The Internet of Things

BY DR. TRAN NGOC HOANG

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CHICKENS' EGGS INTELLIGENT INCUBATOR SUPERVISOR

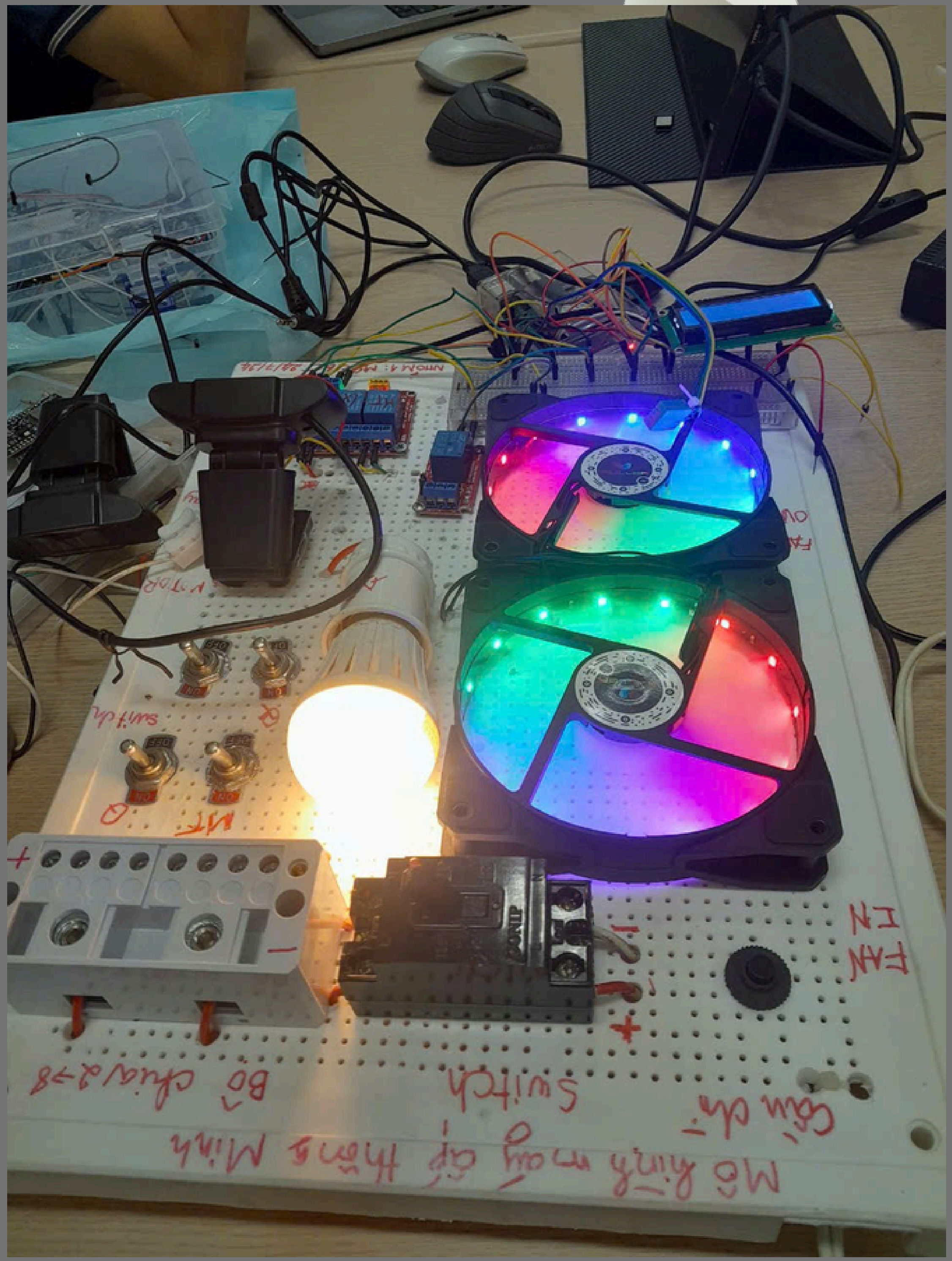
Objective:

This project aims to develop a smart, automated chicken egg incubator using IoT technology. The system will monitor and control temperature and humidity, manage egg rotation, and store data in a MySQL database for analysis.

PROBLEM STATEMENT

Challenges in Manual Incubation: Manual control of egg incubators requires constant monitoring and adjustments, leading to inefficiencies and a higher risk of failure.

Need for Automation: An automated system can ensure consistent environmental conditions, reduce human error, and increase the likelihood of successful hatching.



Content

Tasking

ID	Task	Member
	System Design and Research (Day 1-2)	
	Task 1: Literature Review - Research existing solutions, best practices, and relevant IoT technologies	All member
	Task 2: Component Identification - Identify and select suitable hardware components (sensors, relays, motors, etc.)	Thinh
	Task 3: Software Tools Selection - Decide on programming languages, frameworks, and databases (e.g., Python, Flask, MySQL)	All member
	Hardware Setup and Sensor Integration (Day 3-5)	
	Task 4: Circuit Design and Layout - Design the circuit layout and ensure all components are correctly placed	Thinh
	Task 5: Sensor Calibration and Testing - Integrate the DHT11 sensor with the Raspberry Pi and test for accuracy	Hải
	Task 6: Relay and Actuator Integration - Connect the relay module to the heating element, fan, and motor, and test functionality	Lộc

Chapter 1: Incubator introduction

Temperature:
Maintaining a consistent and optimal temperature is crucial for the development of chicks. Fluctuations in temperature can lead to developmental issues or even death of the embryos.

Humidity:
Proper humidity levels are essential for the growth and hatching of chicks. Incorrect humidity levels can result in shrink-wrapped or malpositioned chicks.

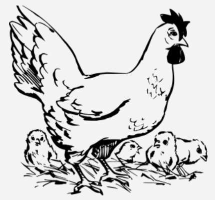
Ventilation:
Sufficient ventilation is necessary to provide fresh air and remove excess carbon dioxide from the incubator. Poor ventilation can lead to inadequate oxygen levels for the developing chicks.

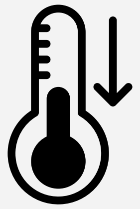
Egg Turning:
Regular and proper egg turning is important to prevent the embryos from sticking to the shell membrane. Lack of egg turning can result in deformities or developmental problems in the chicks.

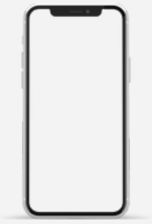
Contamination:
Contamination of the incubator with bacteria or fungi can negatively impact the hatchability of the eggs and the health of the chicks. Proper cleaning and sanitation practices are essential to prevent contamination.

Chapter 1: Incubator introduction

Method for Incubating Chicken Eggs

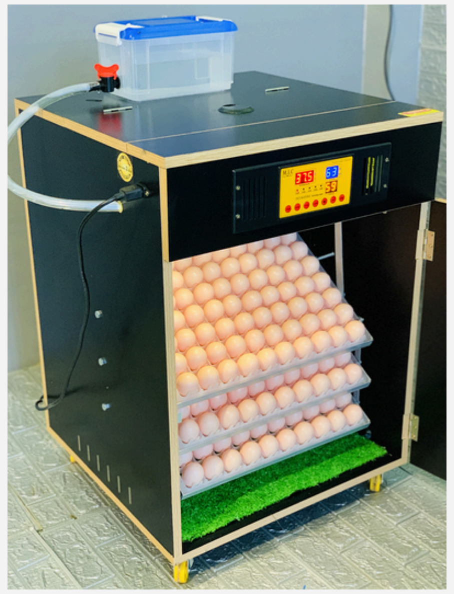






Feature	Natural Incubation by Hens	Thermostat-Controlled Incubator	IoT-Enabled Incubator
Cost	Low	Moderate to High	High
Control	Limited	High	Very High
Labor Requirements	Minimal	Moderate	Low
Scalability	Limited	High	High
Efficiency	Moderate	High	Very High
Disease Transmission	Potential	Minimal	Minimal
Monitoring	Limited	Requires regular checks	Remote monitoring and control
Automation	None	Limited	High
Data Collection	None	Limited	Extensive

Chapter 1: Incubator introduction



Method for Incubating Chicken Eggs (cont..)

Explanation:

Natural Incubation by Hens:

The most cost-effective option, but offers limited control and scalability. Hens can be unreliable incubators and may transmit diseases.

Thermostat-Controlled Incubator:

Provides precise control over incubation conditions, resulting in higher hatch rates. Requires moderate investment and labor.

IoT-Enabled Incubator:

Offers the most advanced features, including remote monitoring, automation, and data collection. However, it comes with a higher cost and technical complexity.

Conclusion: The best choice depends on individual needs and resources. For small-scale operations, natural incubation may be sufficient. For those seeking greater control and efficiency, thermostat-controlled incubators are a reliable option. IoT-enabled incubators provide the most advanced features but require a significant investment and technical expertise.

Accessories

Feature	Description
Temperature and Humidity Monitoring	Use a DHT11 sensor to continuously monitor the temperature and humidity inside the incubator.
Data Logging	Store the temperature and humidity data in a MySQL database for real-time monitoring and future analysis.
Temperature Control	Implement a relay-controlled heating element (e.g., light bulb) to maintain a stable temperature.
Cooling System	Use a fan to reduce the temperature if it exceeds a predefined threshold.
Egg Tray Rotation	Design a mechanism to periodically rotate the egg tray to ensure even heating and development.
User Interface	Develop a web-based interface for monitoring and controlling the incubator remotely.

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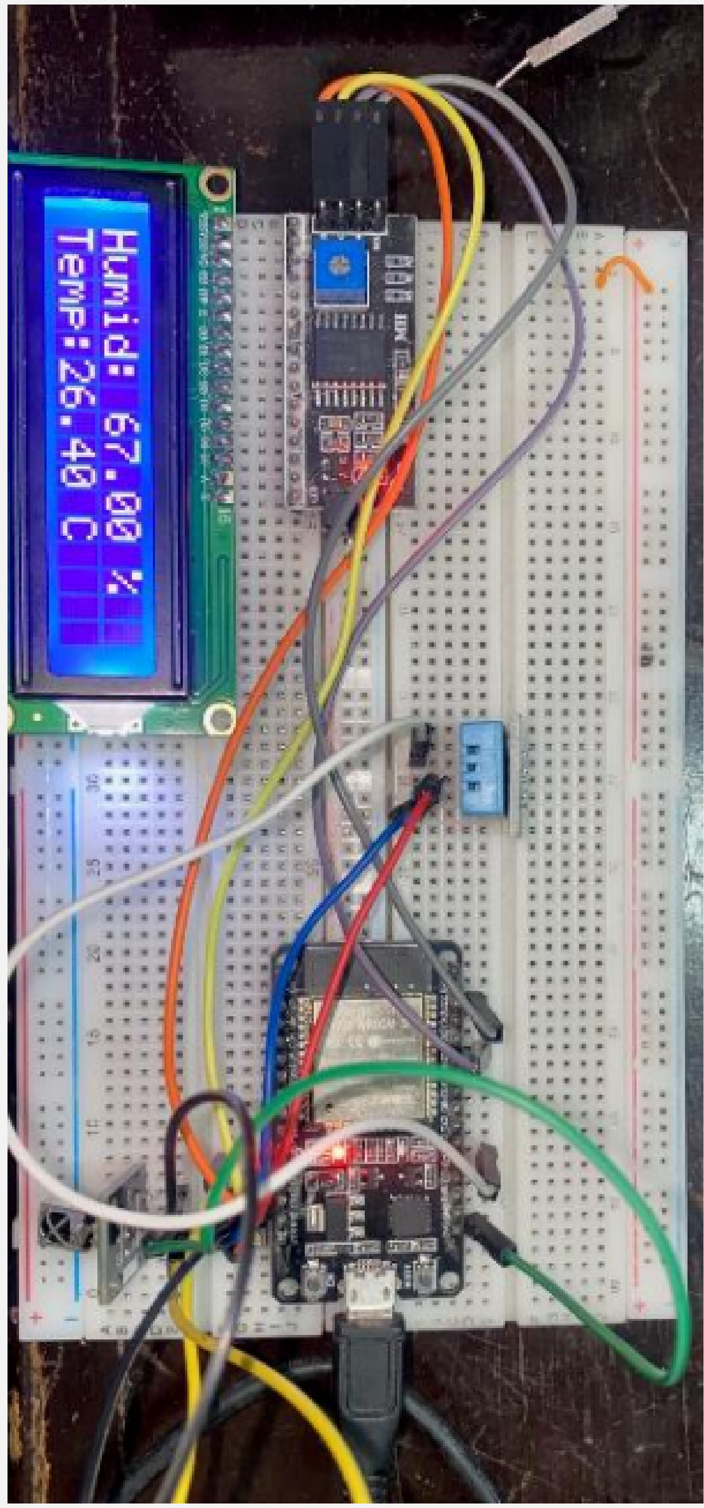
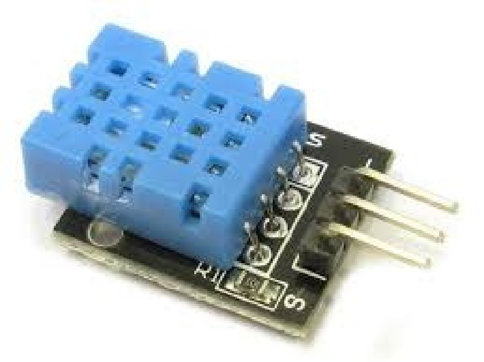


