AN INTELLIGENT ELECTRICITY MANAGEMENT UNIT

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

INTRODUCTION

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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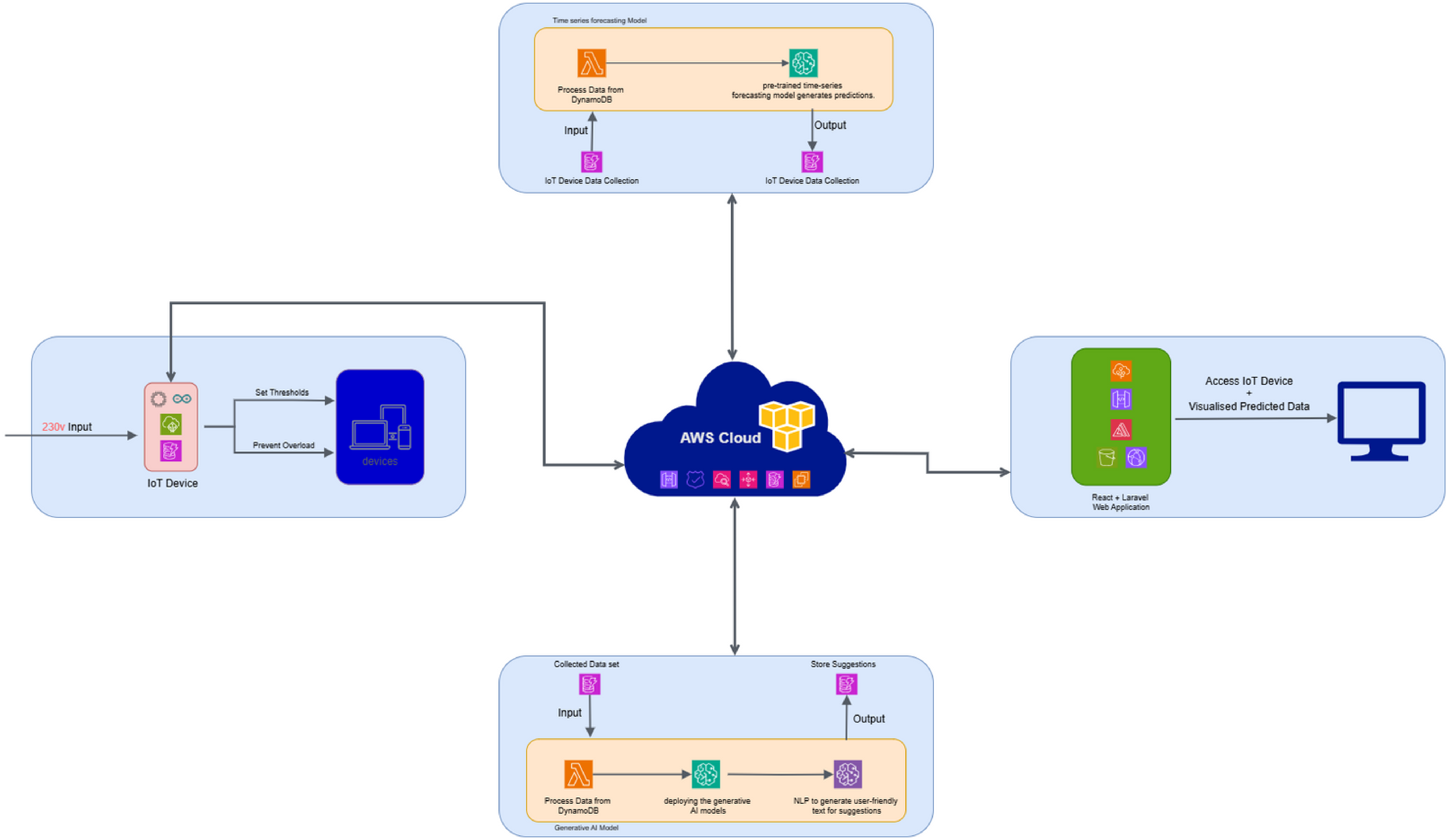
FACULTY OF COMPUTING

Group No: R25-65

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

RESEARCH PROBLEM

- Lack of seamless real-time integration between IoT devices and cloud platforms.
- Inability to enforce user-specific electricity usage thresholds in existing systems.
- Delayed or no real-time response (e.g., power cut-off) based on consumption data.
- Existing solutions are often costly and complex for average household deployment.

OBJECTIVES

- Designed and developed a fully functional IoT device for real-time electricity monitoring of individual appliances.
- Implemented accurate measurement of current, voltage, power (W), and energy consumption (kWh).
- Developed and tested threshold-based power control logic to automatically cut off power when limits are exceeded.
- Design and 3D print a compact, user-safe device container (power brick-style casing).
- Finalize custom PCB design for a cleaner and more reliable hardware layout and Enhance LED indicators for easy to use.

