AN INTELLIGENT ELECTRICITY MANAGEMENT UNIT

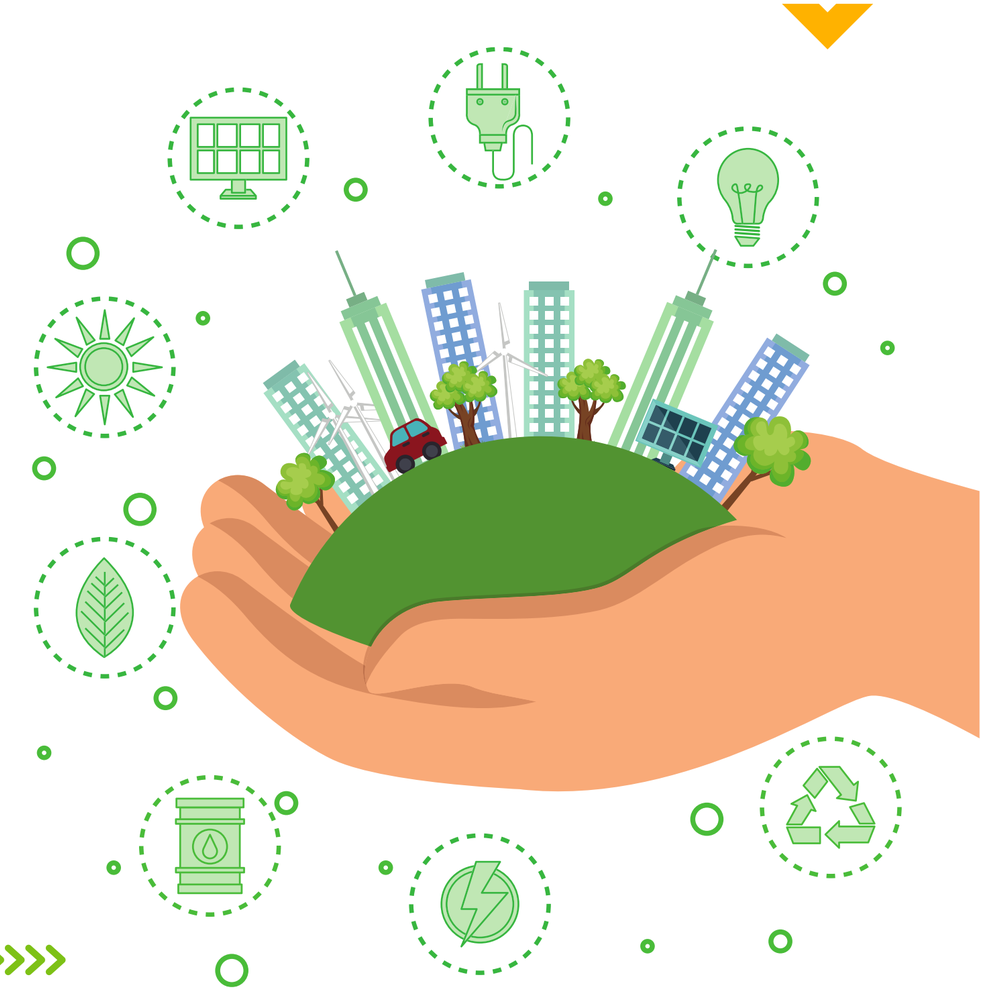
AI-DRIVEN POWER FORECASTING AND PERSONALIZED
Consumption Insights With Application Integration

INTRODUCTION

No. of consumer based on sectors

	Sector	No. of consumer
1	Domestic	6,509,953
2	Religious places	46,207
3	Industries	72,892
4	General Purposes	948,370
5	Hotels	657
6	Government Institutions	9,727
7	Agricultura Purposes	3,296
8	Street Lighting	5,792
	Total	7,596,894

Source *- Annual reports 2023 of CEB, LECO*



RESEARCH PROBLEM

How to cater for the following problems:

- Rising electricity costs make efficient consumption management essential.
- Current systems provide only total energy use, lacking device-level insights.
- Rental properties lack tools to manage electricity supply based on tenant payments
- Renewable energy integration process is complex and expensive.