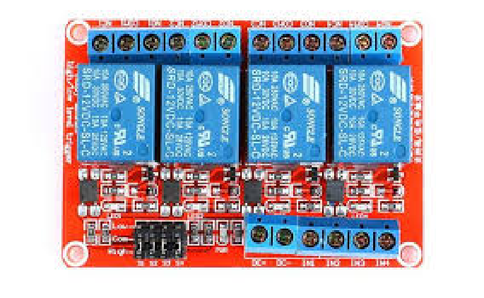
Hardware

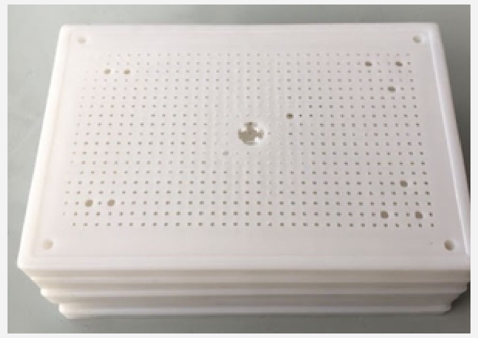
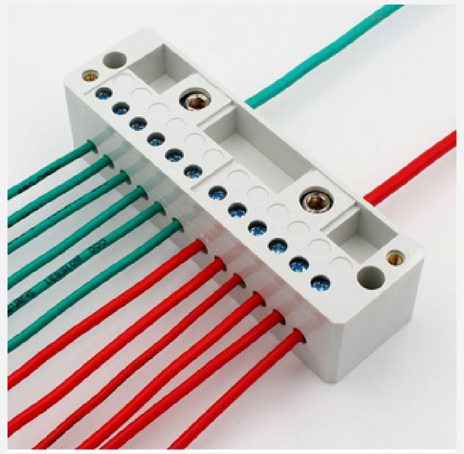
Device	Function	Action
DHT11	Temperature and humidity sensor	Turn on the heating lamp
Egg tray motor	Rotate the egg tray to ensure even temperature and humidity	Rotate the egg tray
Intake fan	Provide fresh air	Turn on the intake fan
Heating lamp	Provide necessary heat for the eggs	Turn on the heating lamp
Exhaust fan	Expel hot air outside	Turn on the exhaust fan
Egg observation camera	Monitor the condition of the eggs	Send images to the monitoring system
Light intensity display	Display the light intensity inside the incubator	Update the display
4-channel relay	Control multiple devices	Activate the corresponding relay
Manual switch	Manually control 4 devices: 1 lamp, 2 fans, 1 motor	Turn on/off the respective device



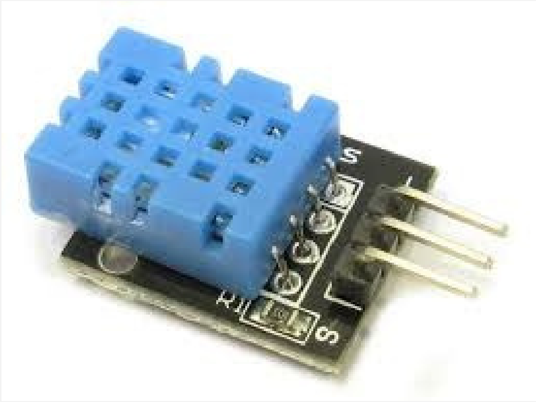







Relay 4 channel



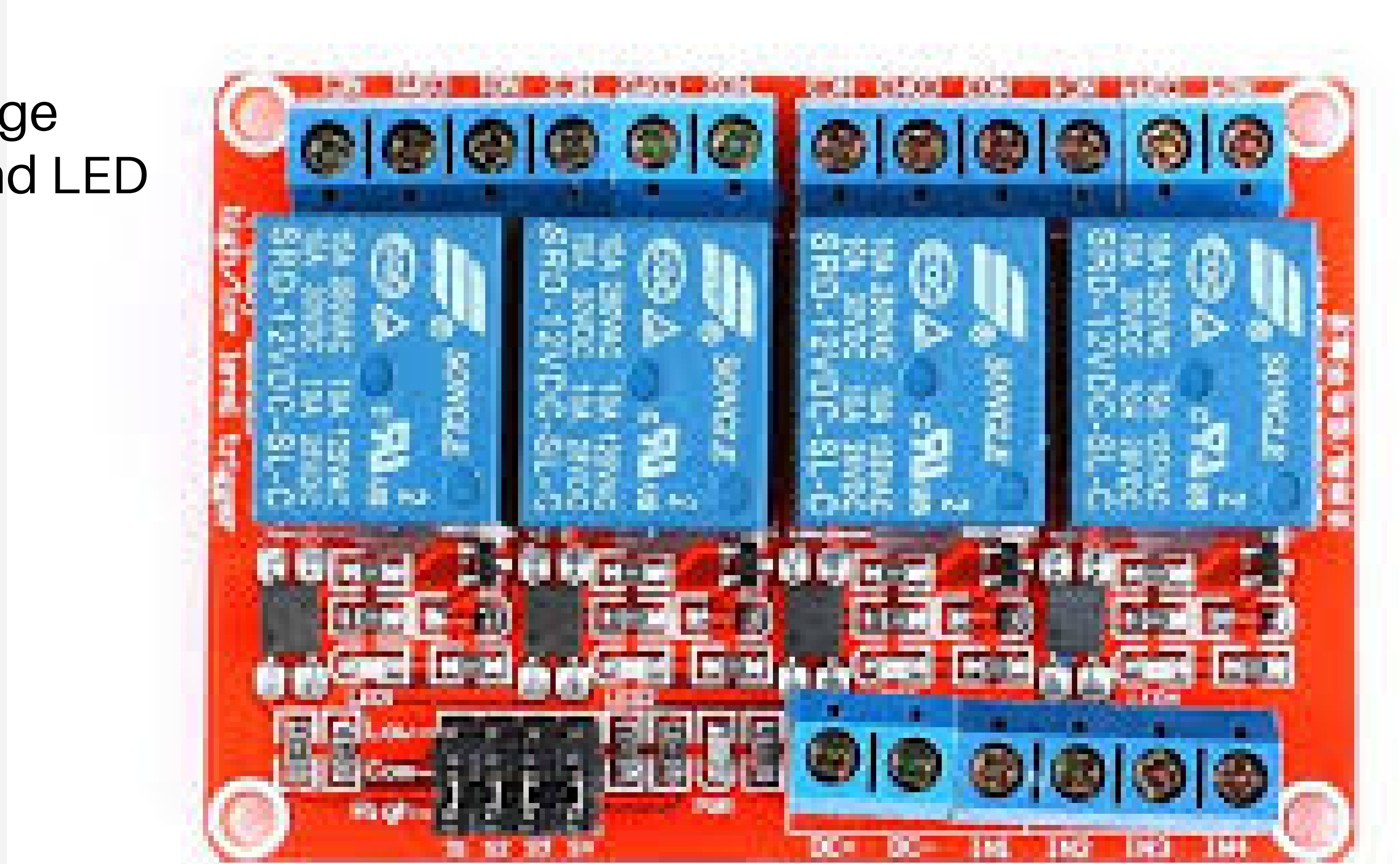
1. Introduction
Overview: Brief introduction to the DHT11 sensor, its purpose, and applications.
Key Features: Highlight the main features such as low cost, ease of use, and digital output.

2. Specifications
Power Supply: 3.3V to 5V DC
Humidity Range: 20% to 90% RH
Temperature Range: 0°C to 50°C
Accuracy: ±5% RH for humidity, ±2°C for temperature
Response Time: 1 second
Sampling Rate: 1Hz (1 reading per second)

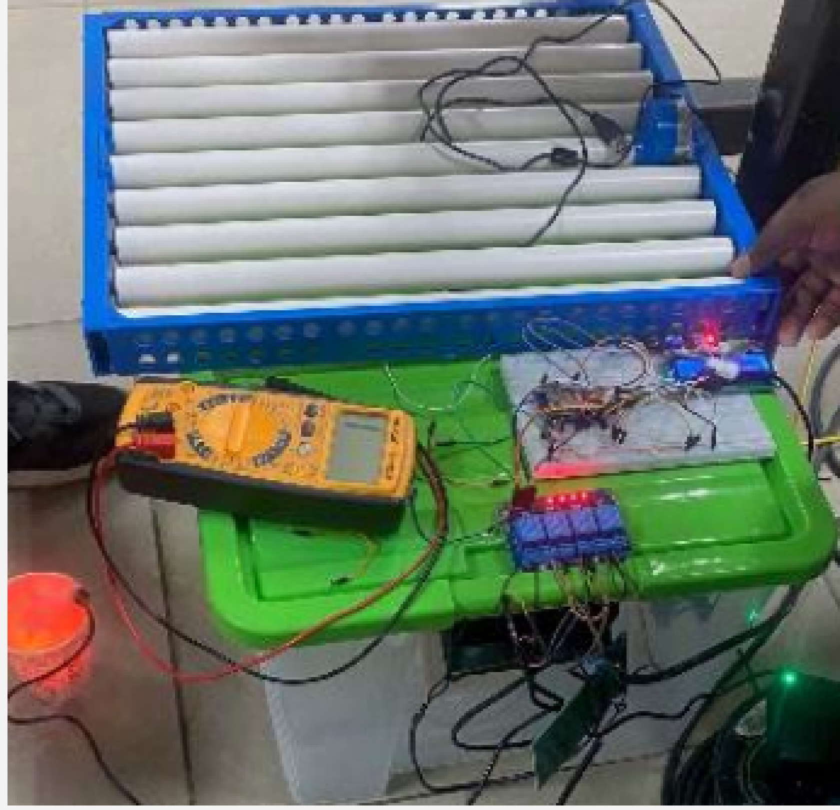
3. Pin Configuration
Pinout Diagram: Visual representation of the DHT11 pin configuration.
Pin Descriptions:
VCC: Power supply (3.3V to 5V)
DATA: Digital output pin
NC: Not connected
GND: Ground

4-Channel 5V Relay Module Presentation
Introduction
The 4-channel 5V relay module allows control of high-voltage devices using low-voltage signals from a microcontroller. It features high-current relays, optocoupler isolation, and LED indicators for each relay.
Specifications

GND: Ground reference
IN1: Input to activate relay 1
IN2: Input to activate relay 2
IN3: Input to activate relay 3
IN4: Input to activate relay 4
VCC: Power supply for the relay module
JD-VCC: Alternate power pin for the relay module



Relay 4 channel



Working Principle
The relay module operates as an electromagnetic switch activated by a low-voltage signal. Optocouplers provide electrical isolation between the control and high-power circuits, ensuring safety. LEDs indicate the status of each relay, making it easy to monitor their operation.