METHODOLOGY

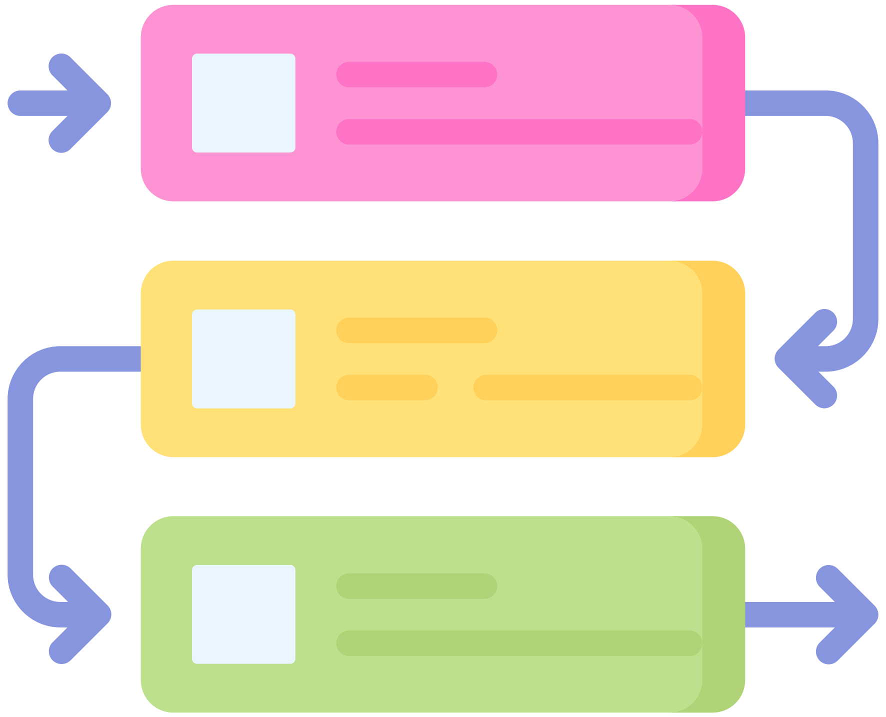
TECHNOLOGIES

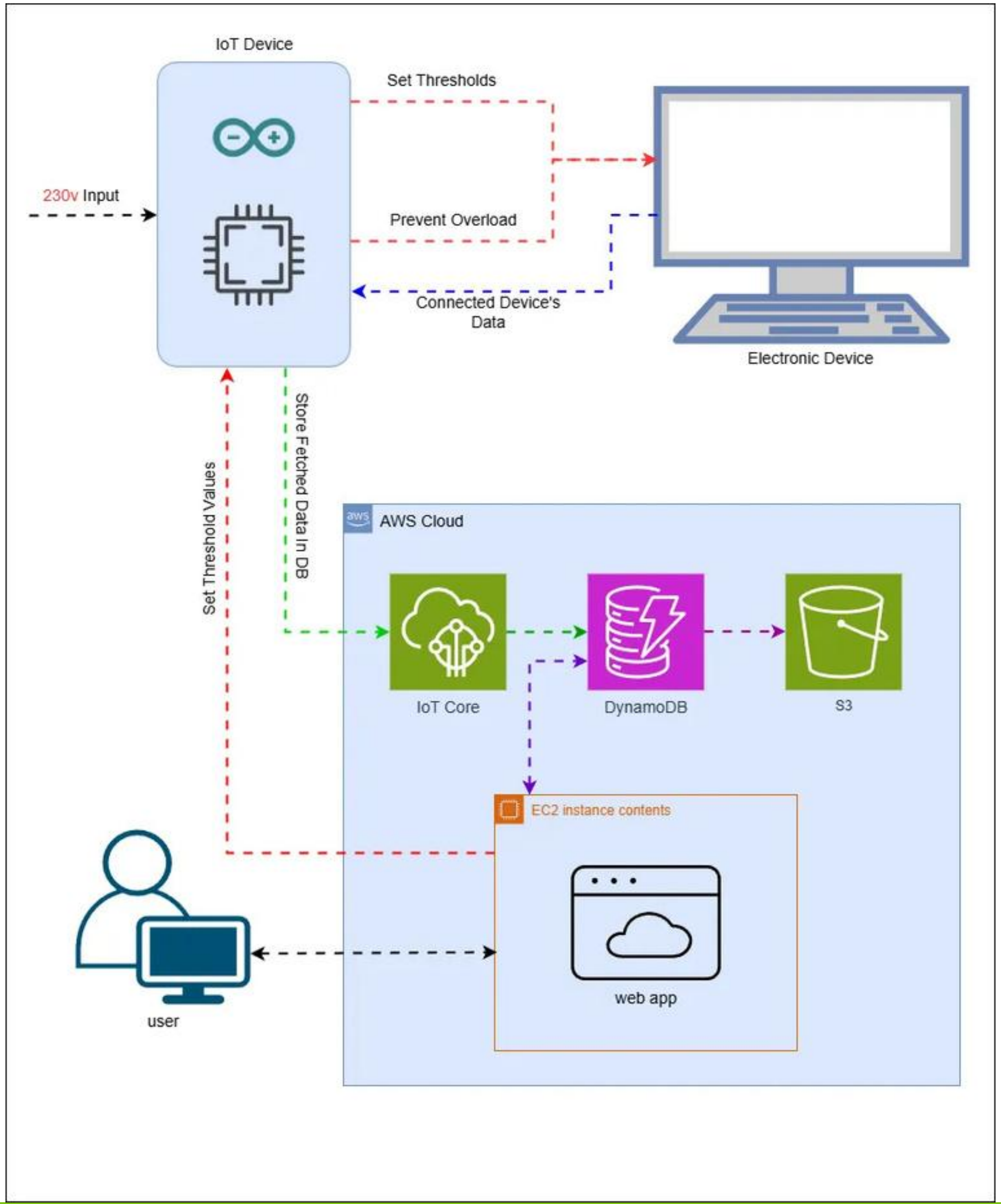
- **Technologies**:
  - ESP32 Microcontroller, ACS712 Current Sensor, ZMPT101B Voltage Sensor, Relay Module.
- **Cloud**:
  - AWS IoT Core, AWS DynamoDB.
- **Techniques**
  - **Real-Time Data Monitoring**: Use sensors to measure current and voltage in real-time, sending data to AWS IoT Core.
  - **Threshold 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.

EQUATIONS & CLARIFICATIONS

- **Voltage Calculation**:
  - $\sqrt{(\Sigma(V^2) / N)} \times CALIBRATION\_FACTOR$
- **RMS Current**:
  - $\sqrt{(\Sigma(I^2) / N)}$, $I = (V - zeroPoint) / sensitivity$
- **Power:**
  - $V \times I$
- **Energy (kWh):**
  - $(P \times time\_hours) / 1000$

SYSTEM DIAGRAM





PROGRESS

COMPLETED 50%

- Fully functional IoT device for measure the energy .
- Developed and tested threshold-based power control logic & WI-FI connectivity.
- Store energy data in AWS DynamoDB via MQTT.

PP2 90%

- Enhance LED indicators for easy to use.
- Design and 3D print a device container.
- Implement secure way to connect with web App.

FINAL 100%

- Implement accessibility features.
- Finalize custom PCB design.