AN INTELLIGENT ELECTRICITY MANAGEMENT UNIT

PLUG & PLAY IoT DEVICE

USAGE PREDICTOR

SMART AI GUIDE

ENERGY TRACKING APP

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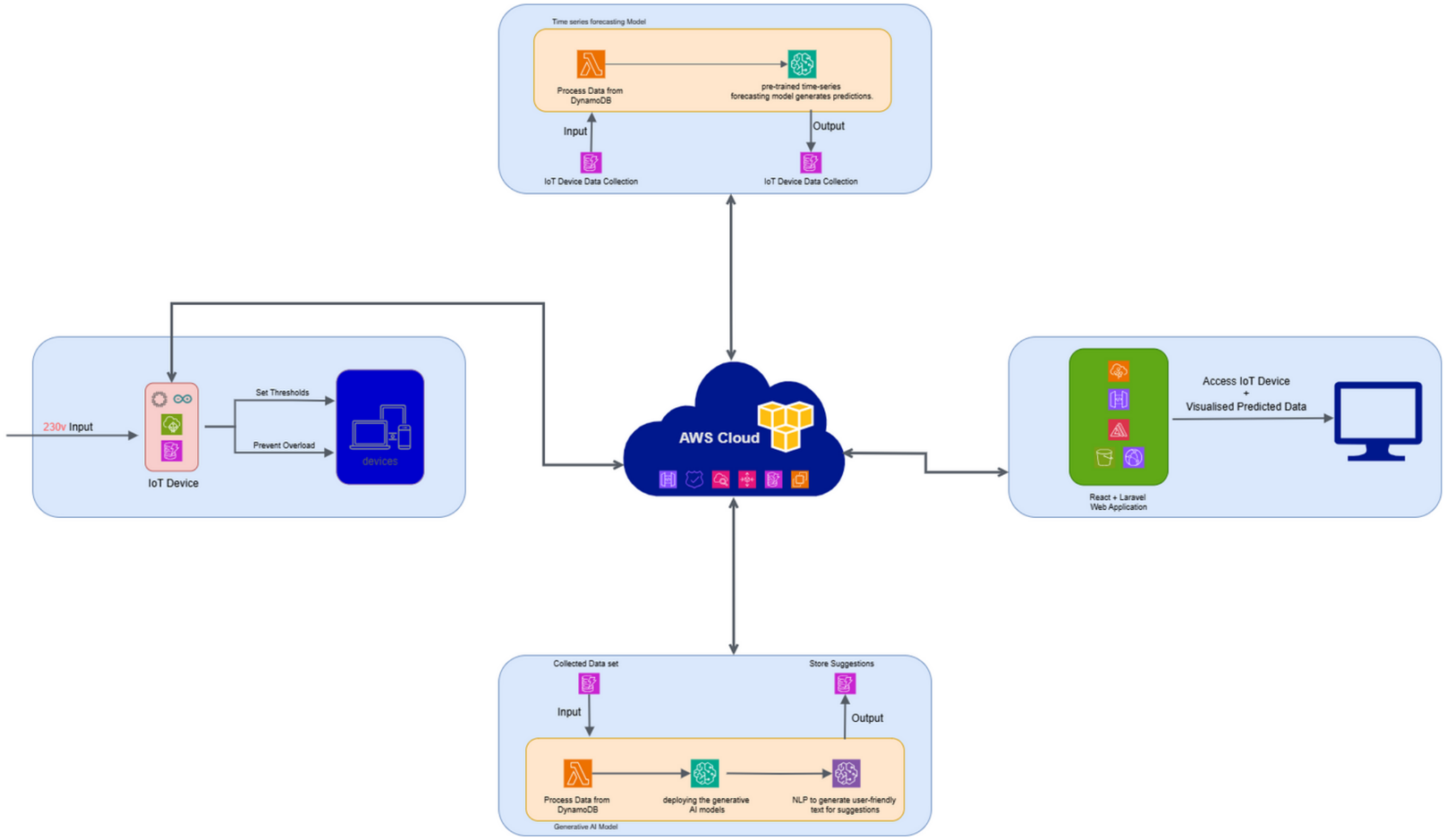
SIMILAR SYSTEMS

	Proposed system	tp-link RELIABLY SMART	Shelly
Real-time device-level energy monitoring	✓	✓	✓
Monthly usage threshold enforcement	✓	✗	✗
Emergency override feature	✓	✗	✗
Integration with cloud platforms	✓	✗	✓

SYSTEM DIAGRAM

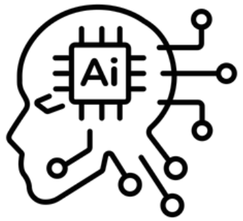


OBJECTIVES

Develop an Intelligent Energy Management Unit integrating IoT, ML, AI via a user-friendly web application that would help to optimize household energy consumption

To manage individual device energy use with set limits.

To predict future energy consumption patterns and identify faults in devices



To generate personalized recommendations for energy savings

To visualize energy data and insights through an intuitive, user-friendly interface.

POWERSENSE IOT CONTROLLER

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INTRODUCTION

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RESEARCH PROBLEM

What solutions can improve integration between IoT devices and cloud platforms for seamless data management and actionable insights?

OBJECTIVES

- To design and build an IoT device that monitors electricity usage in real time for individual devices.
- To implement functionality for setting and enforcing monthly usage thresholds for each device.
- To enable automated power cut-off when thresholds are exceeded, ensuring energy efficiency.
- To integrate a secure emergency override feature for user flexibility during critical situations.
- To connect the IoT device to cloud platforms for seamless data synchronization and insights.

RESEARCH GAP

Feature	Proposed System	Research [1]	Research [2]	Research [3]
Device-level energy management	✓	✗	✗	✗
Real-time electricity usage monitoring	✓	✓	✓	✓
Monthly energy threshold for individual devices	✓	✗	✗	✗
Emergency override for threshold limits	✓	✗	✗	✗

METHODOLOGY

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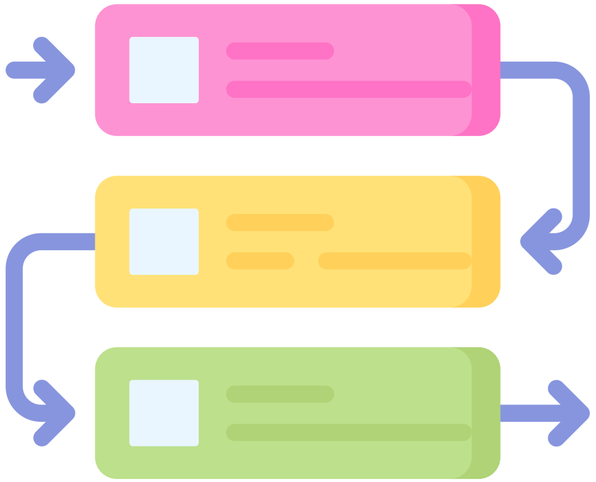
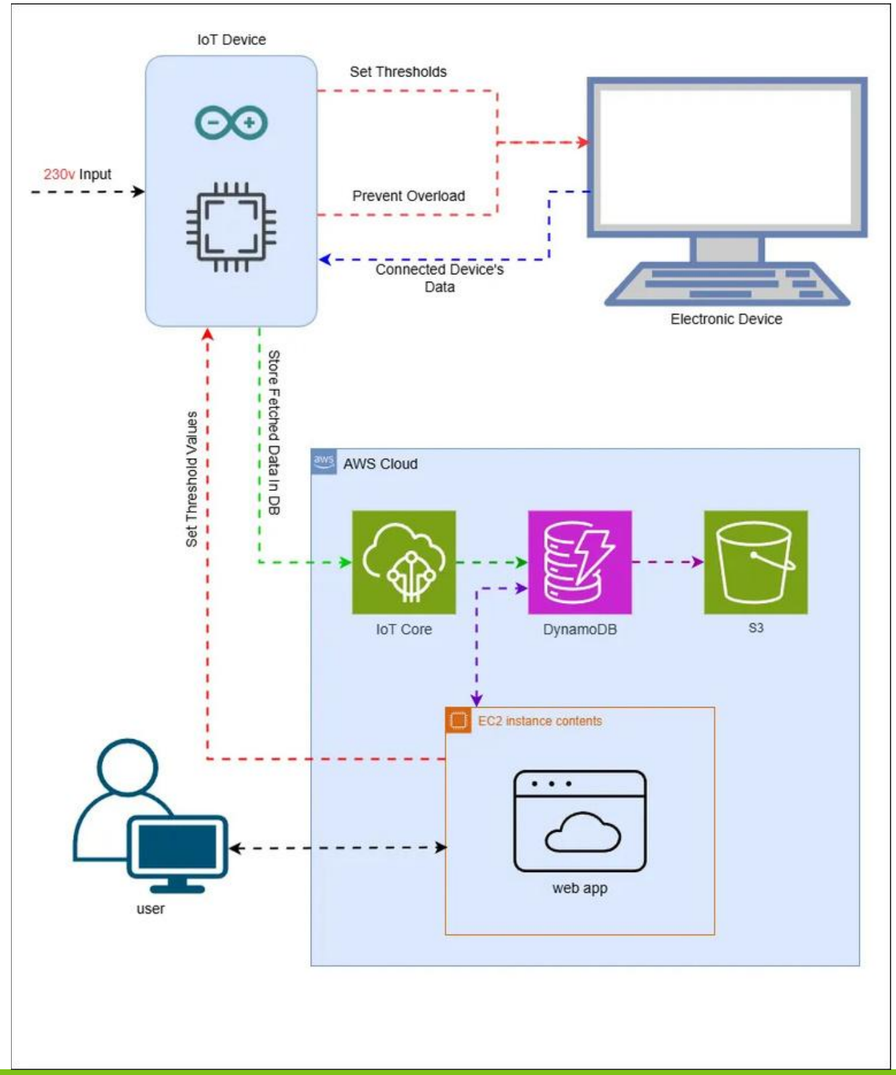
TECHNOLOGIES