Wiring and Connections
To connect the relay module to a microcontroller (e.g., Arduino), use jumper wires to connect the IN pins to the digital output pins of the microcontroller. Connect the VCC and GND pins to the power supply. Ensure proper connections to avoid any issues.

Programming
Include the necessary libraries in your microcontroller's programming environment (e.g., Arduino IDE). Use sample code to control the relays, and provide a line-by-line explanation of the code to help understand its functionality.

Applications
The 4-channel 5V relay module is versatile and can be used in various applications such as home automation, industrial control, and robotics. It allows you to control high-voltage devices with low-voltage signals, providing electrical isolation for safety.

Troubleshooting
Common issues include incorrect wiring and insufficient power supply. Ensure proper connections and adequate power supply for reliable operation. Follow best practices to avoid any potential problems.

Conclusion
In summary, the 4-channel 5V relay module is a powerful tool for controlling high-voltage devices using low-voltage signals. Its features, working principle, and applications make it an essential component in many projects. Future advancements in relay technology and applications hold great potential for further enhancing its capabilities.

Raspberry Pi 3 Structure and Applications

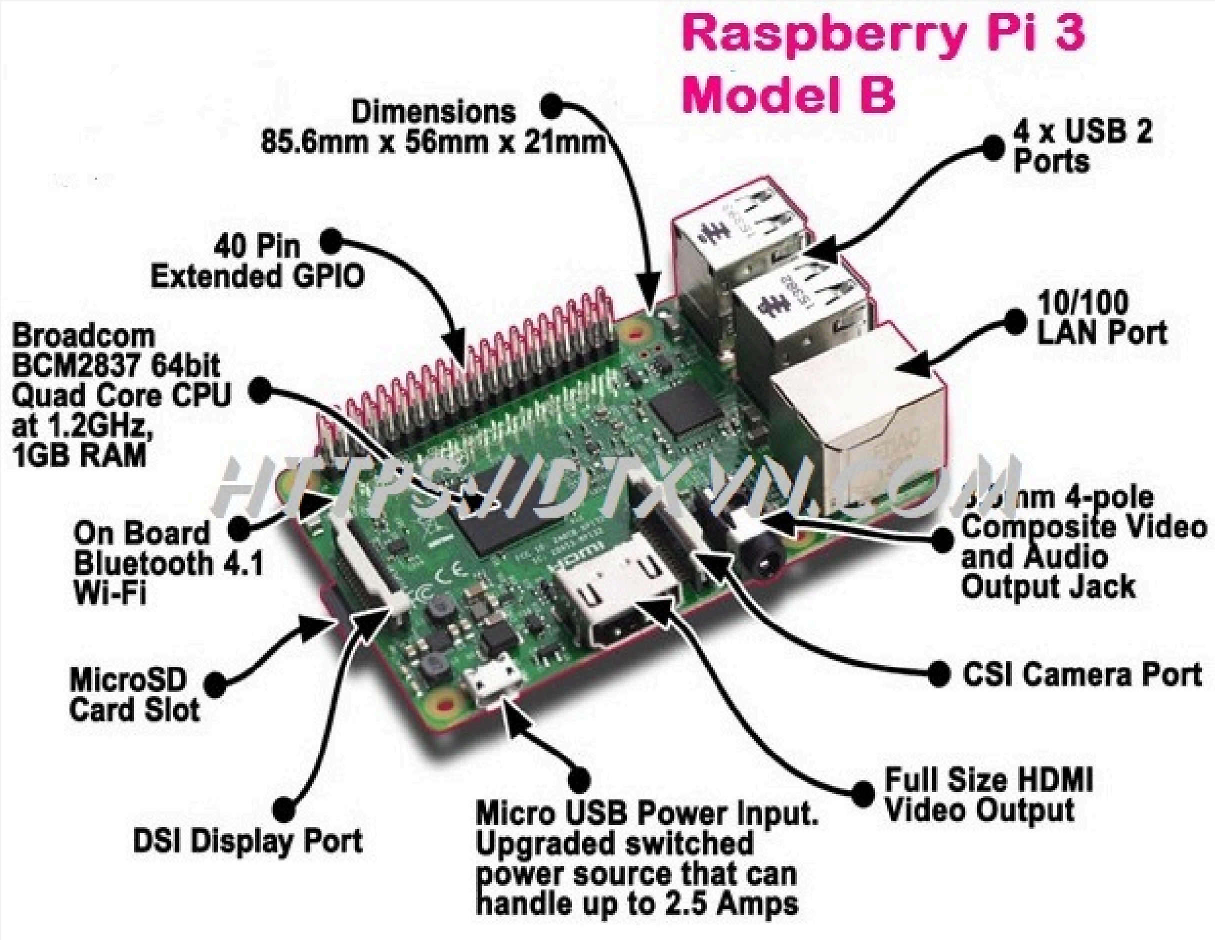
Structure

1. Processor and Memory
CPU: 1.2GHz 64-bit quad-core ARM Cortex-A53
GPU: Broadcom VideoCore IV
RAM: 1GB LPDDR2

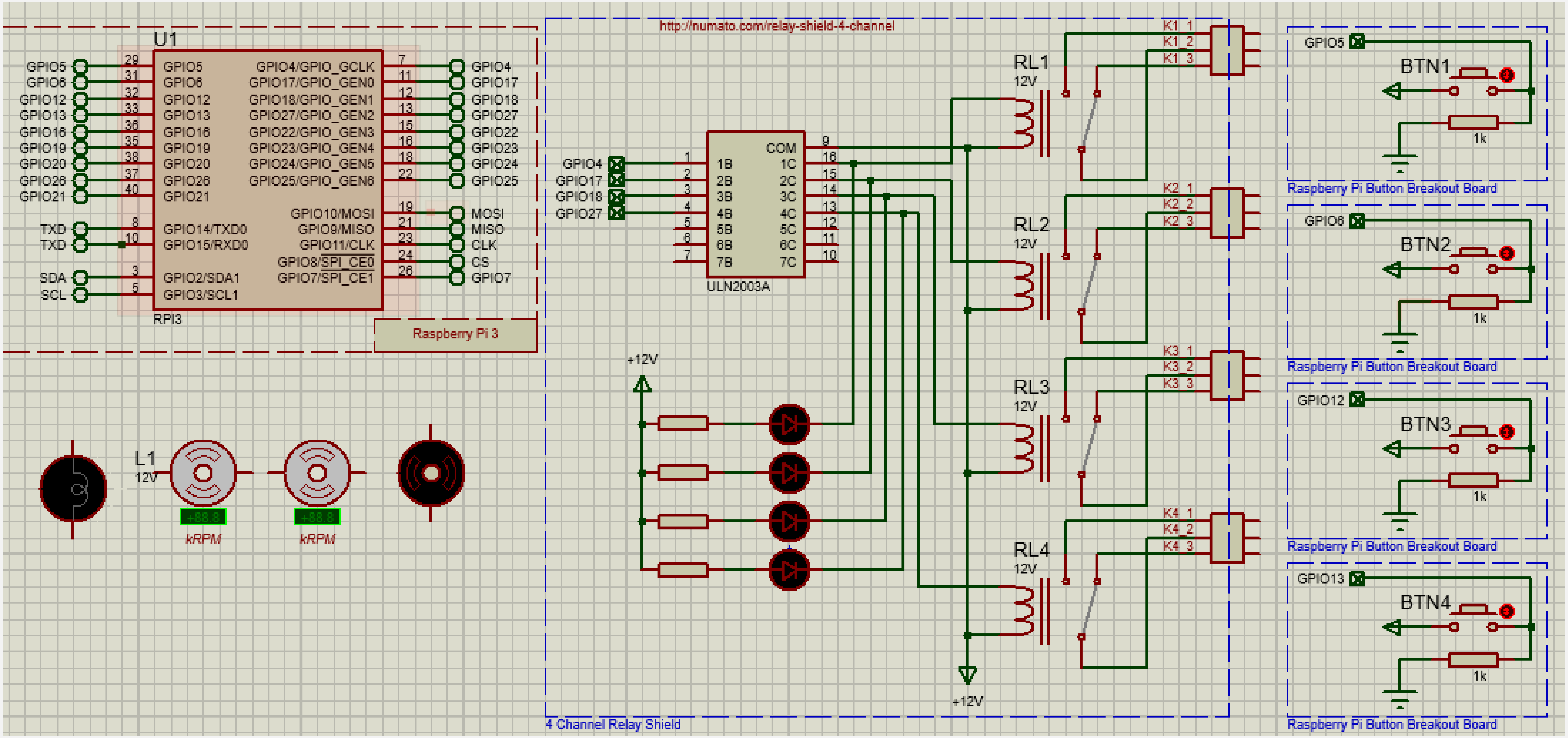
2. Connectivity
Wireless: 802.11n Wireless LAN
Bluetooth: Bluetooth 4.1, Bluetooth Low Energy (BLE)
Ethernet: 10/100 Mbps Ethernet port

3. Ports and Interfaces
USB: 4 USB 2.0 ports
HDMI: Full-size HDMI port
Audio: 3.5mm audio jack
Camera: Camera Serial Interface (CSI)
Display: Display Serial Interface (DSI)
GPIO: 40-pin GPIO header
Storage: microSD slot for loading the operating system and data storage