COST CALCULATION

- **ACS712 Current Sensor - 5A**:
  - Rs 250.00
- **ZMPT101B Sensor Module**:
  - Rs 340.00
- **ESP32 WROOM 32:**
  - Rs 1320.00
- **1 Channel Relay Module (5V):**
  - Rs 240.00
- **230V to 5V 700mA isolated switch**:
  - Rs 500.00
- **Jumper Wires**:
  - Rs 160.00
- **Device Container:**
  - Rs 800.00

3610 LKR

FUTUREWATT USAGE PREDICTOR

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INTRODUCTION

RESEARCH PROBLEM

- Inability to predict future energy usage based on past data for cost optimization
- Lack of easy-to-use interfaces for households to view future energy usage and a guidance on electricity related concepts

OBJECTIVES

- To predict energy use for each appliance.
- To show trends of future usage
- To detect faulty or inefficient devices.
- To help users learn about electricity concepts

METHODOLOGY

TECHNOLOGIES

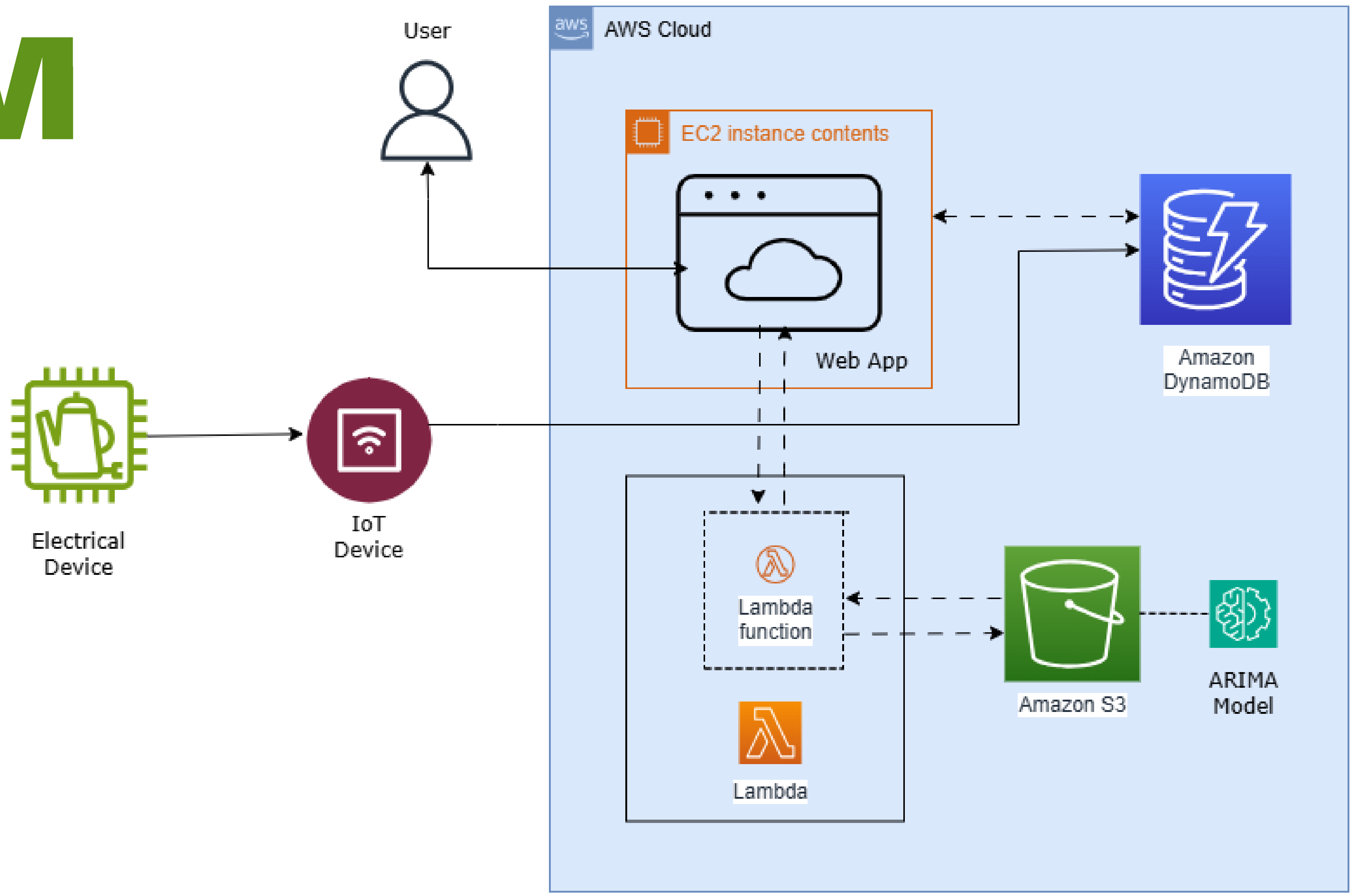
Cloud Architecture:

- **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



MODEL TRAINING

- **Model Type: ARIMA (5,1,0)**
  - p=5: Model considers the last 5 lags of consumption
  - d=1: : Data is differenced once to remove trend and make it stationary
  - q=0: No moving average smoothing
- **Real IoT Dataset Used**
- **Timestamp handling**
- **S3 Integration**

PROGRESS

COMPLETED

50%

- Timeseries model trained using data collected from the IoT Device.
- Developed energy prediction for the next 24 hours.
- Customized chatbot integrated to the future energy prediction

PP2

90%

- Integration with the IoT device, application and cloud architecture
- Implement Fault Detection algorithm

FINAL

100%

- Finetune the model
- QA and Bug testing

SMARTENERGY AI GUIDE

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INTRODUCTION

RESEARCH PROBLEM

- Absence of customized energy-saving recommendations tailored to individual user behavior, despite the abundance of IoT energy consumption data.
- Existing systems provide generalized tips without analyzing individual usage patterns.
- No intelligent mechanism to interpret device-level consumption for tailored suggestions.
- Limited use of AI to transform raw energy data into user-specific recommendations.