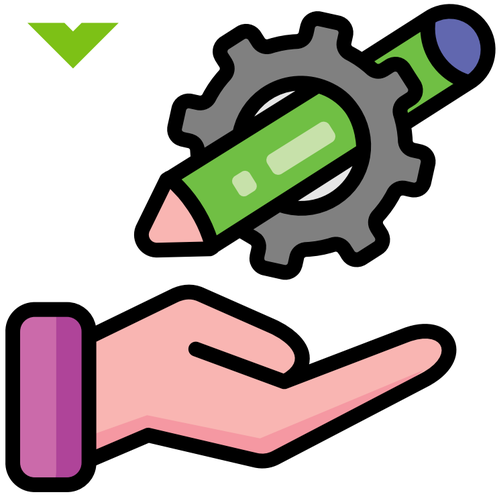
- **Technologies**:
  - ESP32 Microcontroller, ACS712 Current Sensor, ZMPT101B Voltage Sensor, Relay Module.
- **Cloud**:
  - AWS IoT Core, AWS DynamoDB, AWS Lambda.
- **Techniques**
  - **Real-Time Data Monitoring**: Use sensors to measure current and voltage in real-time, sending data to AWS IoT Core.
  - **Threshold Enforcement**: Implement logic in the ESP32 to automatically cut off power when usage exceeds user-defined thresholds.
  - **Cloud Integration**: Utilize MQTT protocol for seamless communication between IoT devices and the cloud.

