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Sakthi Hackathon 1.0

Problem Statement proposal on

IoT and AI in Everyday Life

Title of problem statement

AI-Enhanced Smart Energy Distribution Monitor with Phantom Load Detection and Voice Alert System

College name

St. Joseph's College of Engineering

Student team Details

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Project Proposal

1. **Major Area**
   IoT and AI in Everyday Life - Smart Energy Management

2. **Problem Statement**
   AI-Enhanced Smart Energy Distribution Monitor with Phantom Load Detection and Voice Alert System

3. **Problem statement summary**
   Energy consumption in buildings accounts for 35% of total energy use in India and 40% globally, and this demand is growing rapidly. However, current energy management systems face three key challenges that our project addresses using an AI-powered smart energy distribution system with phantom load detection and bi-directional voice alerts.

Challenge 1: Phantom Load – The Silent Energy Waste
Phantom loads (standby power) are hidden energy drains from devices like TVs, set-top boxes, and chargers that consume power even when switched off. Phantom loads can add 5-10% to electricity bills, costing ₹1,500 to ₹3,000 per year.
Most existing systems cannot detect or automatically cut off these phantom loads, and users often remain unaware of this wasted energy.

Challenge 2: Lack of Real-Time, Intelligent Energy Management
Current energy systems:

- React after energy waste happens instead of preventing it.
- Struggle to manage large, real-time energy data effectively.
- Lack smart decision-making to automatically control devices.

Research shows that IoT-based smart buildings can reduce energy use by up to 30-50%, but many systems today fail to convert data into real-time, intelligent actions.

Challenge 3: Poor Communication and Alerts
Current energy management systems:

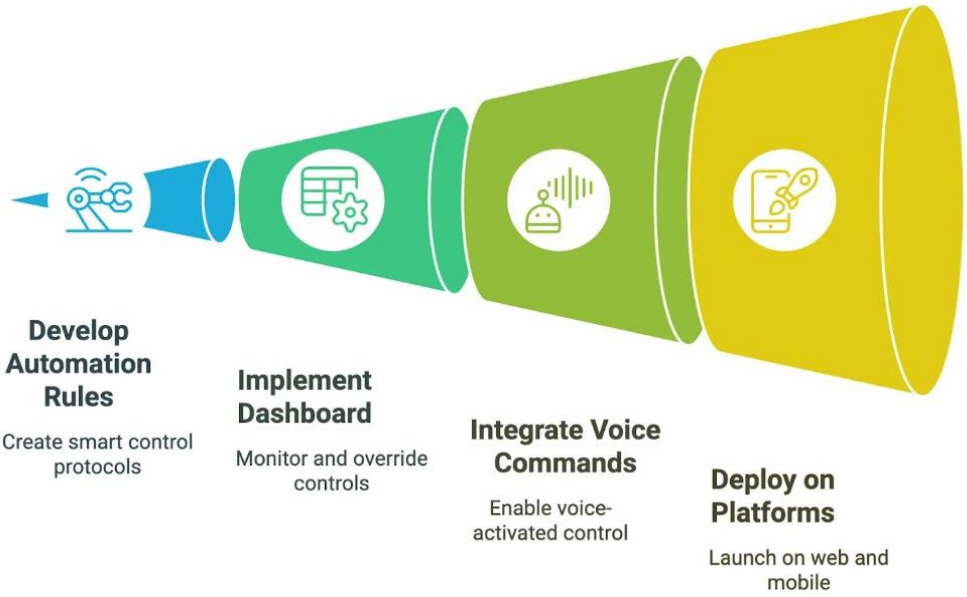
- Rarely use voice assistants like Google or Alexa for energy management.
- Lack smart, multi-channel alerts (voice, mobile, dashboard).
- Cannot notify users quickly during energy issues or emergencies.

71% of smart device users prefer voice interaction, but most energy systems fail to support this feature effectively. Integration gaps between IoT devices and voice assistants create user frustration and limit system usability.

Our solution combines:

- **AI-Powered Detection:**
  Automatically detects phantom loads, predicts energy usage, and spots electrical faults in real-time.

- **Smart Communication:**
  Uses Google Home/Alexa for voice-based control and alerts. Also provides a mobile dashboard for live monitoring and quick user action.
- **IoT-Based Automation:**
  Uses smart relays to automatically cut off phantom loads and WiFi sensors for real-time energy tracking



4. Proposed solution with methodology

Building upon the proven Raspberry Pi Smart Energy Monitor architecture, this enhanced system integrates advanced AI capabilities and voice assistant integration to create a comprehensive energy management solution.