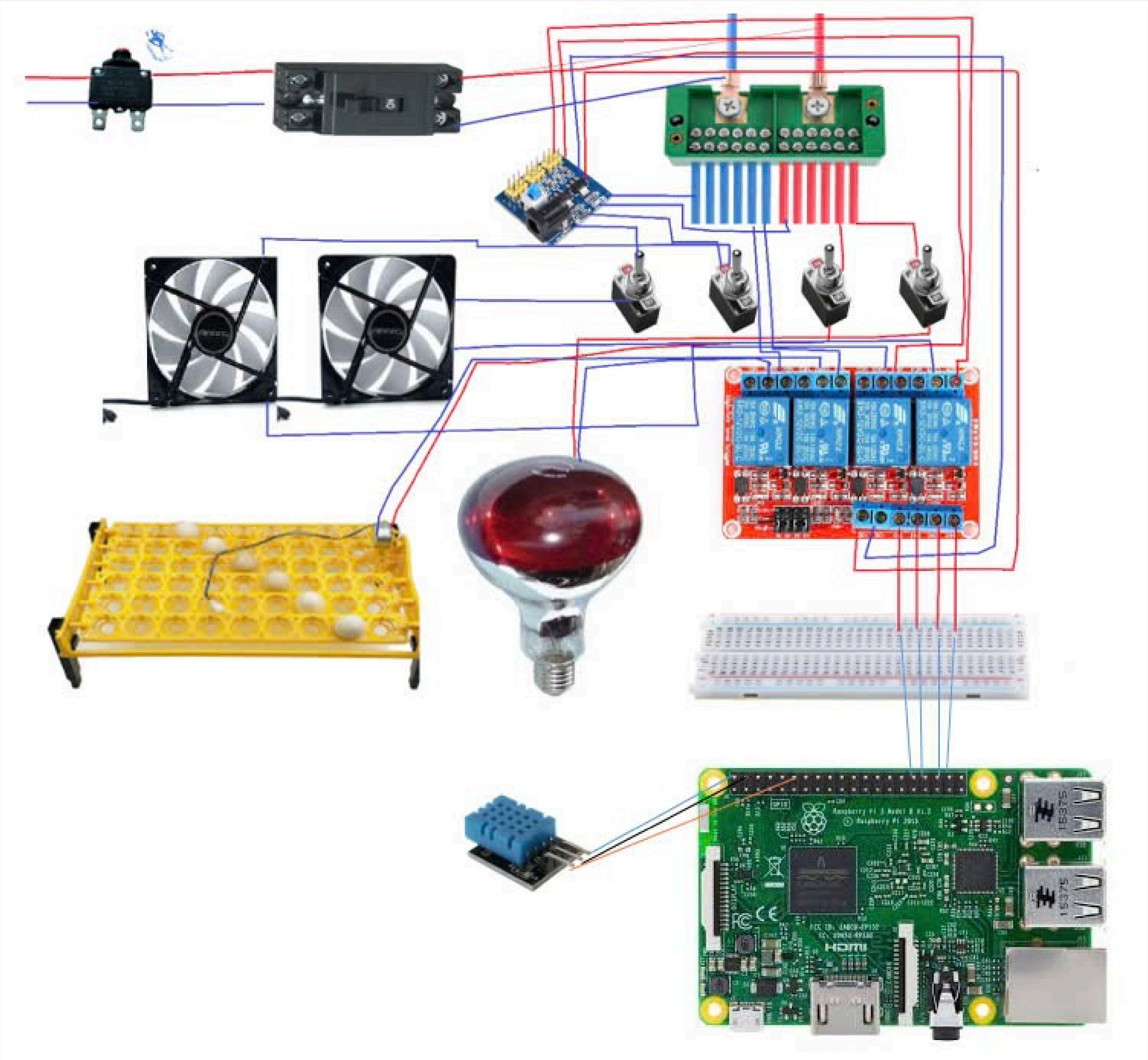
4. Power Supply
Power: 5V/2.5A DC via micro USB connector

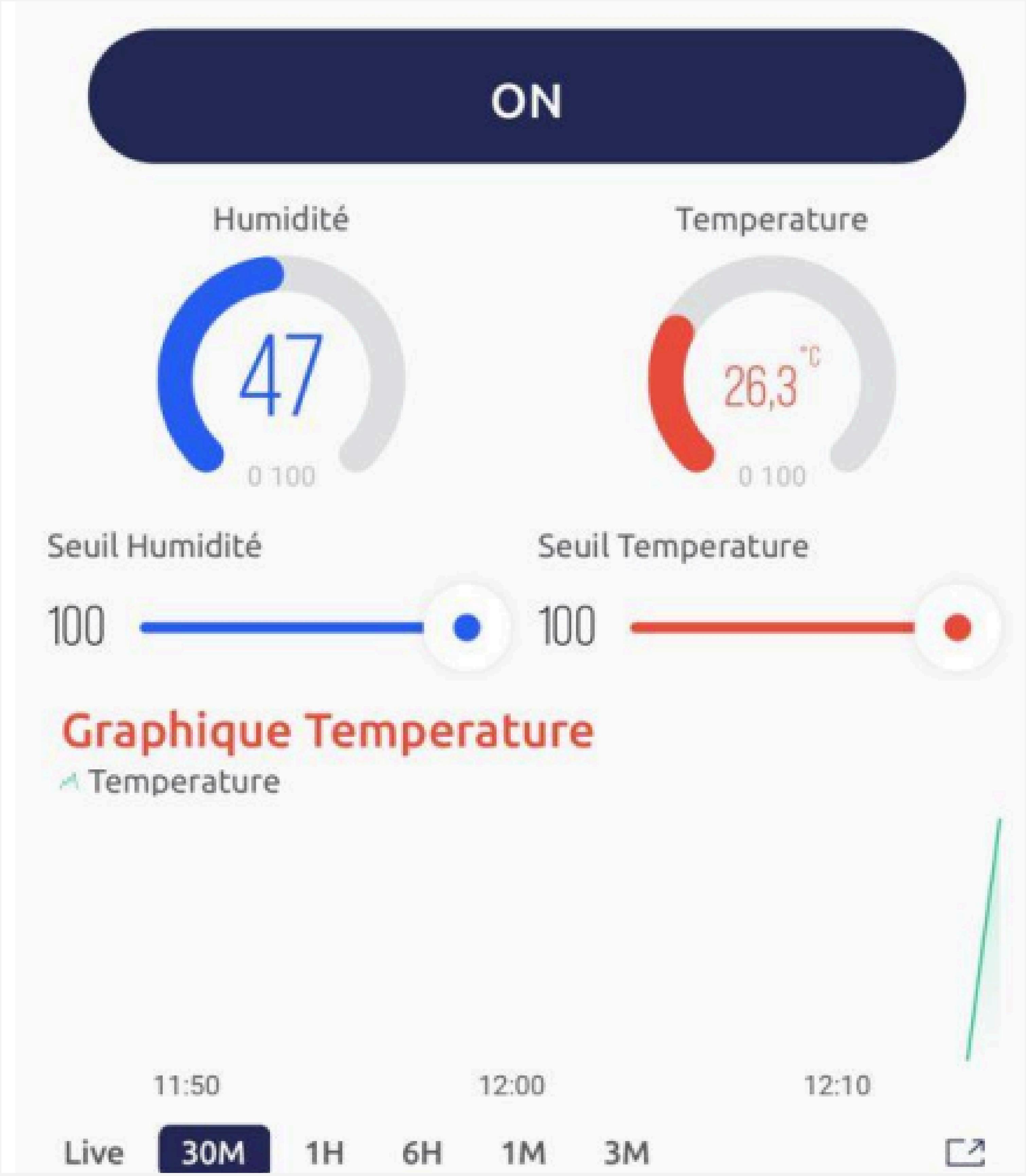


Installing and testing in vitual inviroment



Architech and structure





Chapter 2: Design

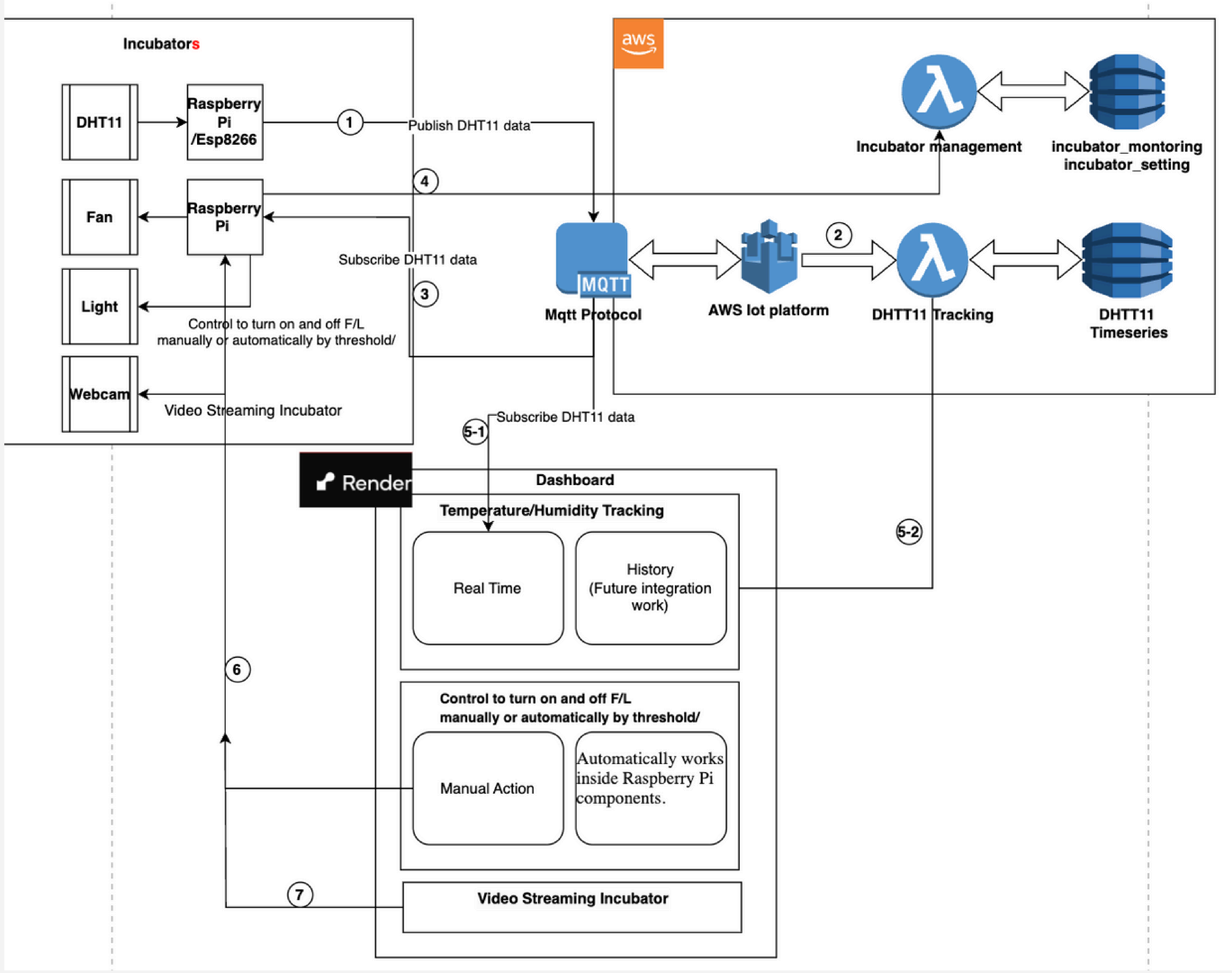
Incubator Software Designs

1. High-Level Design
2. Algorithm Design
3. Database design
4. Component services
5. UI Design
6. Frameworks used
7. Repository
8. Deployment Methodology

Incubator Software Designs

1. High-Level Design (https://shorturl.at/ePjR1)

   + Security
   + Future scalability
   + Independence
   + Decoupled



Incubator Software Designs

2. Algorithm Design:

Automatically trigger algorithm:

Days	Temperature
From 1-7 of days	37.8 C’ degree
From 8-18 of days	37.6 C’ degree
From 19-21 of days	37.2 C’ degree

Days	Humidity
From 1-5 of days	60-61% = 60.5
From 6-11 of days	55-57%=56
From 12-18 of days	50-53% =51.5
From 19 of days	60%
From 20-21 of days	70-75%