SYSTEM DIAGRAM





FUNCTIONAL REQUIREMENTS

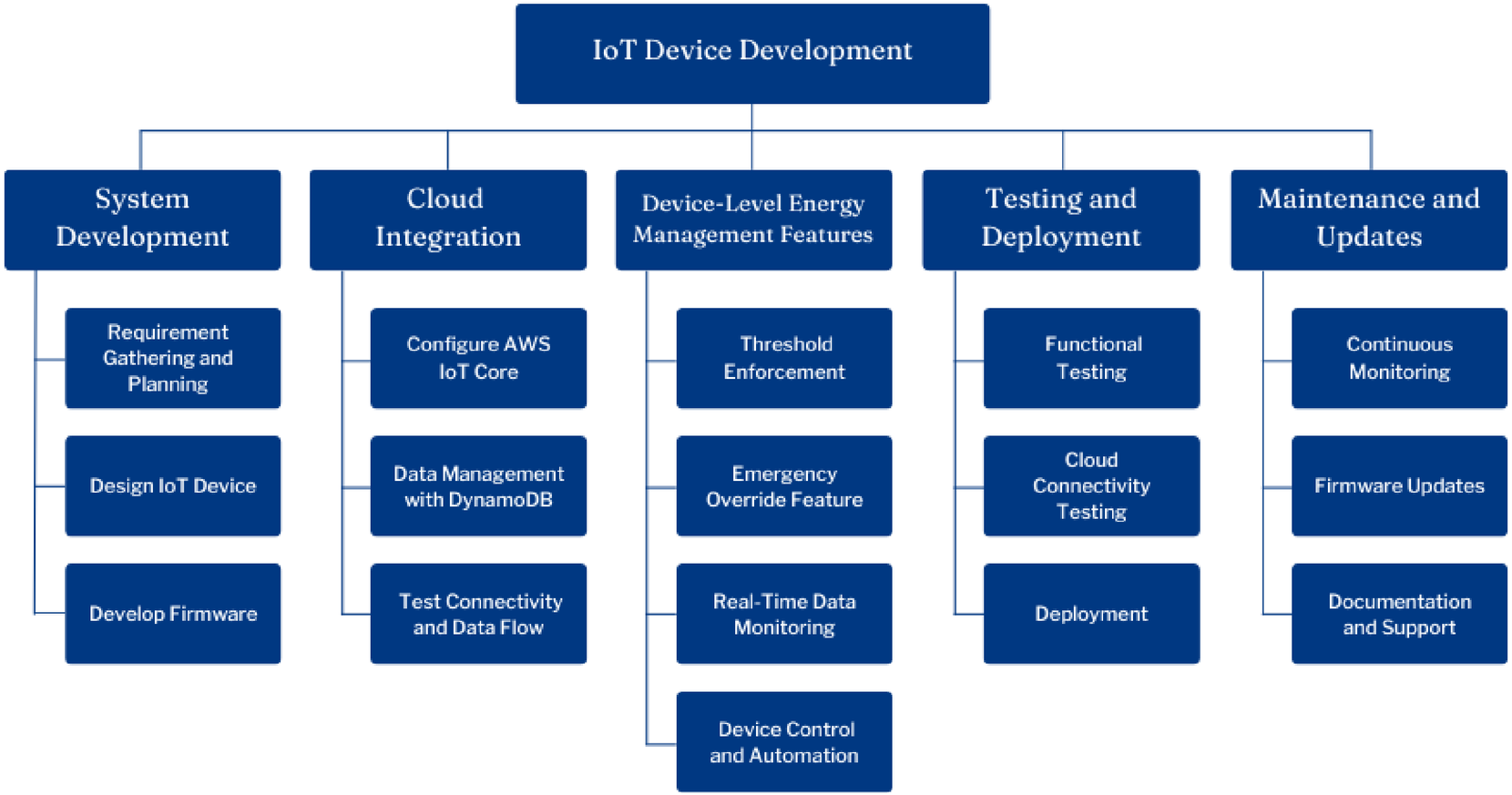


- Real-time monitoring of electricity usage for individual devices.
- Ability to set monthly usage thresholds for each device.
- Automatic power cut-off when thresholds are exceeded.
- Emergency override functionality via a web application.
- Secure communication between IoT devices, cloud, and web app.
- Integration with web applications for on-the-go monitoring and control.

NON-FUNCTIONAL REQUIREMENTS

- **Performance**: Ensure real-time data updates and fast response to threshold changes.
- **Security**: Encrypt all data transmissions between the IoT device, cloud, and web app.
- **Availability**: Ensure 99.9% uptime for cloud-based services.
- **Maintainability**: Use modular and well-documented code for easy updates and troubleshooting.

WORK BREAKDOWN STRUCTURE



FUTUREWATT USAGE PREDICTOR

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RESEARCH PROBLEM

How can households reduce high electricity bills, monitor and plan energy use for individual devices, and quickly detect faulty appliances?

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OBJECTIVES

- To predict energy use for each appliance.
- To show trends for better energy planning.
- To detect faulty or inefficient devices.
- To help reduce energy waste and costs.

RESEARCH GAP

Feature	Proposed System	Research [4]	Research [5]	Research [6]
Device-Specific Fault Detection	✓	✗	✗	✗
ARIMA-Based Time Series Predictions	✓	✗	✗	✗
Real-Time Anomaly Detection	✓	✗	✗	✗
IoT Data Integration for Insights	✓	✓	✓	✗

METHODOLOGY

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TECHNOLOGIES

Cloud Architecture:

AWS S3: Stores historical energy data and ML models.

AWS Lambda: Triggers time series analysis and fault detection.

DynamoDB: Stores real-time data from the IoT Device.

Python: Handles data processing, time series models, and fault detection.

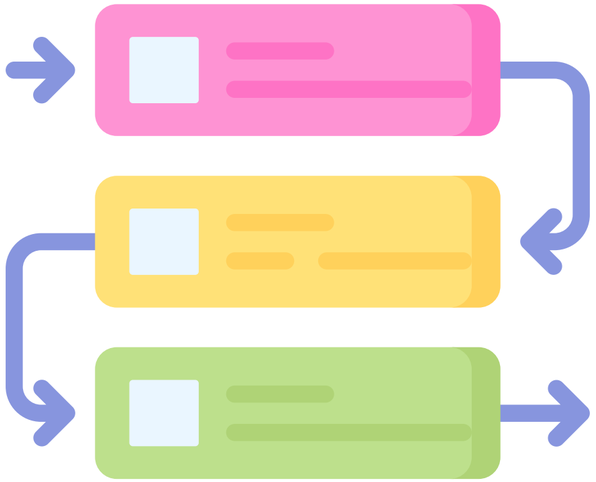
NumPy and Pandas: Preprocess energy usage data.

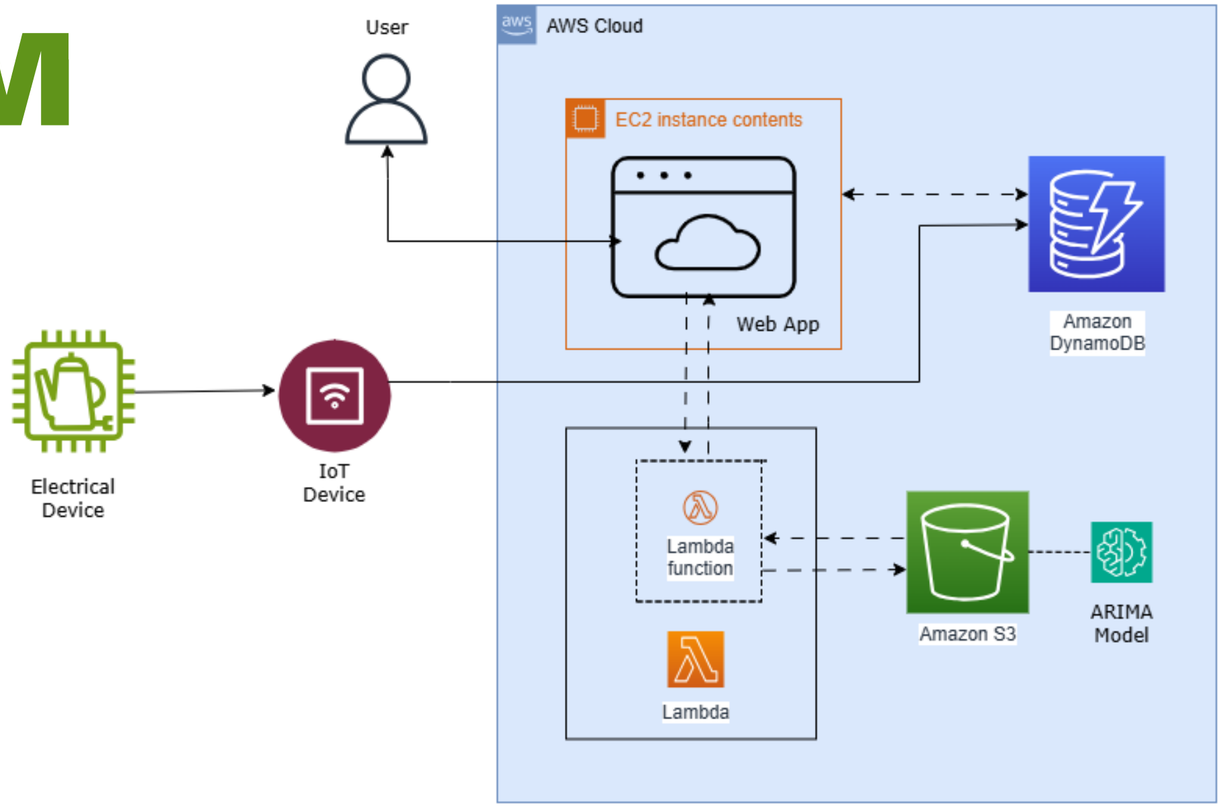
Techniques:

ARIMA: Time series forecasting of energy usage.

Outlier Detection: Fault detection via abnormal consumption patterns.

SYSTEM DIAGRAM





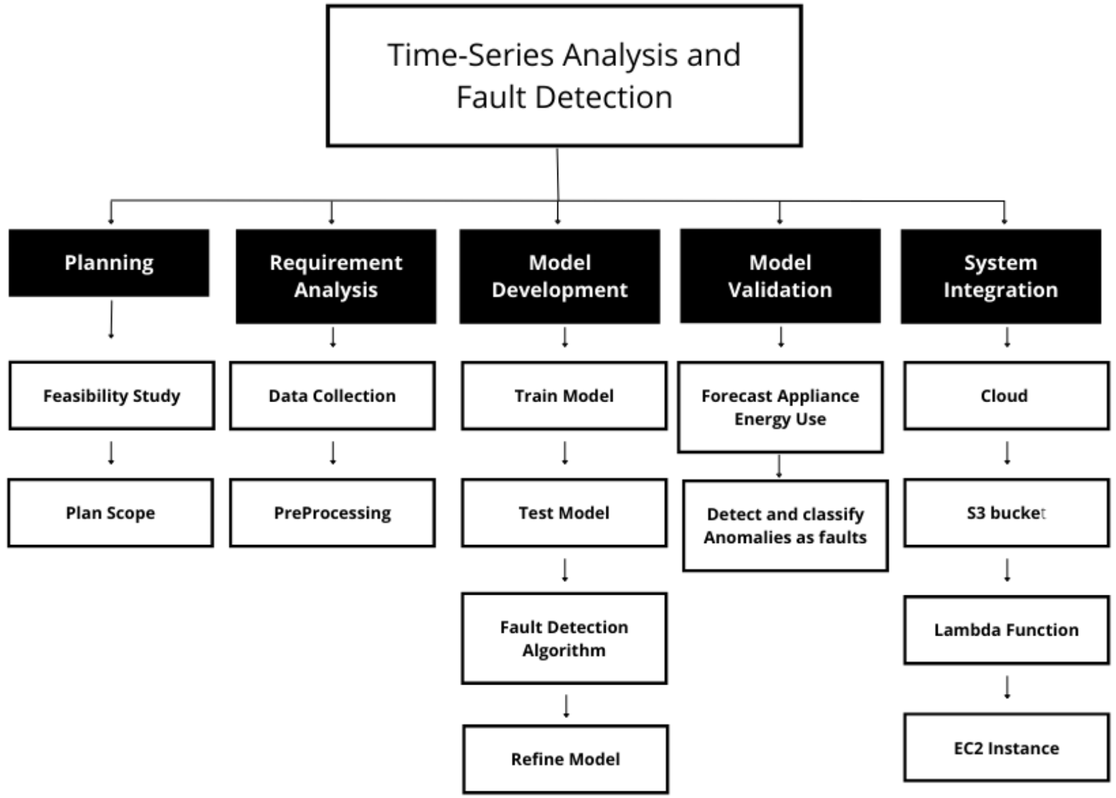
FUNCTIONAL REQUIREMENTS

- Collect real-time appliance energy data (timestamps, device IDs, units consumed)
- Normalize data to analyze for trends, seasonality, and other variations.
- Forecast appliance energy consumption using ARIMA model
- Compare real-time usage with predictions to detect and classify anomalies as faults

NON-FUNCTIONAL REQUIREMENTS

- **Performance:** Real-time data processing and predictions.
- **Reliability:** 99.9% uptime for continuous monitoring.
- **Accuracy:** ≥95% prediction accuracy (ARIMA); <5% false positive rate for fault detection.
- **Usability:** Clear visualizations of energy data and predictions.

WORK BREAKDOWN STRUCTURE



SMARTENERGY AI GUIDE

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INTRODUCTION

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RESEARCH PROBLEM

How can energy management systems provide personalized energy-saving recommendations based on individual consumption patterns?

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OBJECTIVES

- To analyze user consumption patterns to identify individual energy usage behaviors.
- To train and deploy a Generative AI model capable of providing tailored energy-saving recommendations.
- To integrate the AI model with a user-friendly interface for proactive energy management.
- To encourage sustainable practices by delivering actionable recommendations based on real-time and historical data.