Core Architecture Enhancement:
Base System: Raspberry Pi 4 with ADS1115 ADC and SCT-013 current sensors
AI Layer: Machine learning algorithms for phantom load detection and predictive analytics
Voice Integration: Google Home and Alexa API integration for notifications and control
Smart Control: Automated relay-based power cut-off with WiFi connectivity

Implementation Methodology:

Phase 1: Hardware Implementation
Deploy Raspberry Pi 4 with enhanced sensor array including multiple SCT-013 current transformers for distributed monitoring.
Integrate ZMPT101B voltage sensors and ESP32 modules for distributed sensing capabilities.
Install smart relays (16A capacity) with WiFi control for automated power management

Phase 2: AI Development
Develop phantom load detection algorithms using power signature analysis.
Implement anomaly detection for electrical faults and unusual consumption patterns.
Create predictive models for energy consumption forecasting using time-series analysis

Phase 3: Voice Assistant Integration

Implement Google Home notifications using Cloud-to-cloud integration APIs.

Develop Alexa Skills for voice alerts and device control

Create natural language processing capabilities for voice commands

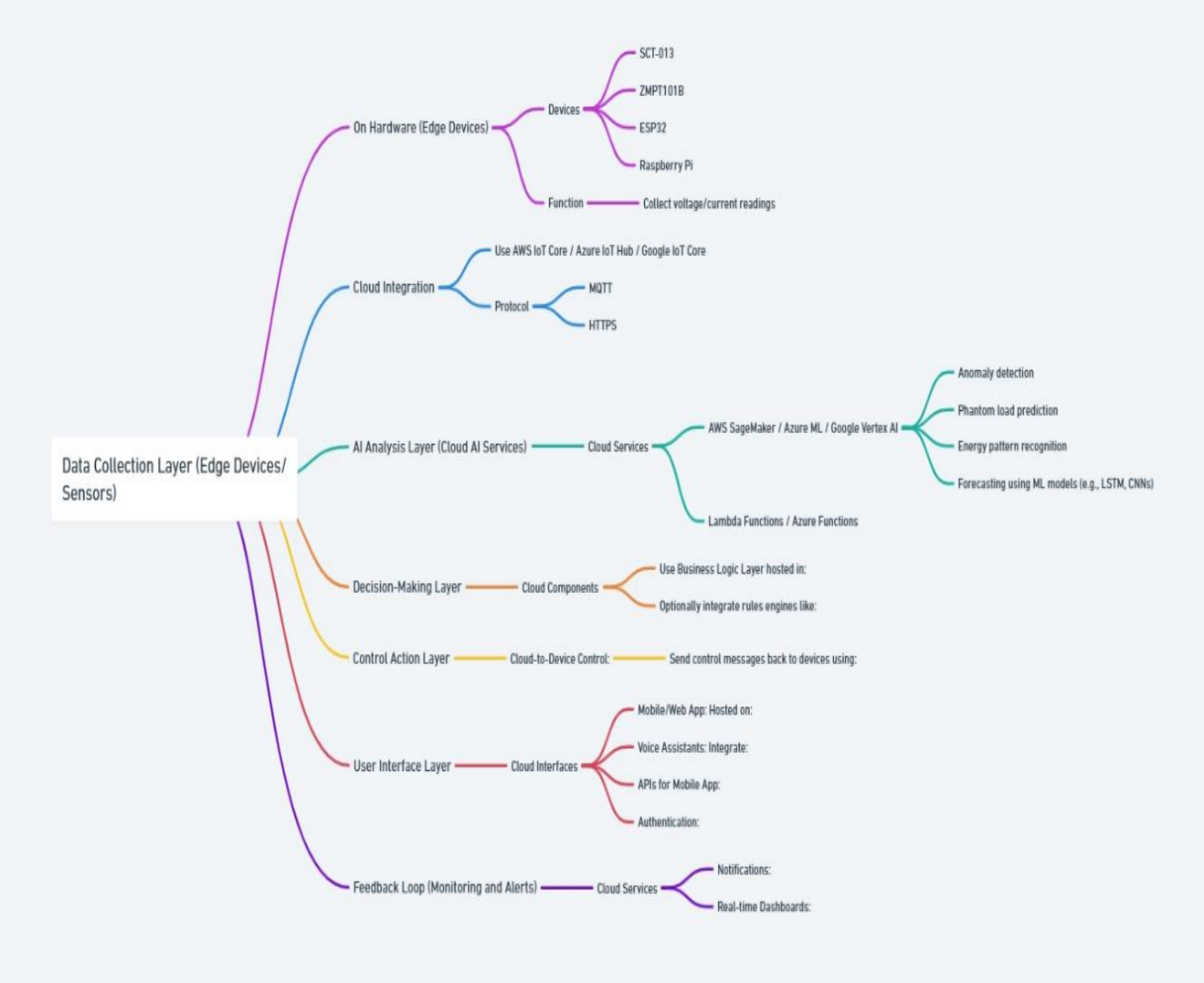
Phase 4: Mobile Dashboard and Cloud Services