Incubator Software Designs

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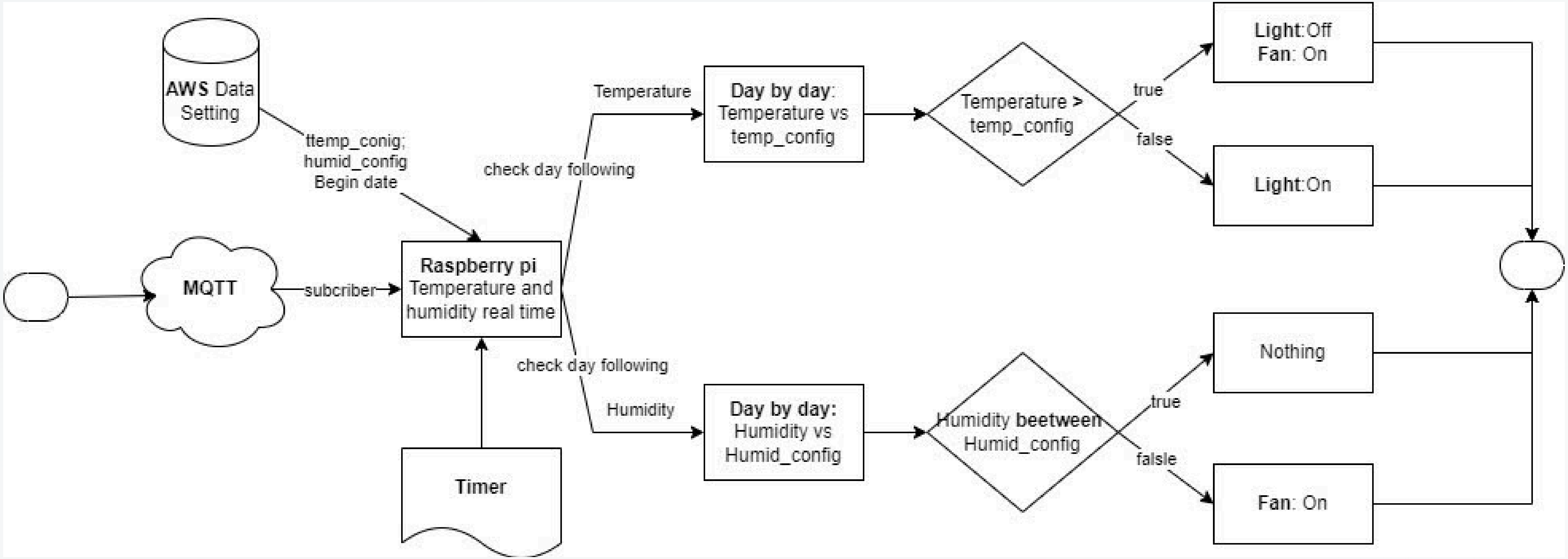

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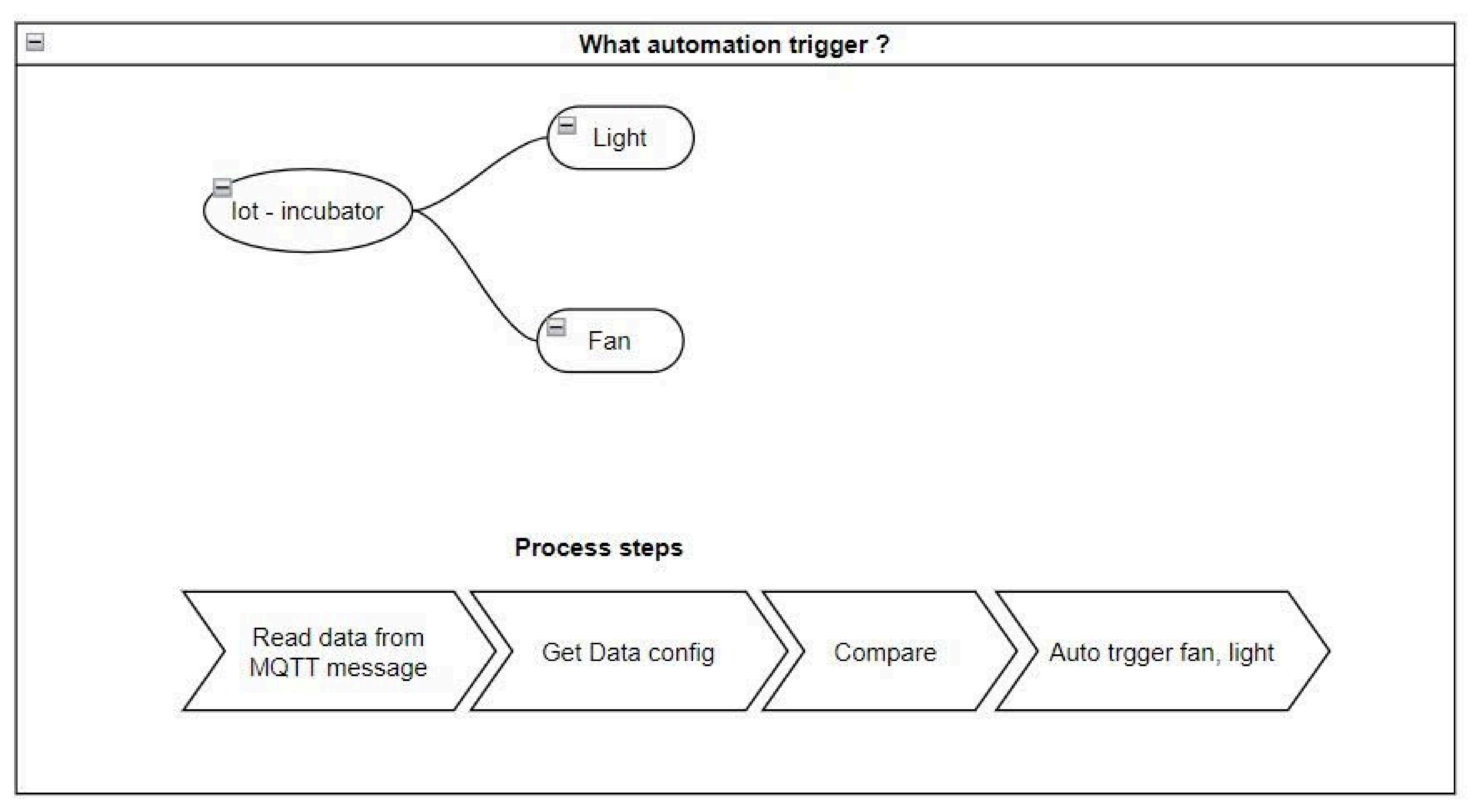


Incubator Software Designs

3. Database design
   Use AWS DynamoDB: NoSQL database

dht11_01

☐	timestamp (String)	payload
☐	1724392420.7104366	{ "Temperature" : { "N" : "37.9" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "55.3" }, "timestamp" : { "N" : "1724392420.710436
☐	1724397376.5363436	{ "Temperature" : { "N" : "37.7" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "56.7" }, "timestamp" : { "N" : "1724397376.536343
☐	1724397388.5395231	{ "Temperature" : { "N" : "37.7" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "60.5" }, "timestamp" : { "N" : "1724397388.539523
☐	1724397616.61277	{ "Temperature" : { "N" : "37.6" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "54.7" }, "timestamp" : { "N" : "1724397616.61277"
☐	1724397394.541213	{ "Temperature" : { "N" : "37.7" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "60.9" }, "timestamp" : { "N" : "1724397394.541213
☐	1724397088.4484417	{ "Temperature" : { "N" : "37.6" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "61.6" }, "timestamp" : { "N" : "1724397088.448441
☐	1724397433.5524693	{ "Temperature" : { "N" : "37.9" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "56.5" }, "timestamp" : { "N" : "1724397433.552469
☐	1724396803.360786	{ "Temperature" : { "N" : "37.7" }, "id" : { "S" : "things/pub/dht11_01" }, "Humidity" : { "N" : "53.2" }, "timestamp" : { "N" : "1724396803.360786

Incubator Software Designs

3. Database design
   Use AWS DynamoDB: NoSQL database

incubator_setting

day (String)	humid	temp	to_humid
18	50	37.6	53
16	50	37.6	53
2	60	37.2	61
13	50	37.6	53
8	55	37.6	57
9	55	37.6	57
1	60	37.8	61
6	55	37.8	57
5	60	37.8	61
4	60	37.8	61
19	60	37.2	60
7	55	37.8	57
11	55	37.6	57
3	60	37.8	61
20	70	37.2	75
21	70	37.2	75
12	50	37.6	53
17	50	37.6	53
10	55	37.6	57
15	50	37.6	53
14	50	37.6	53

Incubator Software Designs

3. Database design
   Use AWS DynamoDB: NoSQL database

	incubator_code *(String)*	start_day *(String)*
☐	incubator_02	22/08/2024
☐	incubator_01	21/08/2024

Incubator Software Designs

4. Component Software Services:

1. DHT11 Publisher: Pushes DHT11 data to AWS IoT Core via the MQTT protocol.

2. DHT11 Subscriber: Receives DHT11 data from AWS IoT Core via the MQTT protocol to handle automatic actions.

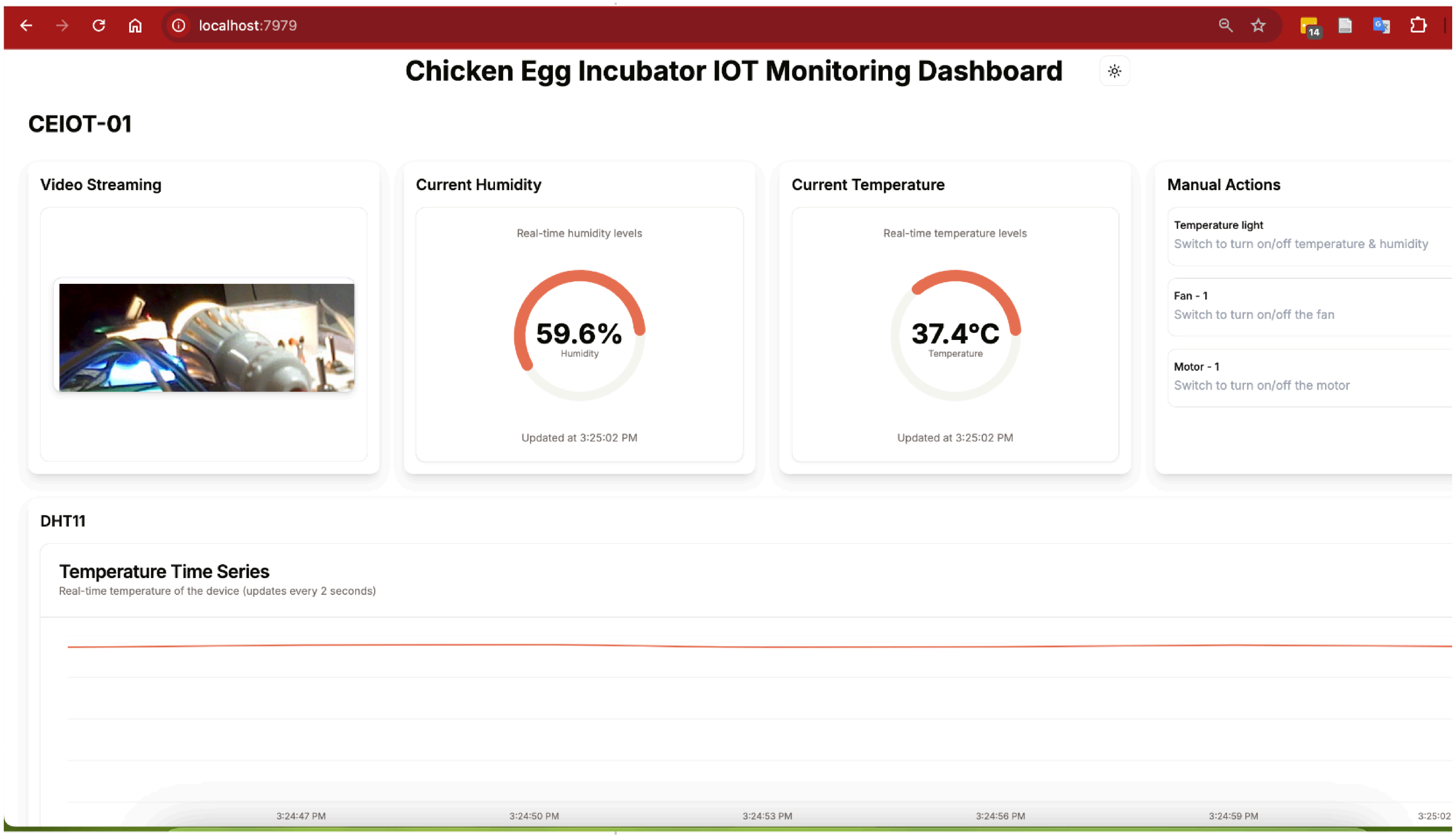
3. Flask Application: Handles manual actions such as turning on/off lights, fans, etc., and streams video.