OBJECTIVES

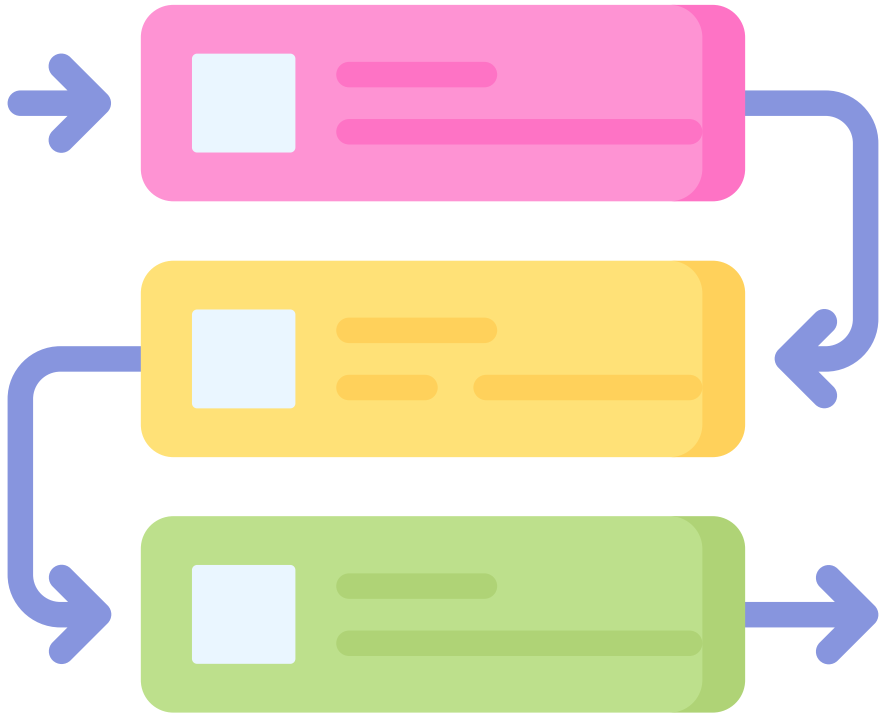
- Analyze appliance-level energy data to find usage patterns.
- Create a labeled dataset mapping patterns to energy-saving tips.
- Fine-tune a GPT-based model with LoRA for personalized suggestions.
- Integrate a Machine Learning model to predict future energy usage trends and optimize suggestion generation.
- Build a generative AI system for real-time, user-specific tips.
- Deploy the model on AWS Cloud and tested outputs for relevance and clarity.

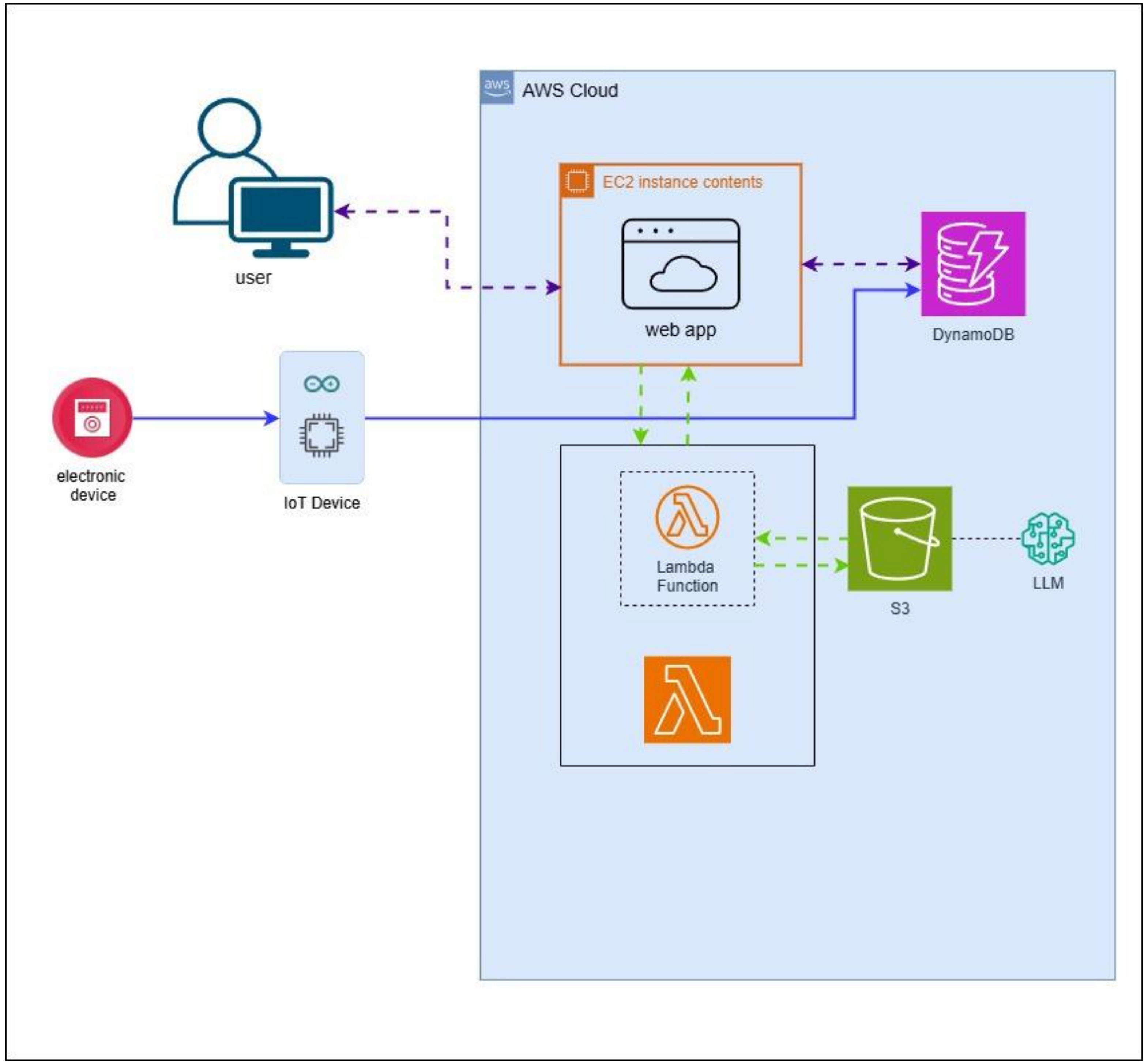
METHODOLOGY

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





PROGRESS

COMPLETED

50%

- Analyzed appliance-level energy data to identify usage patterns.
- Fine-tuned 3 GPT-based models (Llama-3.2-1B/GPT-2/GPT-Neo) using LoRA and evaluated accuracy.
- Selected the most effective model for generating personalized energy-saving suggestions.