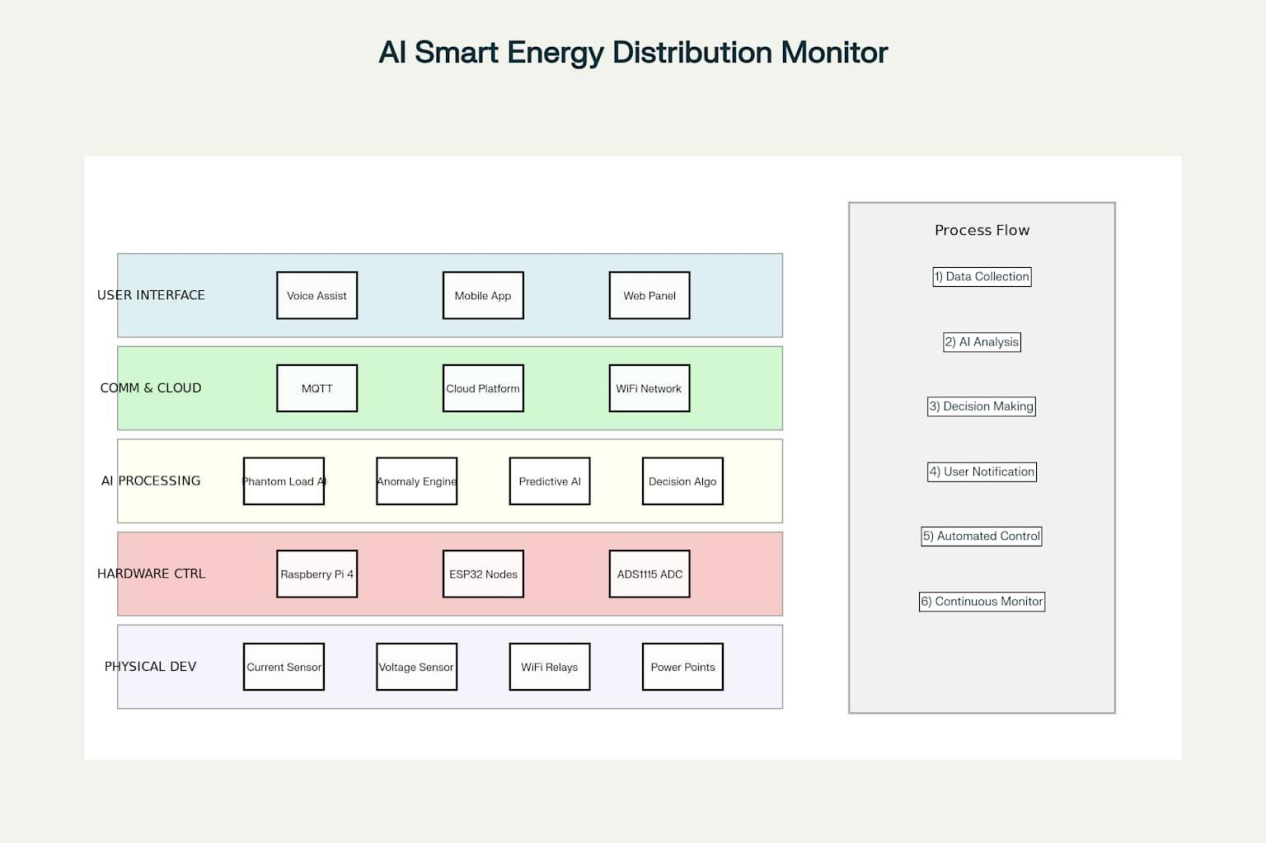
Build React Native mobile application for real-time monitoring and control