RESEARCH GAP

Feature	Proposed System	Research [7]	Research [8]	Research [9]
Aimed at Sri Lankan Households	✓	✗	✗	✗
Integration of IoT Devices for Real-Time Tracking	✓	✓	✗	✗
Gen AI for Personalized Recommendations	✓	✗	✗	✓
Long-Term User Behavior Adaptation	✓	✗	✓	✗

METHODOLOGY

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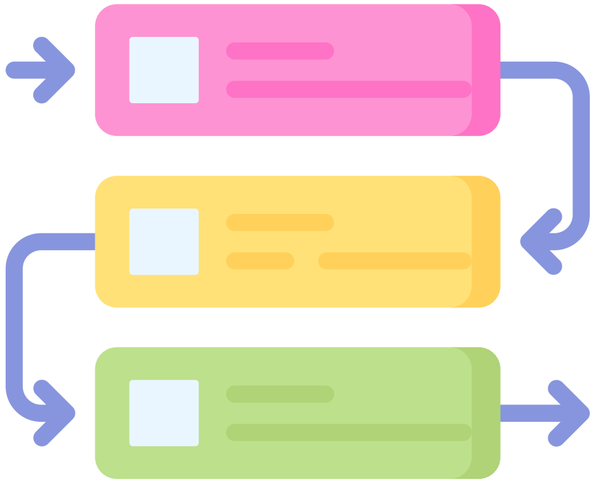
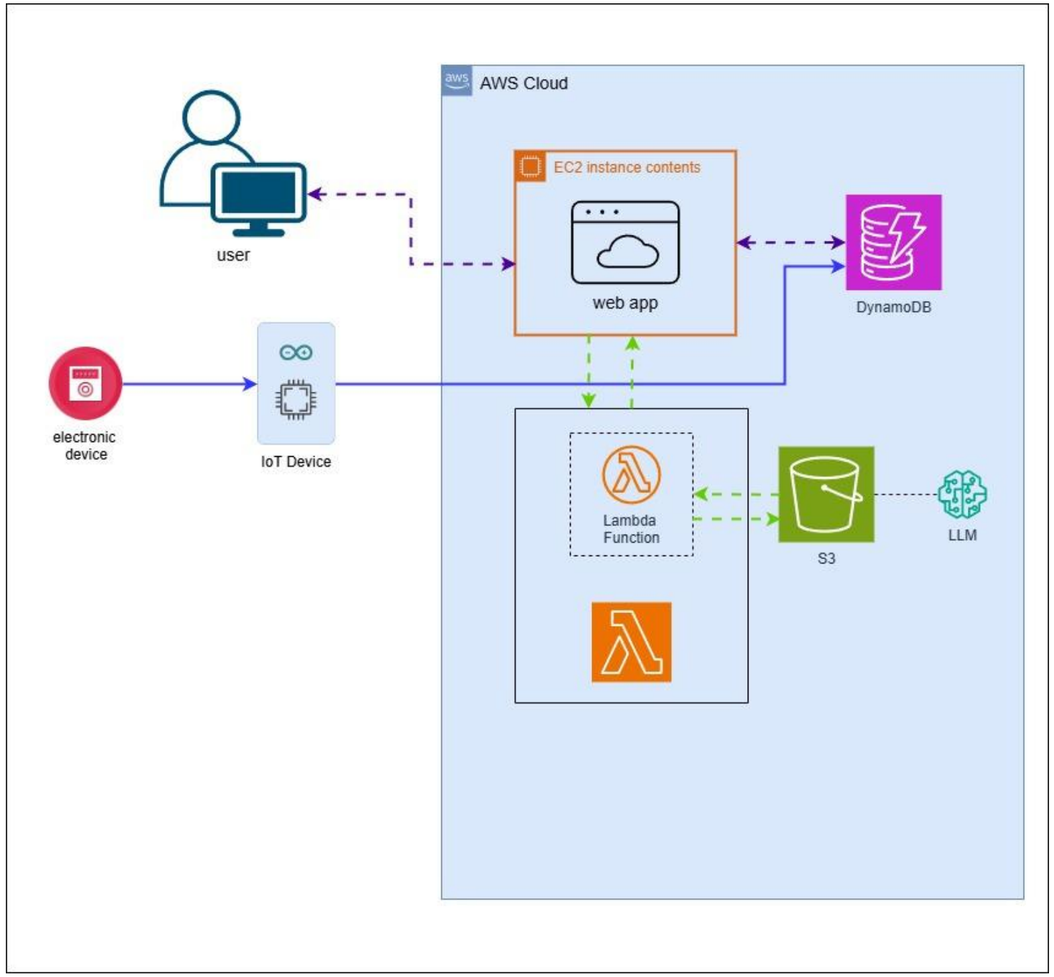
TECHNOLOGIES

- **Technologies**:
  - Backend: Python with FastAPI (AI Model Integration)
  - Cloud: AWS (EC2, S3, Lambda)
  - Database:DynamoDB
  - AI Frameworks: PyTorch
- **Techniques**
  - **Generative AI Model**: Use Generative AI (e.g., GPT-based models) to create tailored energy-saving suggestions.
  - **Recommendation System**: Generate personalized recommendations using fine-tuned AI models.
  - **Real-Time Communication**: Use REST APIs to connect the backend with IoT devices and the web app for real-time updates.