PP2

90%

- Integrate ML model , personalized energy-saving suggestions based on user behavior.
- Improve accuracy.
- Set up backend APIs and AWS Cloud deployment.
- Link AI backend with web app.

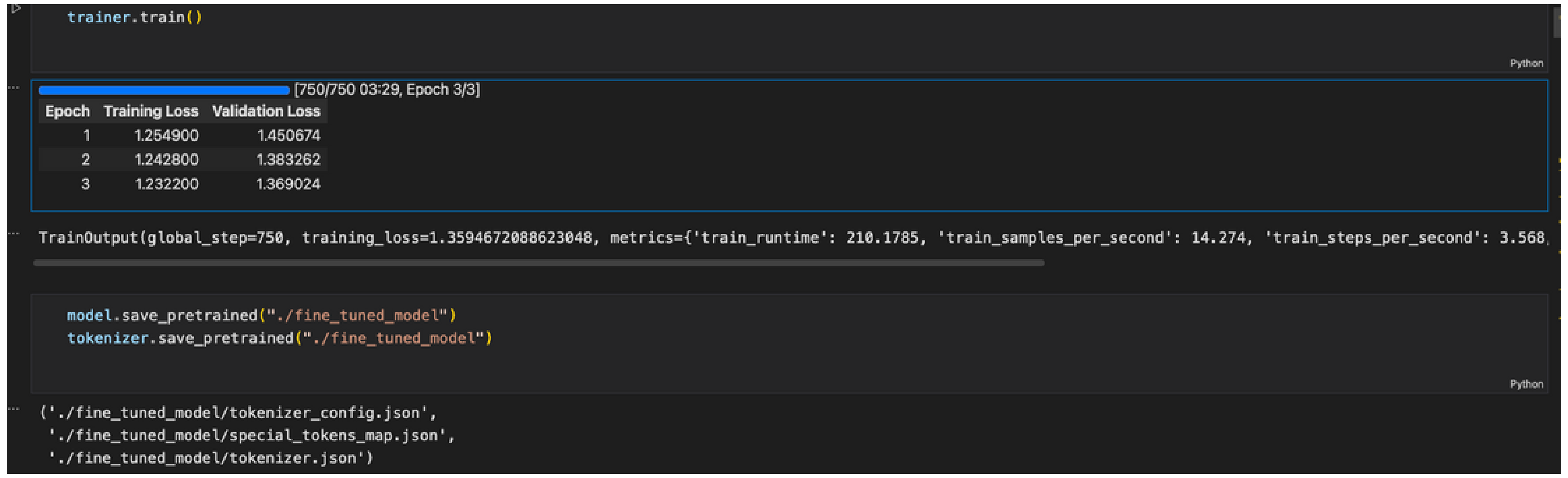
FINAL

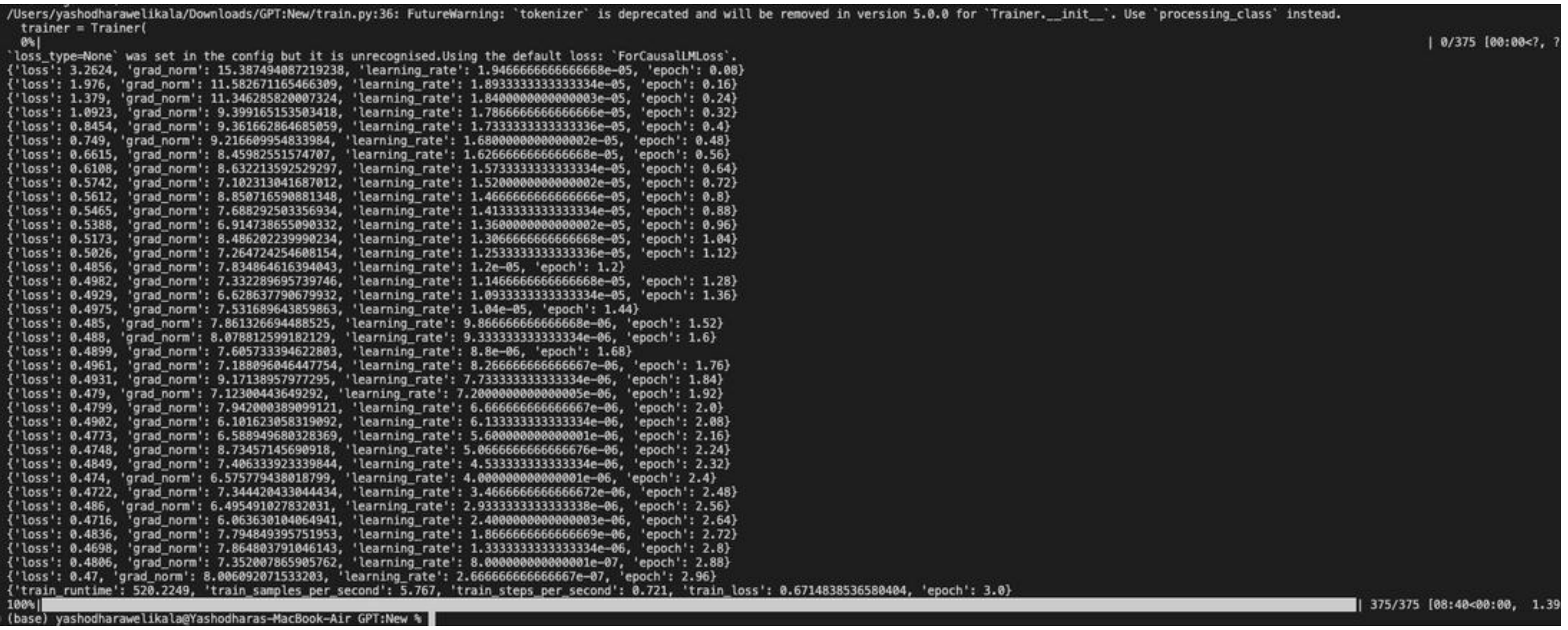
100%

- Deployed AI model on AWS for real-time use.
- Evaluated model with BLEU scores and expert feedback