Implement MQTT communication protocol for IoT device coordination

Deploy cloud services using Adafruit IO or ThingSpeak for data analytics

Figure 1. Process flow/Methodology of proposed solution





5. Technical Approach

🔧 Hardware Components:

- Primary Controller: Raspberry Pi 4 (main processing unit)
- Sensors: ADS1115 16-bit ADC, SCT-013 current sensors, ZMPT101B voltage sensors
- Distributed Nodes: ESP32 modules for multi-point energy monitoring
- Control System: Smart WiFi relays (16A capacity) for automated power cut-off
- Connectivity: WiFi modules using MQTT protocol for real-time communication

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💻 Software Stack:

- Languages: Python (core), JavaScript (Node.js backend), React Native (mobile app)
- AI/ML Tools: TensorFlow or PyTorch for machine learning
- Communication Protocols: MQTT for IoT, HTTP/HTTPS for cloud connectivity
- Cloud Platforms: Adafruit IO, ThingSpeak, or custom cloud solution

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🤖 AI and Intelligence Features:

- Phantom Load Detection: Machine learning to identify standby power patterns

- Anomaly Detection: Real-time monitoring for electrical faults and abnormal power spikes
- Predictive Analytics: Forecasts energy consumption based on historical trends
- Behavioural Learning: Adapts to user habits for smart energy optimization

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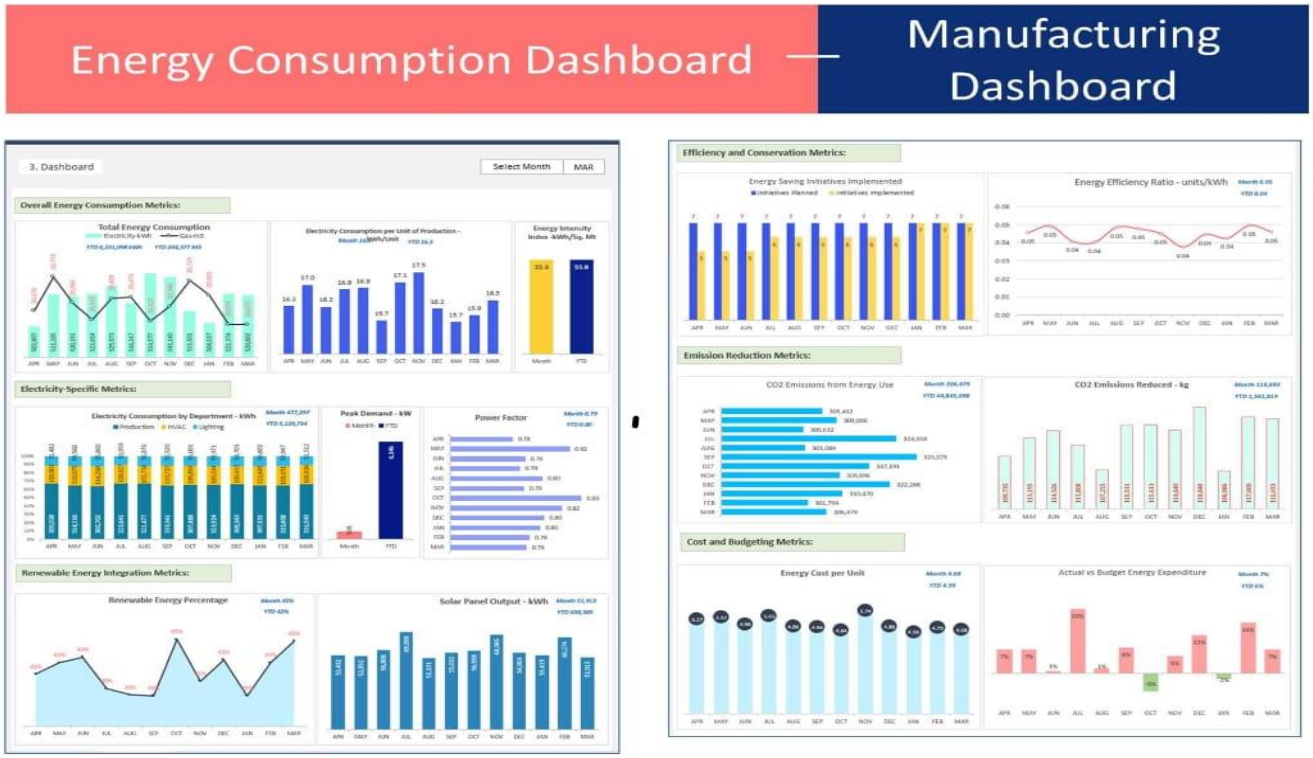
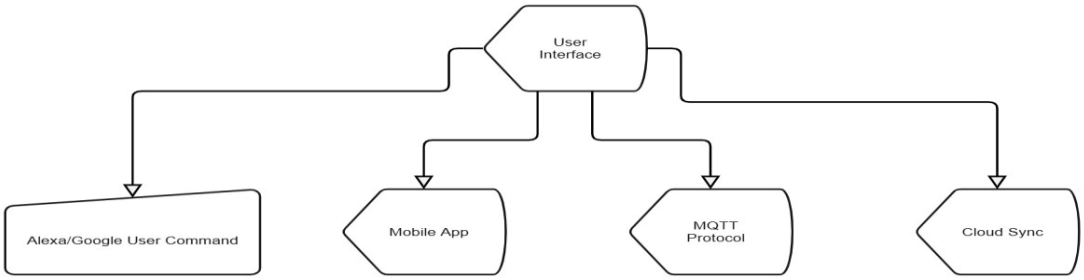
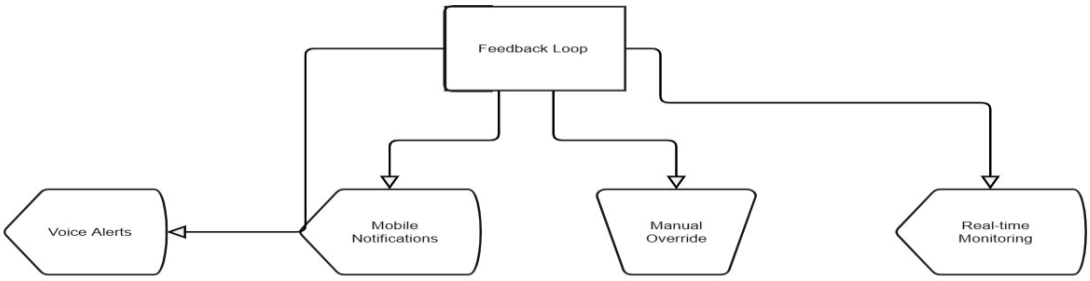
📢 **Voice Assistant Integration:**

