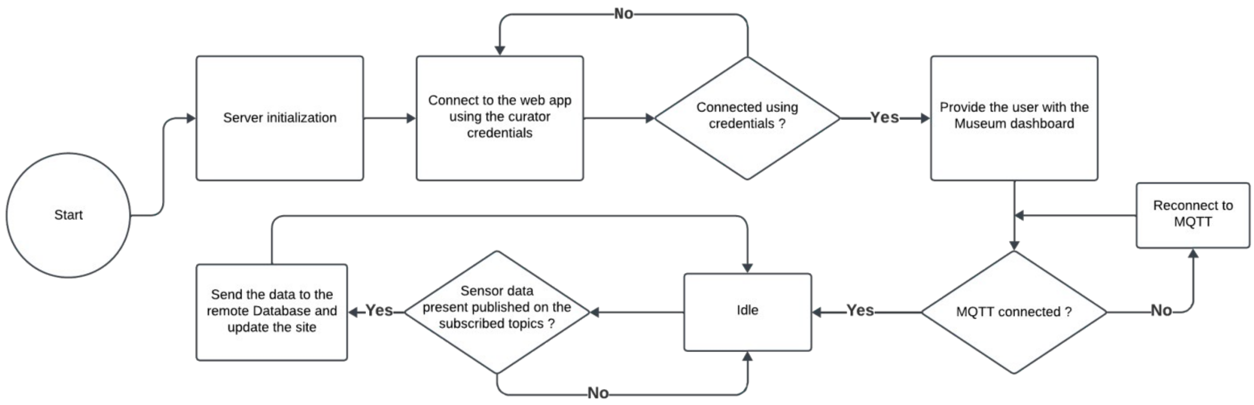
The Room Entry sensor works in the way that it once it detects movement, it sends the message with “detected”: 1 while the Exhibit piece sensor only sends the message when the distance of the nearest person is less than 250cm. For both sensors we introduce a delay of 500ms before sensors are active again. The later is done to reduce power consumption and to ensure that the results provided are coherent.

The subsystem finally goes back into idle until either sensor provides relevant room entry or exhibit piece presence data again.

For the wiring of the subsystem, it is provided as follows:

Component	Pin/Label	NodeMCU Pin	Function
ESP8266 NodeMCU	-	-	Microcontroller
LCD Display	VCC	5V	Power
	GND	GND	Ground
	SDA	D2	Data Line
	SCL	D1	Clock Line
PIR Sensor	VCC	5V	Power
	GND	GND	Ground
	OUT	D6	
HC-SR04 Ultrasonic Sensor	VCC	5V	Power
	GND	GND	Ground
	TRIG	D6	Trigger Pin
	ECHO	D5	Echo Pin

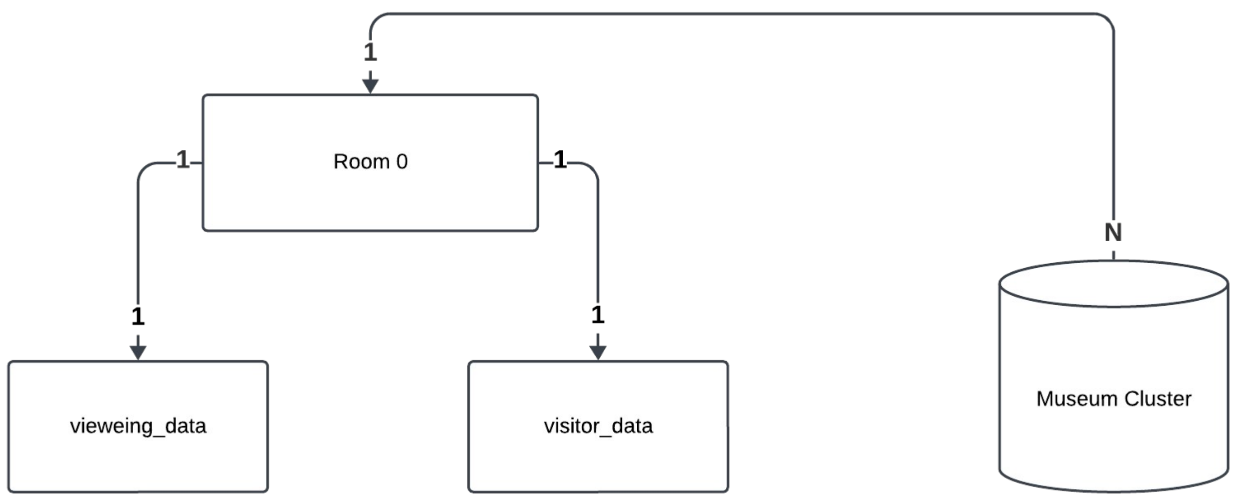
1.2. The Server



The system begins by starting up the Flask web server and then will allow the curator to login using appropriate credentials, which can be changed later on. After, the system will provide the user with the main museum dashboard which compromises the whole client side of the system.

The server then subscribes to the previously mentioned topics for the rooms and the exhibits in each room and upon a new message being published, the Flask server will proceed update the remote database the system is connected to with the data received. The connection to the remote database is managed via config file.

The project uses a mongodb nosql database, and it is organized as follows:



The data stored in the museum cluster is arranged into collections of rooms with each containing viewing data and visitor data which correspond respectivaly to data from the exihibit piece sensors and data from the room entry sensor.

1.3. The Client

The client provides the curator the ability to manage and see the collected data from the museum’s rooms in real time, and also inspect past data taken from the remote server’s database.

The client comes in the form of a Flask web application which has the following API Endpoints:

Enpoint	**Method**	**Parameters**	**Description**
/	GET	-	The main entry of the web application
/login	GET, POST	user, password	Allows the curator to login
/logout	GET	-	Allows the curator to log out
/change_password	GET, POST	old_password, new_password	Allows the curator to change their account password
/viewing_data	GET	-	Provides the viewing data taken from the remote database
/visitor_data	GET	-	Provides the visitor data taken from the remote database