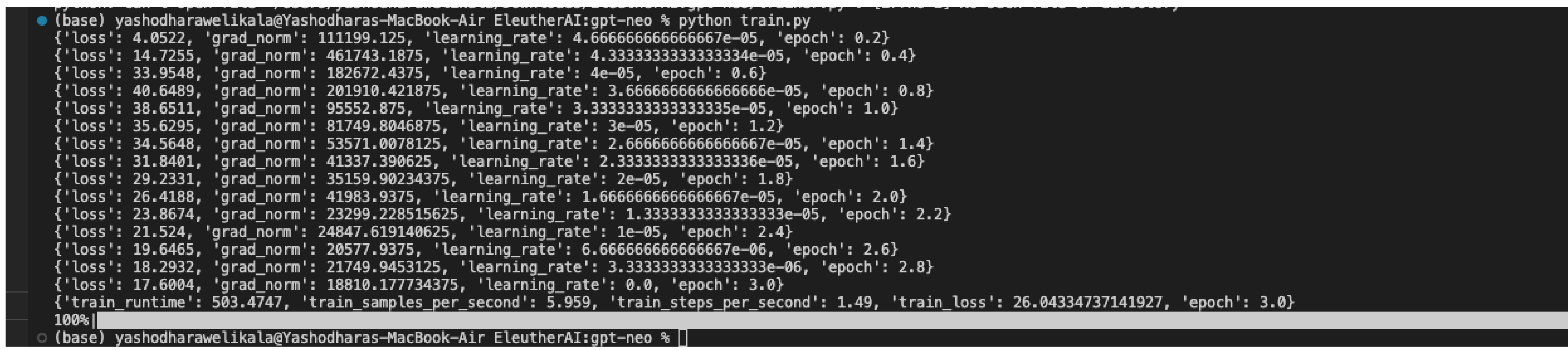
MODELS TRAINING

Llama-3.2-1B Training





GPT-2-125m Training



EleutherAI/gpt-neo-125m Training

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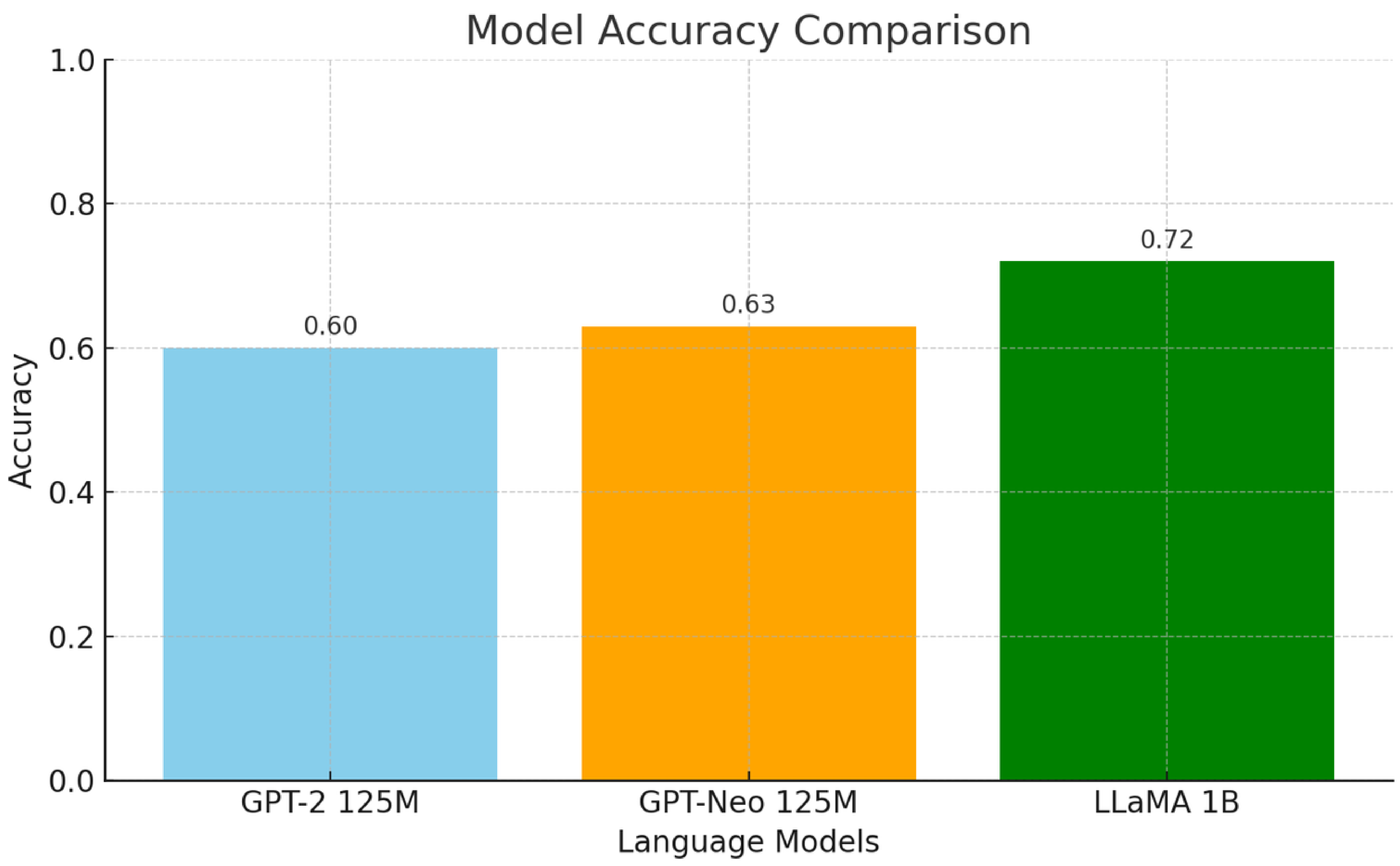
MODEL ACCURANCY



ECOTRACK DASHBOARD

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INTRODUCTION

RESEARCH PROBLEM

- Existing energy apps only show total consumption – not device-level usage.
- Users don’t know which device impacts the bill the most.
- Lack of motivation – users see data, but don’t take action.
- No proper engagement strategies to encourage energy-saving habits.
- Poor support for color blindness and other accessibility needs.