- Google Home: Integrated via Google Assistant SDK for voice alerts and control
- Alexa: Custom Alexa Skills for voice commands and energy status updates
- Notifications: Voice alerts, mobile push notifications, and dashboard updates
- User Confirmation: Voice or mobile app confirmation for power cut-off actions



USER INTERACTION LAYER





6. Impact and Benefits

Energy Efficiency and Cost Savings:
Phantom Load Elimination: Potential 15-30% reduction in energy consumption through intelligent standby power management
Automated Optimization: AI-driven power scheduling during off-peak hours for additional cost savings
Real-time Insights: Comprehensive energy analytics enabling informed decision-making.

Safety and Protection:
Fault Detection: Automatic identification and response to electrical anomalies, overcurrent, and potential fire hazards.
Proactive Alerts: Immediate voice and mobile notifications for urgent electrical events.
Remote Monitoring: Continuous surveillance even when users are away from home

User Experience and Convenience:
Hands-free Operation: Voice control through popular smart speakers for accessibility.
Multi-platform Access: Mobile app, web dashboard, and voice interface options.
Intelligent Automation: Learning user patterns to provide personalized energy management

Scalability and Integration:
Smart Home Compatibility: Integration with existing Home Assistant, Google Home, and Alexa ecosystems.

Modular Design: Expandable system architecture for multi-room or multi-building deployment.
Commercial Applications: Adaptable for residential, commercial, and industrial energy management.

Environmental and Social Impact:
Carbon Footprint Reduction: Decreased energy waste contributes to environmental sustainability.
Energy Awareness: Educational value in promoting conscious energy consumption habits.
Economic Benefits: Reduced electricity bills and improved energy efficiency for households and businesses.