4. LCD Temperature and Humidity Display: Displays temperature and humidity inside the incubator.

5. Dashboard: Shows the status outside the incubator, allowing monitoring and control.

Incubator Software Designs

5. UI Design:



Incubator Software Designs

6. Frameworks used

1. **Python:** Used to control GPIO pins on the Raspberry Pi 4.
2. **Flask:** Serves as the web server framework.
3. **AWS IoT Core and MQTT:** Utilized for streaming data between the Raspberry Pi and other devices.
4. **Next.js:** Used to build the dashboard interface.
5. **AWS Lambda function:** Handles backend processing on the AWS side.

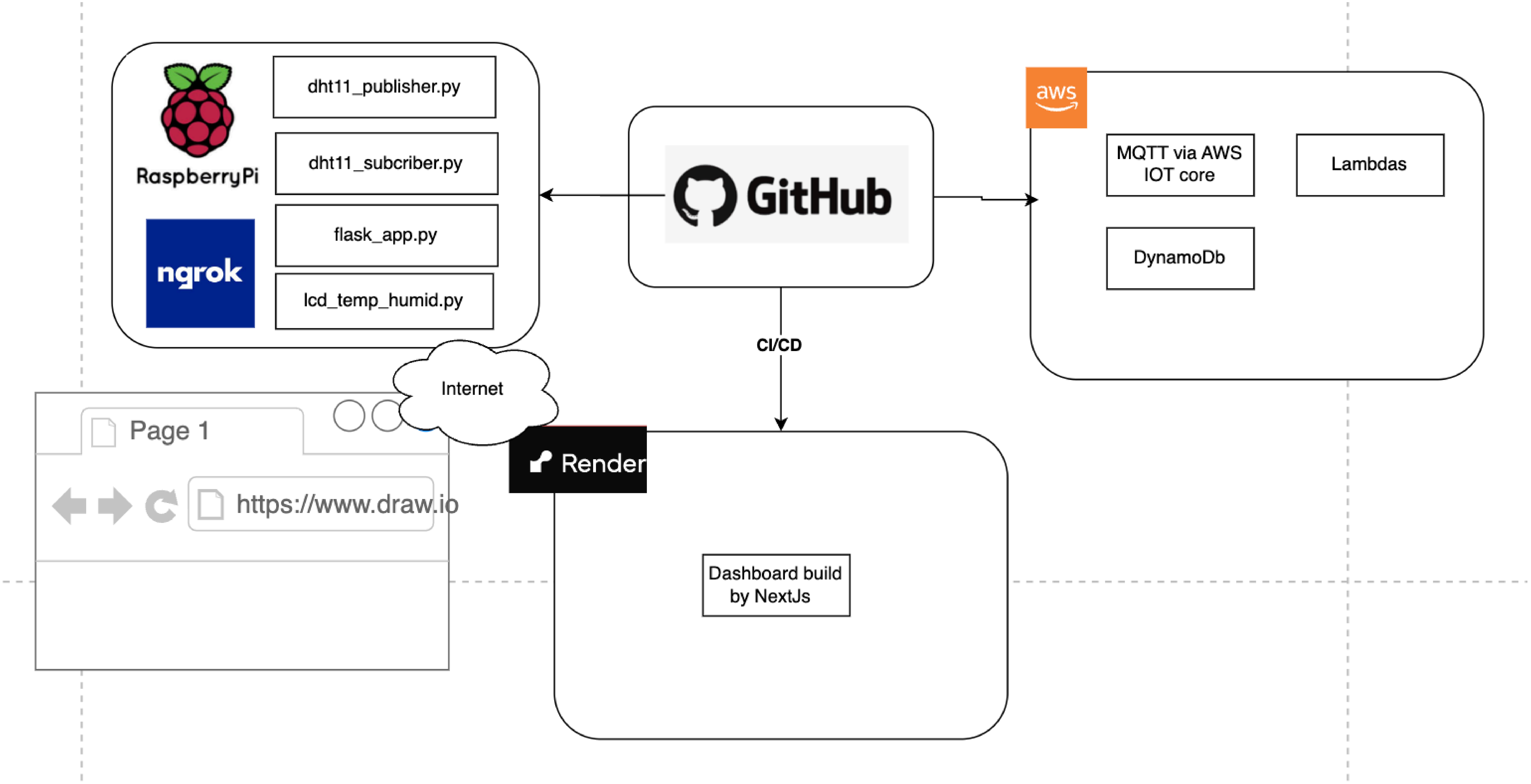
Incubator Software Designs

7. Repository:

GitHub: Used to store source code and design documents.

Incubator Software Designs

8. Deployment Methodology



Chapter 3: Experieces and Results

Integration process

Stage	Description
Day 1-3: Setting Eggs	Eggs are carefully placed in the incubator with the pointed end facing downwards. The temperature and humidity levels are adjusted to create an optimal environment for embryo development.
Day 4-18: Embryo Development	During this period, the embryos develop rapidly inside the eggs. The incubator maintains a constant temperature and humidity to support the growth of the embryos. Egg turning occurs multiple times a day to prevent the embryos from sticking to the shell membrane.
Day 19-21: Hatching	As the eggs approach the final days of incubation, the embryos position themselves for hatching. The chicks start to break through the eggshell using their egg tooth. The hatching process can take up to 24 hours, with the chicks emerging from their shells and entering the world.
Final Day: Grown Up of Chickens	After hatching, the chicks are initially weak and require time to dry off and fluff up. The chicks are transferred to a brooder for warmth, food, and water. Over the following weeks, the chicks grow rapidly, developing feathers and transitioning into young chickens ready for the next stage of their lives.

Experieces and Results

Integration process

Some disadvantages of hatching eggs using a hen

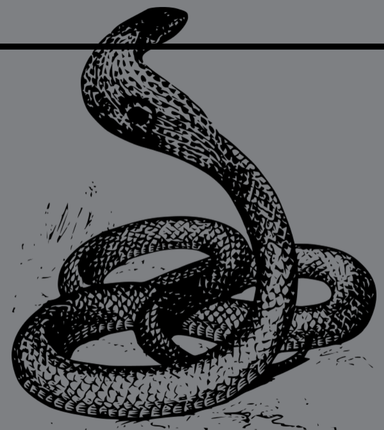
Disadvantage	Description
Limited Timing	Hens typically go broody only in spring and early summer, limiting hatching to these seasons
Unpredictability	You can't force a hen to go broody, making it hard to plan hatching schedules
Limited Capacity	A hen can only hatch a limited number of eggs at a time
Nest Abandonment	Hens may abandon their nests if they become stressed or uncomfortable
Inconsistent Conditions	Hens may not maintain consistent temperature and humidity, leading to lower hatch rates
Cleanliness Issues	Hens may poop on their nests or break their eggs
Disease Control	Incubators can help control disease better than hens, especially if you're running a vaccination program

Experieces and Results

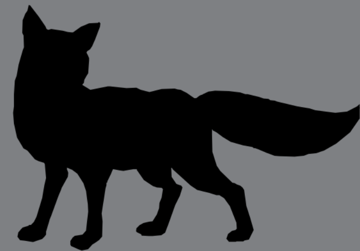
Integration process

Some animals that can affect the incubation of eggs include:

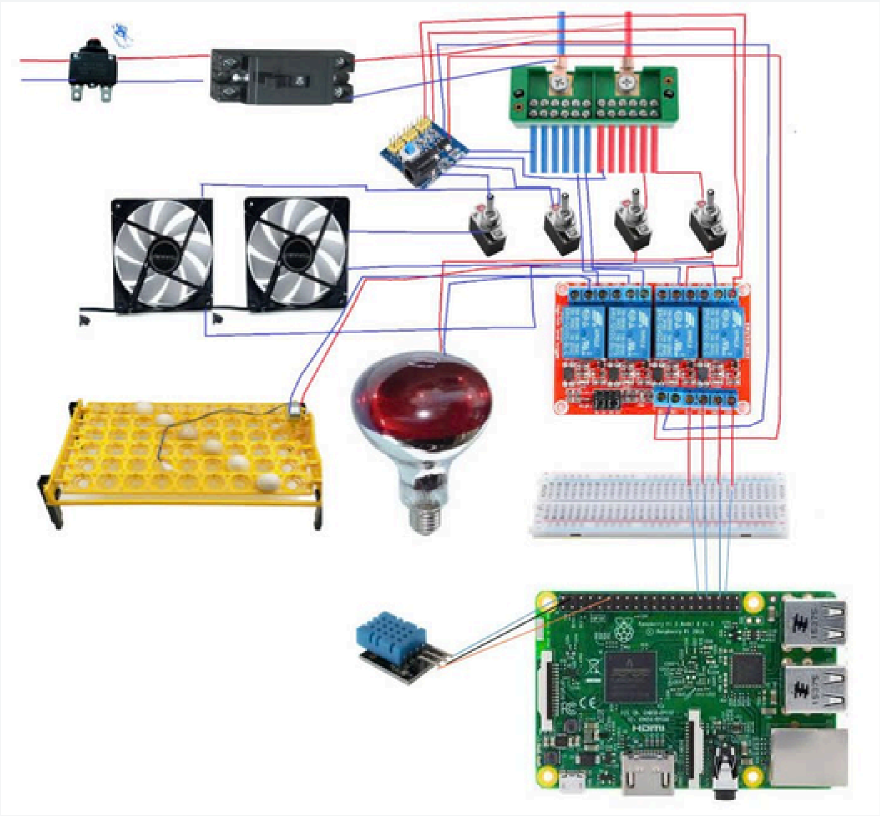
Animal	Impact on Egg Incubation
Raccoons	Known to raid nests and eat eggs, causing significant losses in egg numbers
Snakes	Often consume eggs directly from nests, impacting the success rate of incubation
Birds of Prey	Predatory birds may attack incubating birds or steal eggs from nests
Rodents	Mice and rats can invade nests, eating eggs and disturbing the incubation process
Domestic Pets	Cats and dogs may disturb nests, leading to broken or eaten eggs
Insects	Ants and beetles can invade nests, damaging eggs and affecting the incubation environment.







Experieces and Results
Integration process



- **Hardware Components:**
  1. DHT11 Sensor: For measuring temperature and humidity.
  2. Relay Module: To control the heating element (light bulb).
  3. Fan: For cooling the incubator when necessary.
  4. Motor/Servo: To rotate the egg tray.
  5. Raspberry Pi: As the central controller for processing sensor. data and controlling actuators.