OBJECTIVES

- User management [Registration, Authentication, Profile Section (update details, reset password, delete account)].
- Display real-time, device-level energy monitoring through the web app.
- Visualize data through interactive graphs and intuitive dashboards.
- Design a language-independent UI using icons and visual cues.
- Implement accessibility features for differently-abled users (ex: color-blined).
- Conduct a user survey to shape UI/UX based on real preferences.
- Ensure continuous engagement with tasks, goals, and achievements.

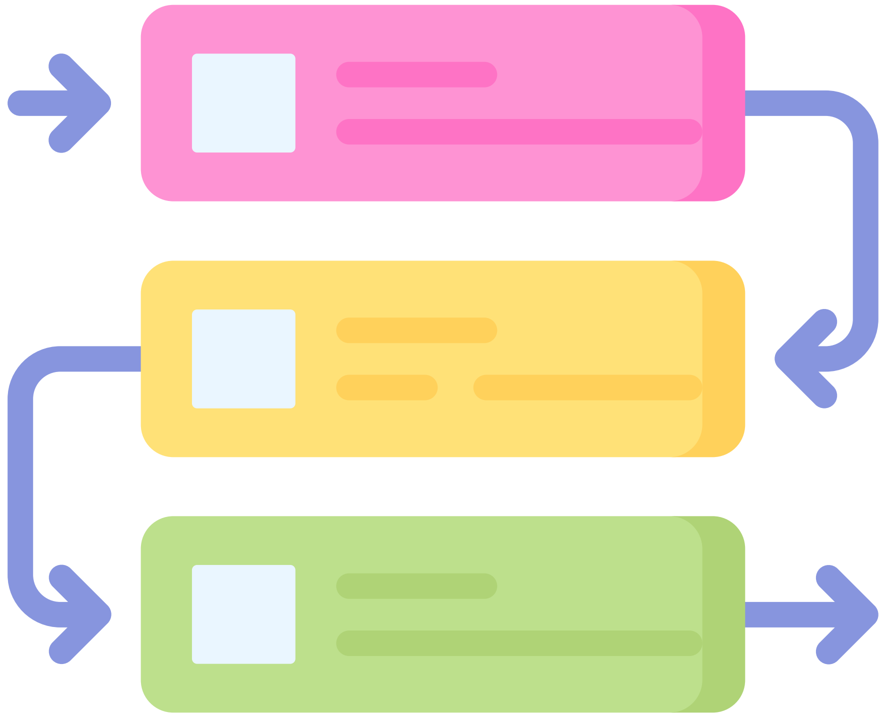
METHODOLOGY

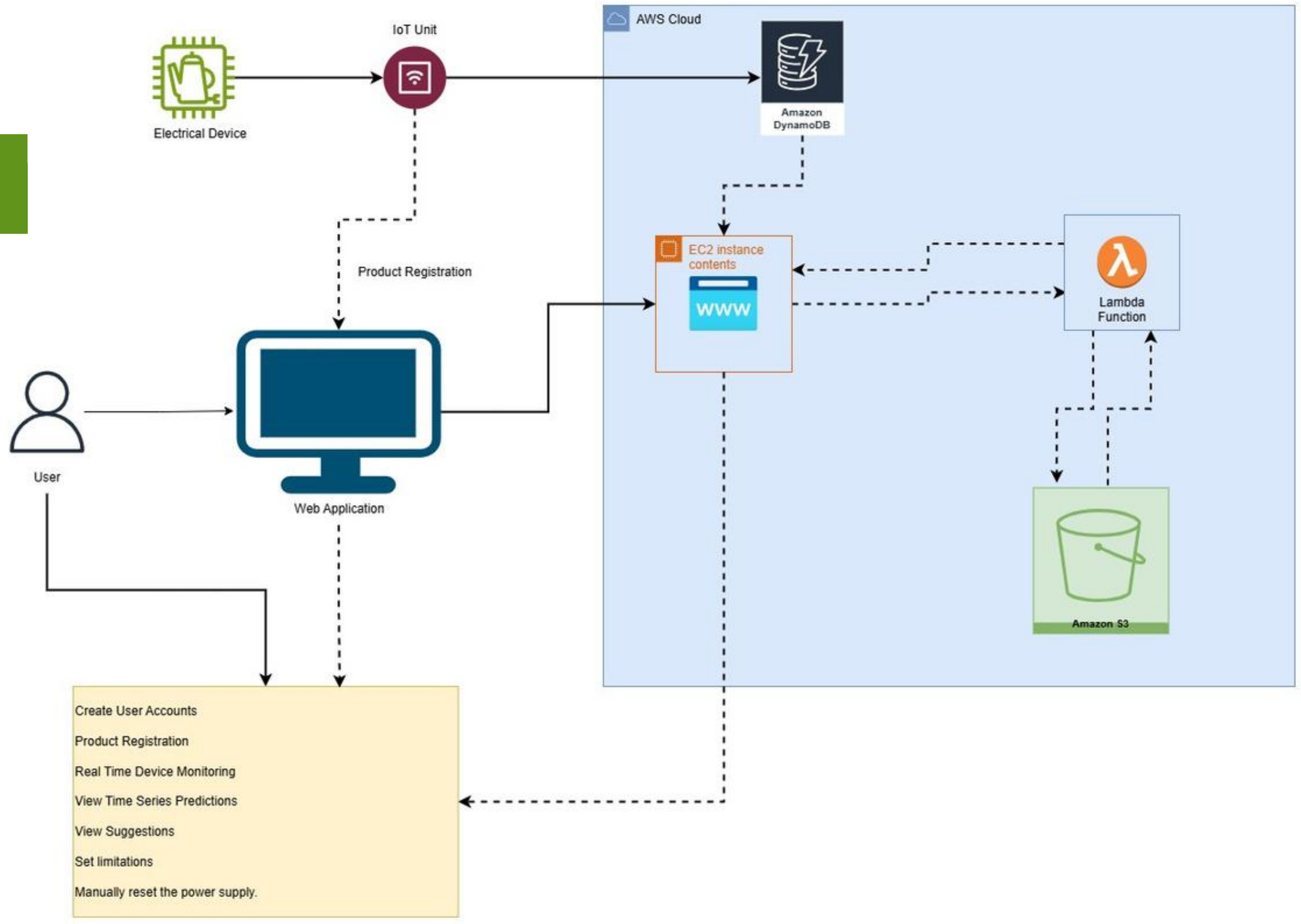
TECHNOLOGIES

- **Technologies:**
  - Frontend: React.js (UI Development)
  - Backend: Laravel 12 (API & Data Handling)
  - Cloud: AWS (EC2)
  - Database: RDS(MySQL) / DynamoDB (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