SYSTEM DIAGRAM





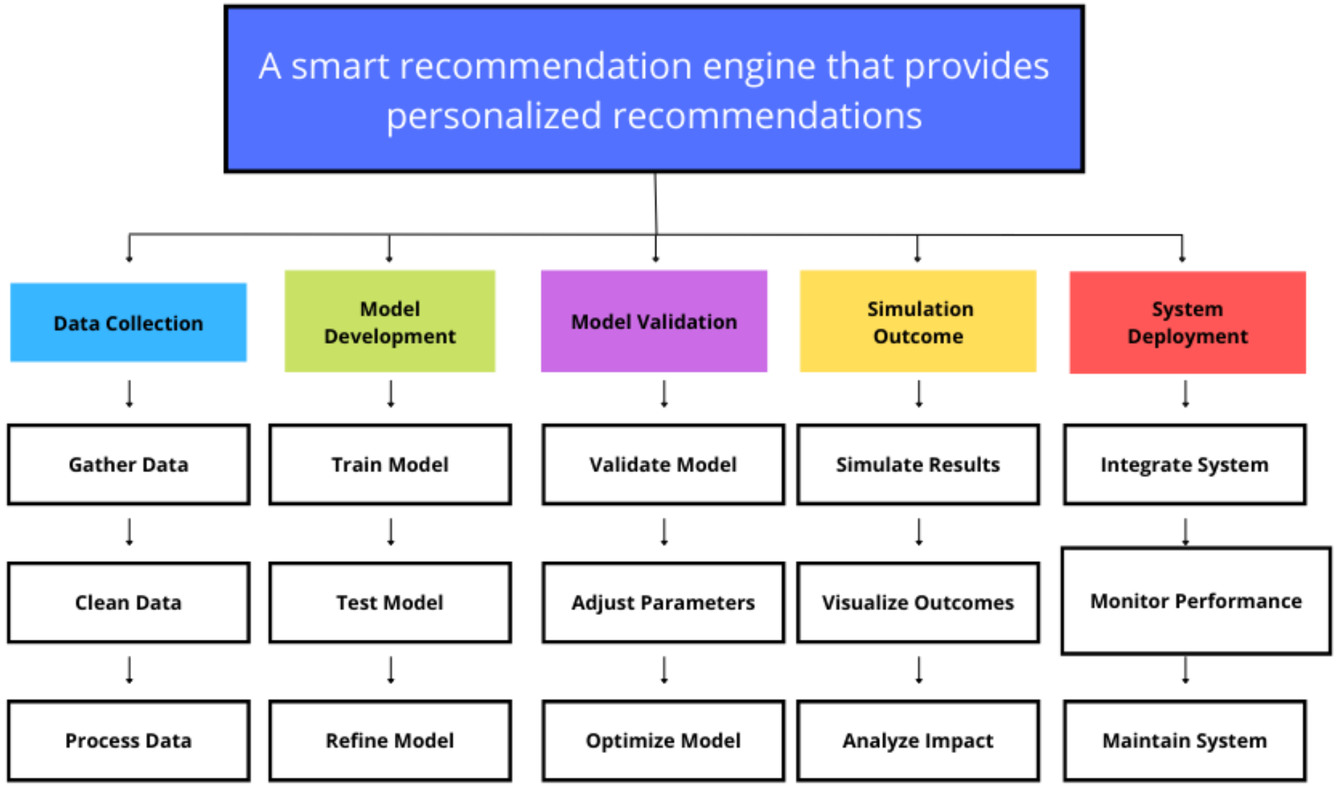
FUNCTIONAL REQUIREMENTS

- Collect and preprocess IoT energy data.
- Analyze consumption patterns using AI.
- Generate personalized energy-saving recommendations..
- Allow user feedback for model improvement.
- Provide real-time alerts for energy usage.

NON-FUNCTIONAL REQUIREMENTS

- **Performance**: Fast real-time AI responses.
- **Scalability**: Efficiently handle growing users and data.
- **Security**: Encrypt user data and recommendations.
- **Availability**: 99.9% uptime.
- **Maintainability**: Modular, well-documented code.

WORK BREAKDOWN STRUCTURE



ECOTRACK DASHBOARD

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INTRODUCTION

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RESEARCH PROBLEM

What methods can streamline the registration and management of energy monitoring units via a web application?

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OBJECTIVES

- Develop a web app to register and manage IoT energy units.
- Provide an intuitive dashboard for viewing energy-related data.
- Enable users to assign nicknames and icons to registered units.
- Allow users to set and reset energy limits via the app.
- Ensure seamless data retrieval and visualization from the cloud.

RESEARCH GAP

Feature	Proposed System	Research [10]	Research [11]	Research [12]
Iot Unit Discovery and Registration via Wi-Fi	✓	✗	✗	✗
User Account Creation and Management	✓	✓	✗	✗
View Time Series Predictions & GenAi Suggestions	✓	✗	✓	✗
Setting and Resetting Energy Limits	✓	✗	✗	✗

METHODOLOGY

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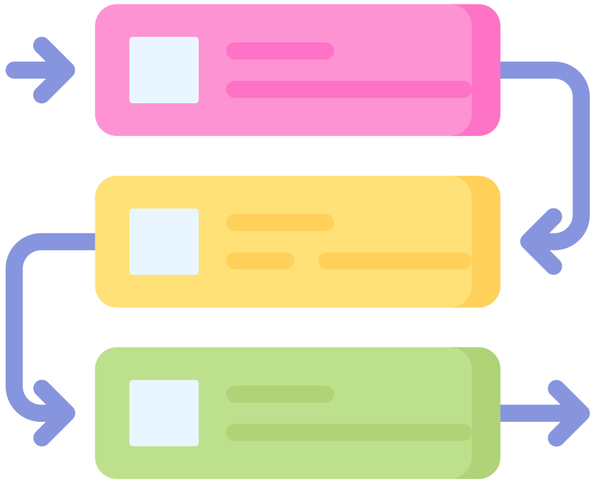
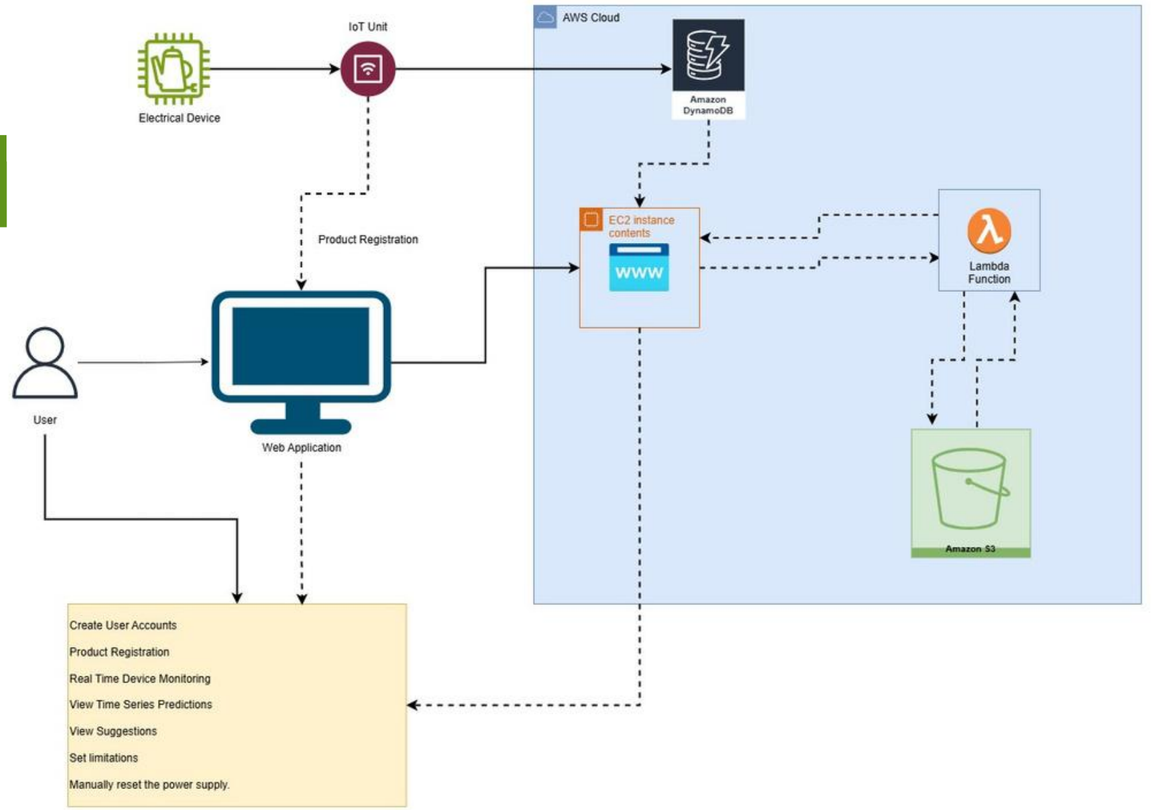
TECHNOLOGIES