- **Software Components:**
  1. DHT11 Publisher: Pushes DHT11 data to AWS IoT Core via the MQTT protocol.
  2. DHT11 Subscriber: Receives DHT11 data from AWS IoT Core via the MQTT protocol to handle automatic actions.
  3. Flask Application: Handles manual actions such as turning on/off lights, fans, etc., and streams video.
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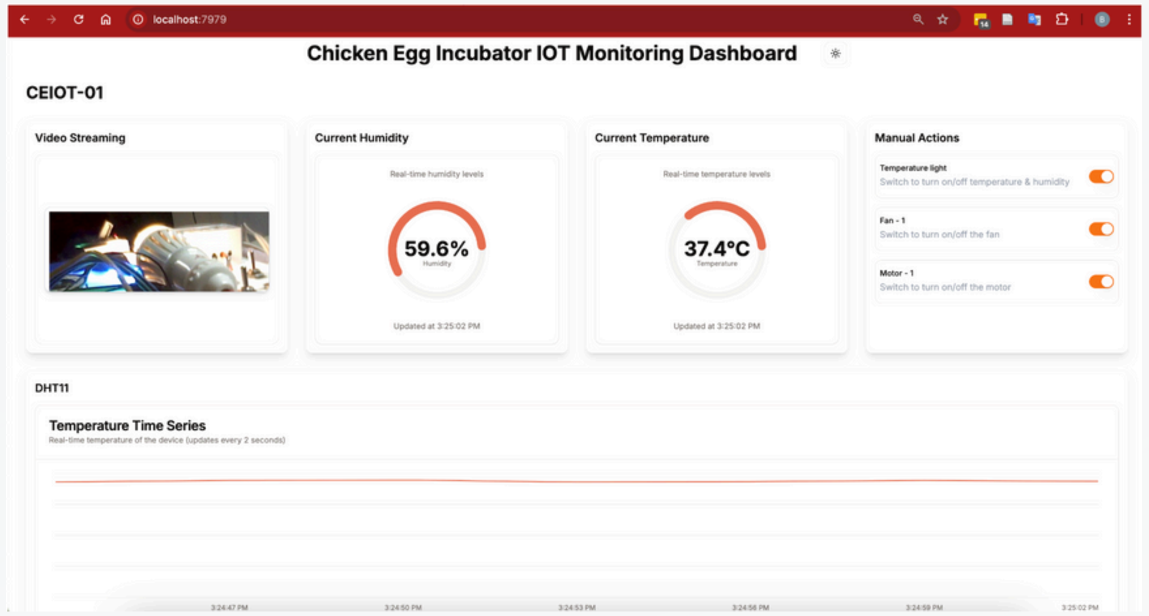
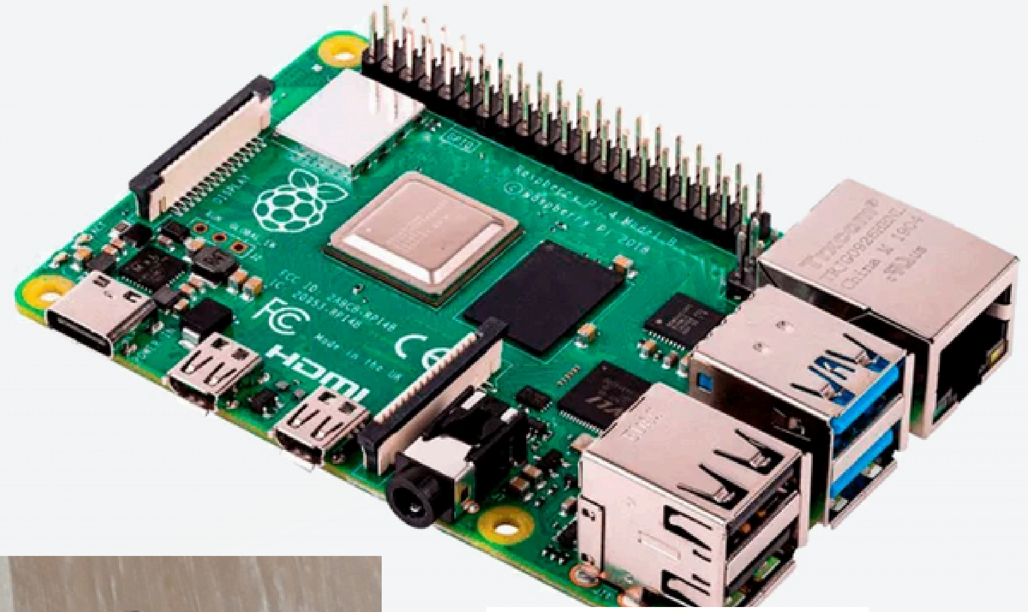
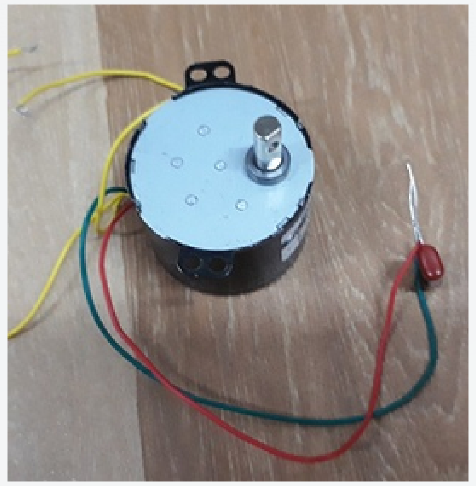
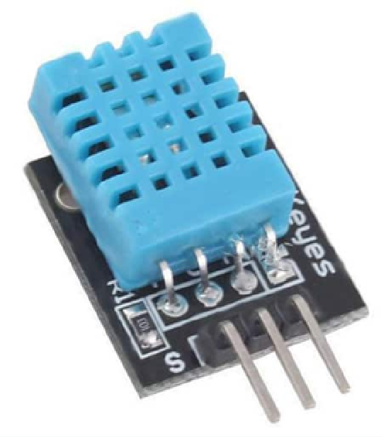


Integration process

Methodology







The development of the IoT-based egg incubator will involve the following steps:

- Hardware Setup

Micro controller:

A Raspberry Pi will act as the central processing unit for the system. It will manage data from the sensors, execute control algorithms, and interface with the actuators.

Sensors:

A DHT11 sensor will be employed for real-time monitoring of temperature and humidity inside the incubator. This sensor will provide critical data to maintain the optimal incubation environment.

Actuators:

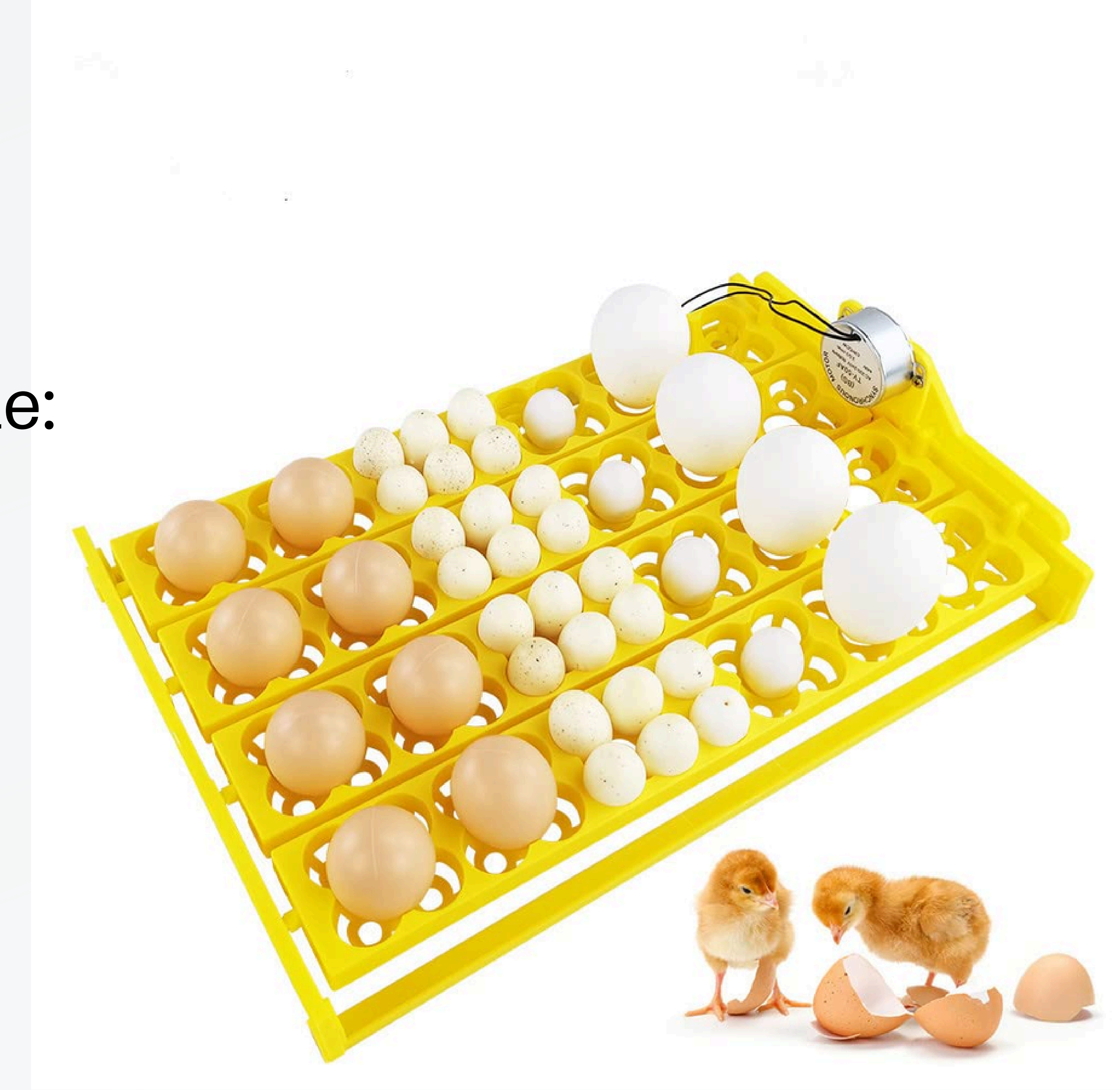
The system will include several actuators:

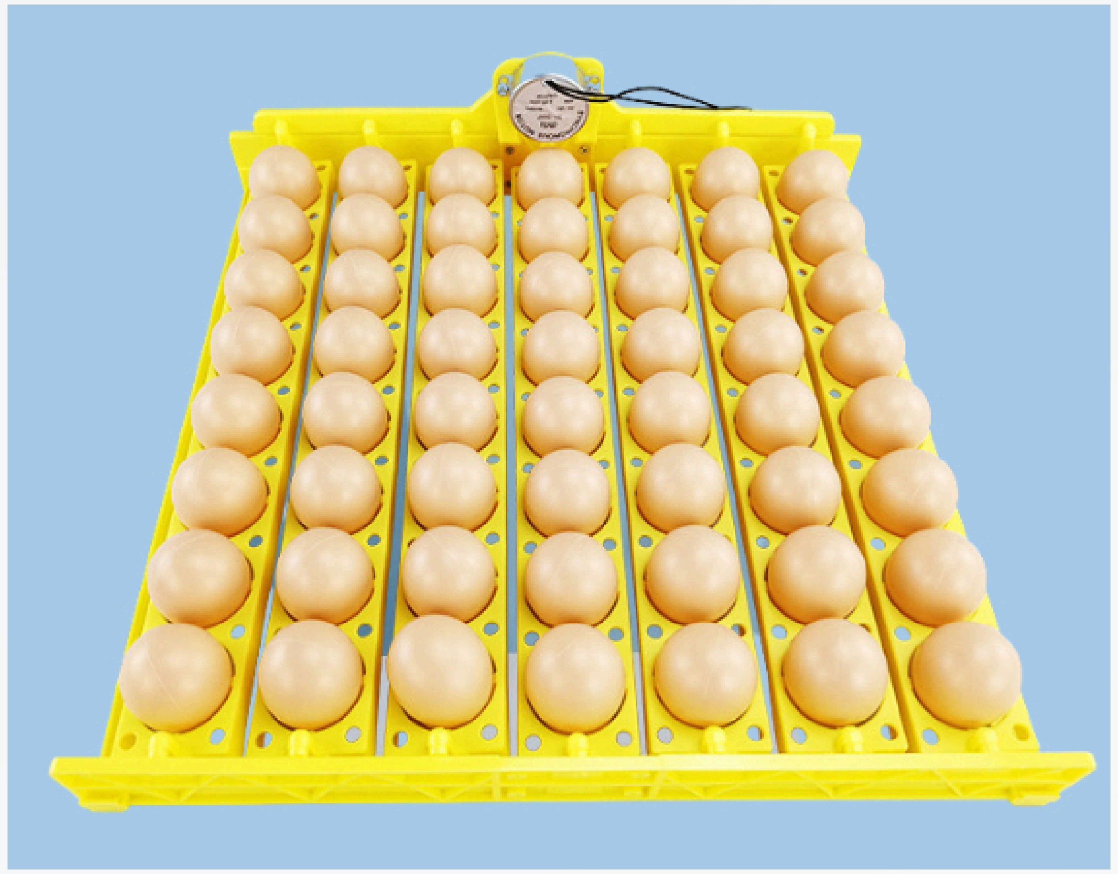
- A motor for automatic egg turning, ensuring even rotation of the eggs.
- A fan for air circulation to maintain uniform temperature and humidity.
- A light bulb for temperature regulation, providing additional heat when necessary.