PROGRESS

COMPLETED

50%

- User Management Part
- Display real-time, device-level energy usage
- Set/Reset threshold value using web app
- Conduct a user survey and interview
- Do research on accessibility features

PP2

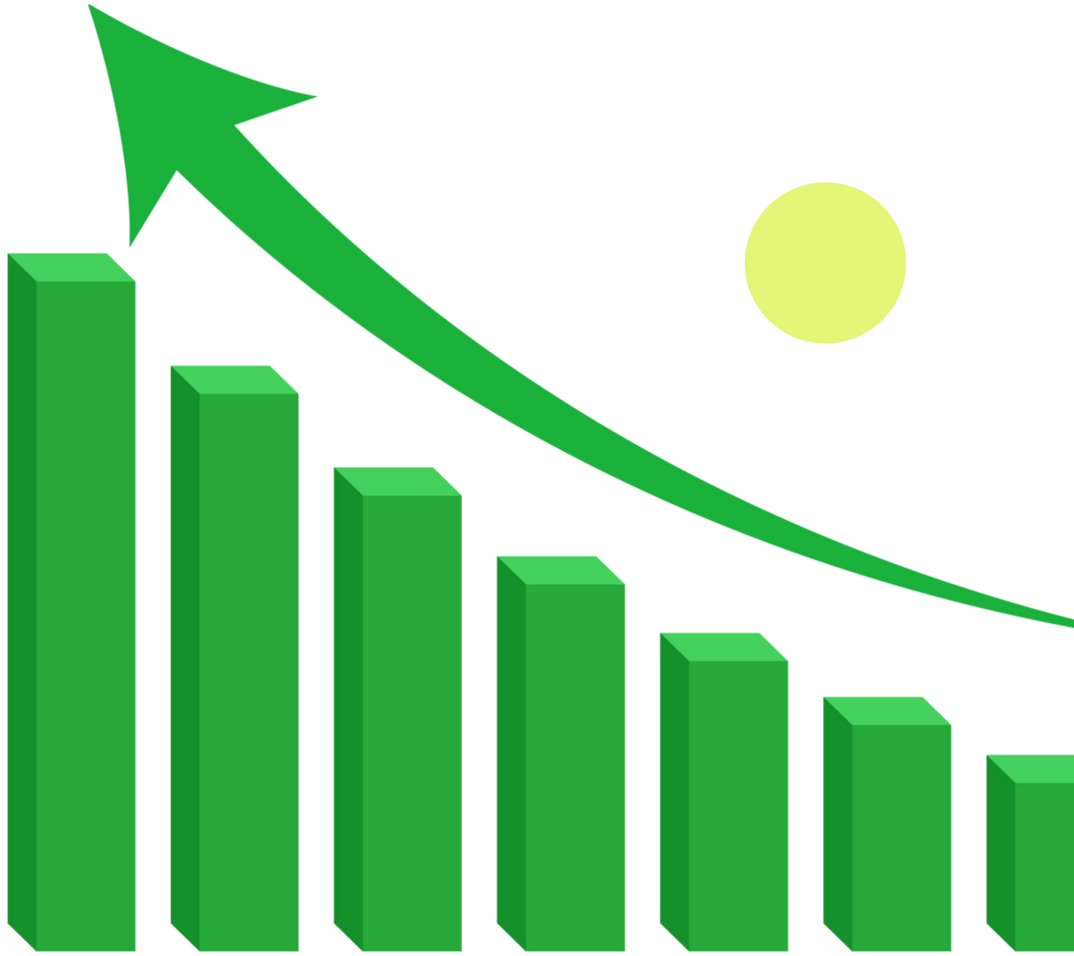
90%

- Product registration using Wi-Fi
- Visualize data (ML predictions/AI suggestions)
- Improve UI for language-independent

FINAL

100%

- Implement accessibility features
- QA testing & bug fixes



USER SURVEY INSIGHTS

FEATURE	MOSTLY PREFERED CHOICE	PERCENTAGE
Interface	Simple and minimalistic	63%
Data visualization technique	Graphs and charts	43%
Quick access dashboard	Very important, I want to see key infoimmediately	70%
Data on home screen	Real-time electricity usage	40%
Charts type	Bar charts	43%
Alerts type	Pop-up notifications inside the app	43%

"UNDERSTANDING USER Needs THROUGH REAL-WORLD FEEDBACK"

USER INTERVIEWS

USER	NEED	UI/UX Insight
1 - Farmer	Electricity bill is always high. If something shows me what eats most power, I'll use it.	• Wants simple icons with no reading • Needs clear alerts • Should be easy to understand
2 - School Teacher	It's useful if I can monitor and reduce my bill monthly. I want to save.	• Likes daily reports and notifications • Requests easy-to-understand graphs • Appreciates tips and suggestion popups
3 - Garage Owner	I just want to know when machines waste power. That saves my business money.	• Needs dashboard with visual meters • Wants alerts when devices overuse • Prefers energy suggestions
4 - Architect	Real-time, device-level insights? That would be very useful for smart home users.	• Expects minimalist design with dark/light themes • Interested in AI-powered recommendations • Likes reward system and charts
5 - Landowner	I don't know how to reduce electricity. But if something shows and alerts, I'll ask my staff to follow.	• Needs assistant-friendly access • Prefers simple status view: red/yellow/green indicators • Wants device grouping (home/garden/factory)
6 - CEO	Energy efficiency is key. I'd love to see impact, forecasts, and compare usage trends.	• Demands data-rich dashboards with export options • Wants carbon footprint insights • Appreciates cross-device sync and smart alerts

"VOICEs frOM EVERY CORNER: REAL PEOPLE, REAL NEEDS"

THANK YOU