- **Technologies:**
  - Frontend: React.js (UI Development)
  - Backend: Laravel (API & Data Handling)
  - Cloud: AWS (EC2)
  - Database: MySQL (Unit and User Data Management)

- **Techniques:**
  - Wi-Fi-based Unit Discovery: Connect to ESP32 units via Wi-Fi.
  - REST API Communication: Facilitate data exchange between web app and backend.
  - Data Visualization: Charts and graphs for consumption insights.

SYSTEM DIAGRAM





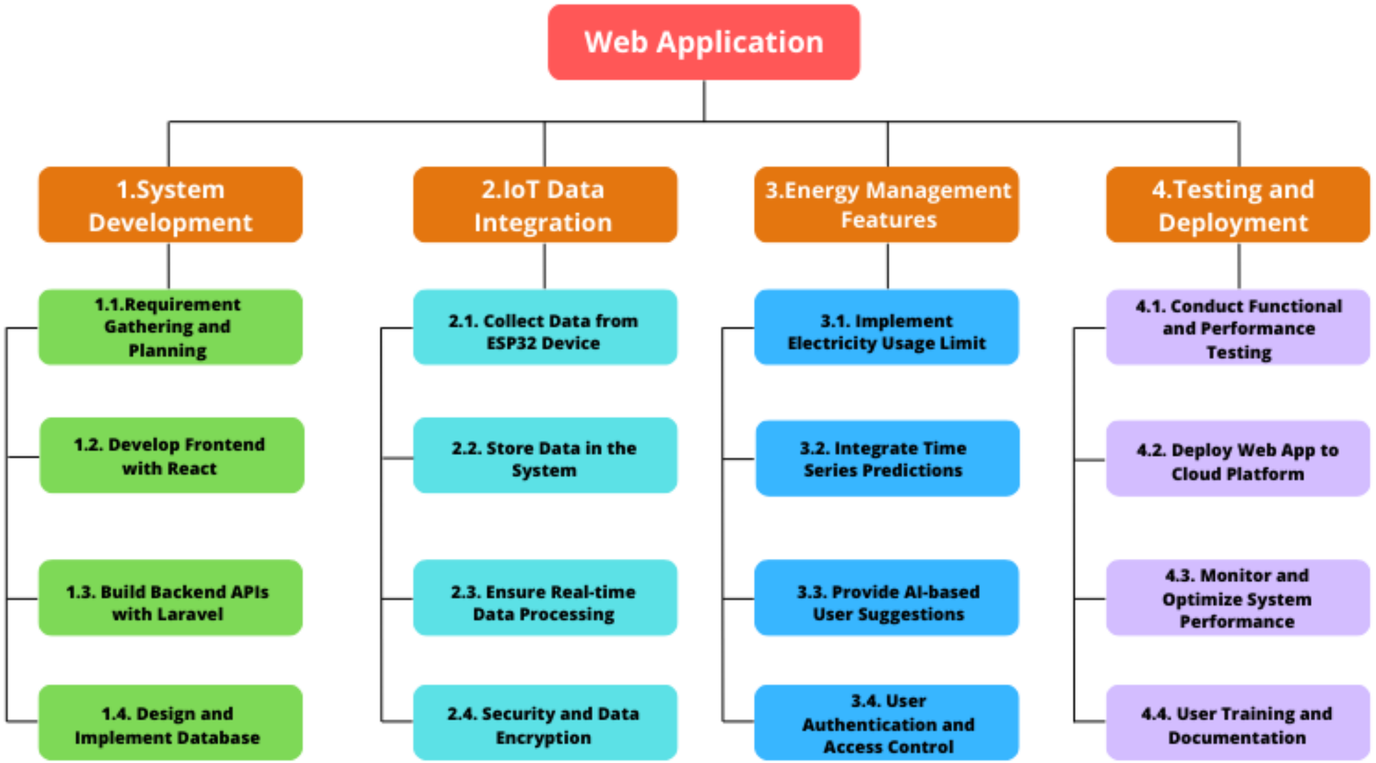
FUNCTIONAL REQUIREMENTS

- Discover and register IoT units via Wi-Fi.
- Create and manage user accounts.
- Assign custom names and icons to units.
- Display unit-specific data from AWS cloud.
- Set and reset energy consumption limits.
- Provide notifications and alerts for energy usage.

NON-FUNCTIONAL REQUIREMENTS

- **Performance**: Fast response times for data retrieval and actions.
- **Scalability**: Support multiple users and devices efficiently.
- **Security**: Secure user authentication and data encryption.
- **Usability**: Responsive design for web and mobile access.
- **Availability**: 99.9% uptime with AWS cloud infrastructure.
- **Maintainability**: Well-structured codebase for easy updates

WORK BREAKDOWN STRUCTURE



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THANK YOU

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