Integration process

Egg Tray Rotation Schedule:

- Frequency: Every 2 hours
- Rotation: 2 minutes





Integration process

Team Development Methodology

- Pair Programming:

Team members work in pairs, with one writing the code while the other reviews it in real-time. This approach enhances code quality, facilitates knowledge sharing, and improves problem-solving efficiency.

- Regular Meetings:

The team holds regular meetings to discuss progress, share updates, and align on project goals. These meetings include daily stand-ups, sprint planning, and retrospective sessions to continuously improve processes.

- Collaborative Coding Sessions:

Team members collaborate on coding tasks, sharing ideas and solutions in real-time. This includes joint coding sessions where complex issues are tackled together, leveraging the collective expertise of the team.

- Debugging:

Debugging sessions are conducted collectively or in pairs to identify and resolve issues efficiently. The team utilizes tools and techniques to trace bugs and ensure smooth operation of the code.

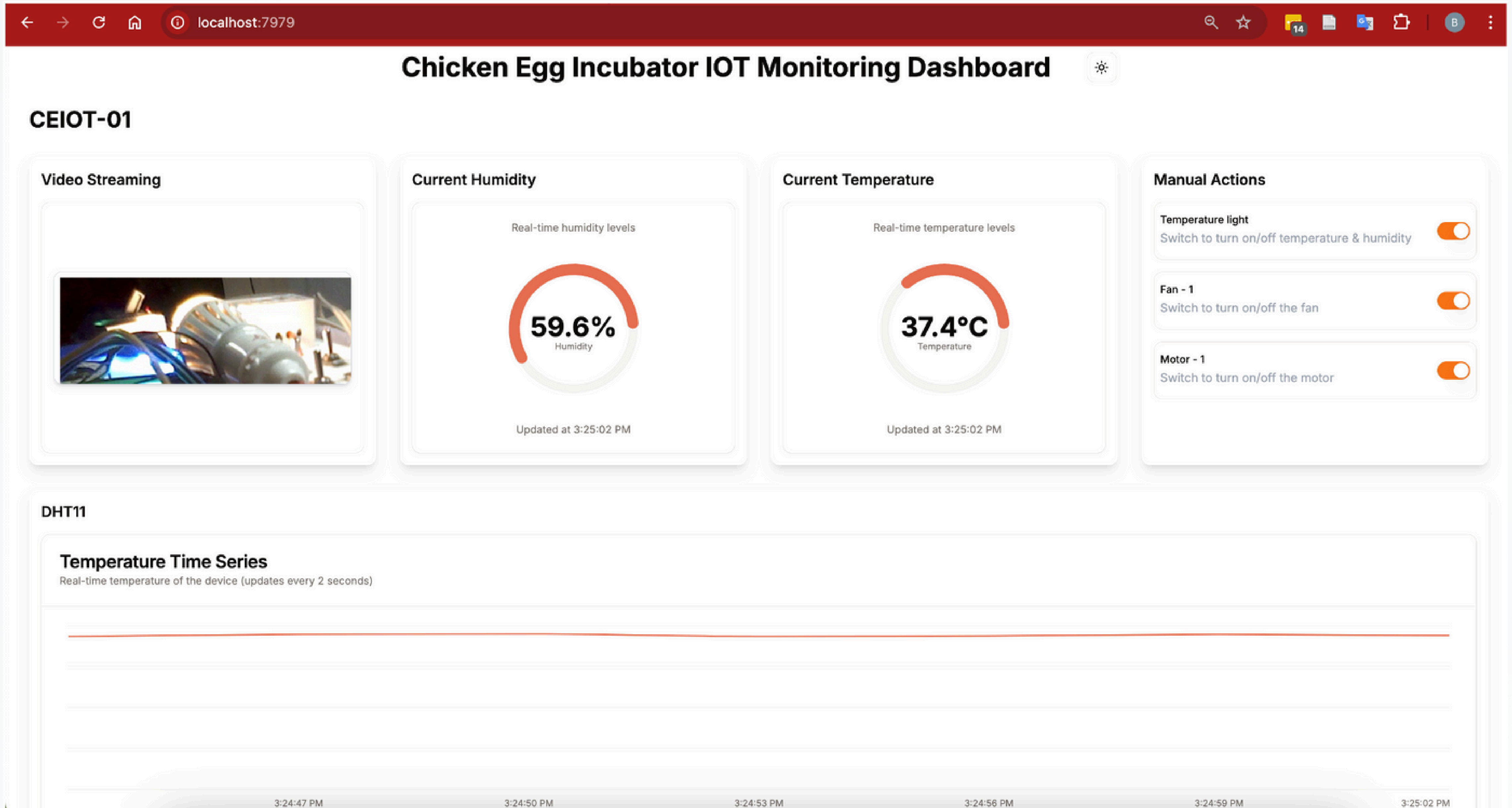
- Continuous Deployment:

The team follows a continuous deployment process, where code is regularly integrated, tested, and deployed. This approach ensures that updates are delivered quickly and reliably, with automation tools used to streamline the deployment pipeline.

Chapter 4: Conclusion

Expected Outcomes

- Automated Control: A fully automated egg incubator that maintains optimal conditions for hatching.
- Data Analysis: Historical data available for analysis to improve the incubation process.
- Remote Monitoring: Ability to monitor and control the incubator remotely through a web interface.



Day	Tasks
Day 1-2	- Research and component selection
	- Identify project requirements and objectives
	- Research suitable hardware components and sensors
	- Select and procure necessary components
Day 3-5	- Hardware setup and sensor integration
	- Assemble the hardware components
	- Integrate sensors with the hardware
	- Test individual components to ensure proper functionality
Day 6-8	- Development of control algorithms and database schema
	- Design and implement control algorithms
	- Develop the database schema to store sensor data
	- Test algorithms with simulated data

Day	Tasks
Day 9-11	- Web interface development and system integration
	- Develop the web interface for user interaction
	- Integrate the control algorithms and database with the web interface
	- Ensure seamless communication between hardware and software components
Day 12	- Testing and validation
	- Conduct comprehensive testing of the entire system
	- Validate the performance and accuracy of the system
	- Identify and fix any issues or bugs
Day 13	- Final deployment and report writing
	- Deploy the system in the target environment
	- Write a detailed report documenting the project

Results and Discussion

Lessons Learned

Challenges and Solutions: Several challenges were encountered during the project, including sensor calibration issues and network connectivity problems. Sensor calibration was addressed by implementing a more rigorous testing and adjustment process. Network connectivity was improved by optimizing the communication protocols and using more reliable hardware components.

Recommendations for Improvement:

1. Enhanced Sensor Accuracy: Future iterations of the incubator could benefit from higher precision sensors to further improve environmental control.
2. Advanced Data Analytics: Implementing advanced data analytics could provide deeper insights into the incubation process, helping to identify patterns and optimize conditions.
3. User Experience Enhancements: Improving the user interface with more intuitive controls and visualizations could enhance user experience and accessibility.
4. Scalability: Designing the system with scalability in mind would allow for easier expansion and adaptation to different types of eggs or larger incubation setups.

This section highlights the key findings and insights gained from the development and testing of the IoT egg incubator, providing a foundation for future improvements and innovations.

Improve Web Interface
Objective: Enhance usability and user-friendliness.

Actions:
Redesign the layout: Simplify navigation with a clean, intuitive design. For example, use a dashboard layout that highlights key metrics and alerts.

Optimize the display of real-time data: Implement dynamic charts and graphs that update in real-time to provide a clear overview of current conditions.

Incorporate features like detailed reports and analytics: Allow users to generate custom reports and perform in-depth analysis of historical data. For instance, users could filter data by date range or specific parameters.

Develop Mobile Application

- **Objective:** Enable remote monitoring and control.
- **Actions:**
  - **Create a mobile app for smartphones:** Design an app compatible with both iOS and Android platforms.
  - **Provide real-time notifications:** Send alerts for critical events, such as temperature fluctuations or system malfunctions.
  - **Offer access to historical data:** Allow users to view and analyze past data directly from their mobile devices.
  - **Allow users to adjust settings on the go:** Enable remote control of incubation parameters, such as temperature and humidity, through the app.

Integrating New Technologies

Machine Learning and AI

Objective: Optimize incubation parameters.

Actions:
Implement machine learning techniques: Use algorithms to analyze data patterns and make recommendations for optimal settings.

Develop predictive models to forecast hatch rates: Create models that predict hatch success based on historical data and current conditions.

Analyze historical data and environmental conditions: Continuously refine models by incorporating new data and adjusting for changing conditions.

Exploring New Technologies

- **Objective:** Enhance monitoring and analysis.
- **Actions:**
  - **Investigate the use of LiDAR technology:** Use LiDAR sensors to map the spatial distribution of temperature and humidity within the incubator.
  - **Collect detailed data on temperature and humidity distribution:** Use this data to identify and address any inconsistencies in the incubation environment.

Expanding Applications

Application in Poultry Farming

- **Objective**: Adapt the system for broader use.

- **Actions**:
    - Modify the system for different poultry species: Adjust settings and parameters to suit the specific needs of various poultry species, such as ducks or quails.
    - Integrate with existing poultry management systems: Ensure compatibility with popular farm management software to streamline operations.

Partnership with Farms

- Objective: Test and refine the system in real-world conditions.
- Actions:
  - **Establish partnerships with farms**: Collaborate with local farms to pilot the system and gather practical insights.
  - **Gather feedback from farmers**: Use surveys and interviews to collect feedback on system performance and usability.
  - **Improve system performance and usability**: Implement changes based on farmer feedback to enhance the system’s effectiveness and ease of use.

This final project showcases the practical application of IoT in automating the egg incubation process, significantly enhancing hatching rates and reducing the need for manual intervention. By integrating various sensors such as the DHT11 for temperature and humidity monitoring, a fan, relay, motor rotation, and a lamp, the system ensures optimal environmental conditions for egg incubation.

The use of a web interface and a mobile application allows for real-time monitoring and control, providing users with the flexibility to manage the incubation process remotely. Additionally, the incorporation of a database facilitates the collection and analysis of valuable data, enabling further optimization of incubation parameters through machine learning and AI techniques.

Overall, this project not only improves the efficiency and effectiveness of the incubation process but also demonstrates the transformative potential of IoT technologies in agricultural applications.

Chapter 5: Conclusion

We have designed an intelligent incubator using electronic components from the IoT. We proposed an architecture of the incubator which made it possible to set up a functional prototype. The system that has been put in place makes it possible to automatically and autonomously control the temperature, humidity of the incubator as well as the rotation of the eggs using the automatic cell. All this promotes increased egg hatching compared to a manual incubator. In future work, we will integrate a solar system to power the incubator, which will reduce the cost of energy use and allow the incubator to still be operational in the event of a power outage.

DEMO

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