Smart Occupancy & Emergency Response System

Soteria

Objective

Develop a PoE-powered system that uses sensors and smart automation to provide real-time, energy-efficient emergency response with guided LED evacuation.

Problem Statement

Current systems lack real-time occupancy detection and visual guidance, leading to slower evacuations and reduced responder awareness.

Project Solution

Create a scalable emergency response framework for schools, hospitals, and commercial buildings.

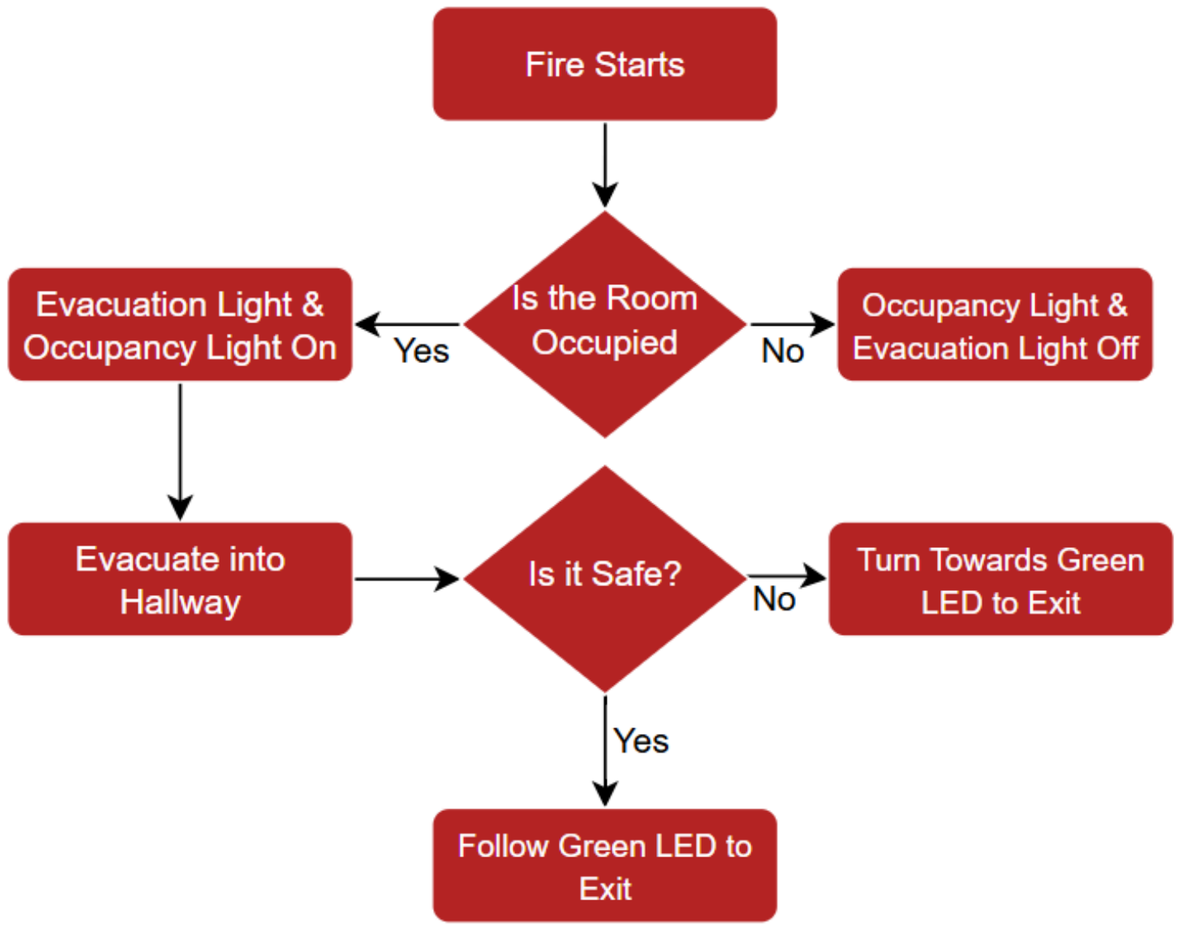
Technologies Used

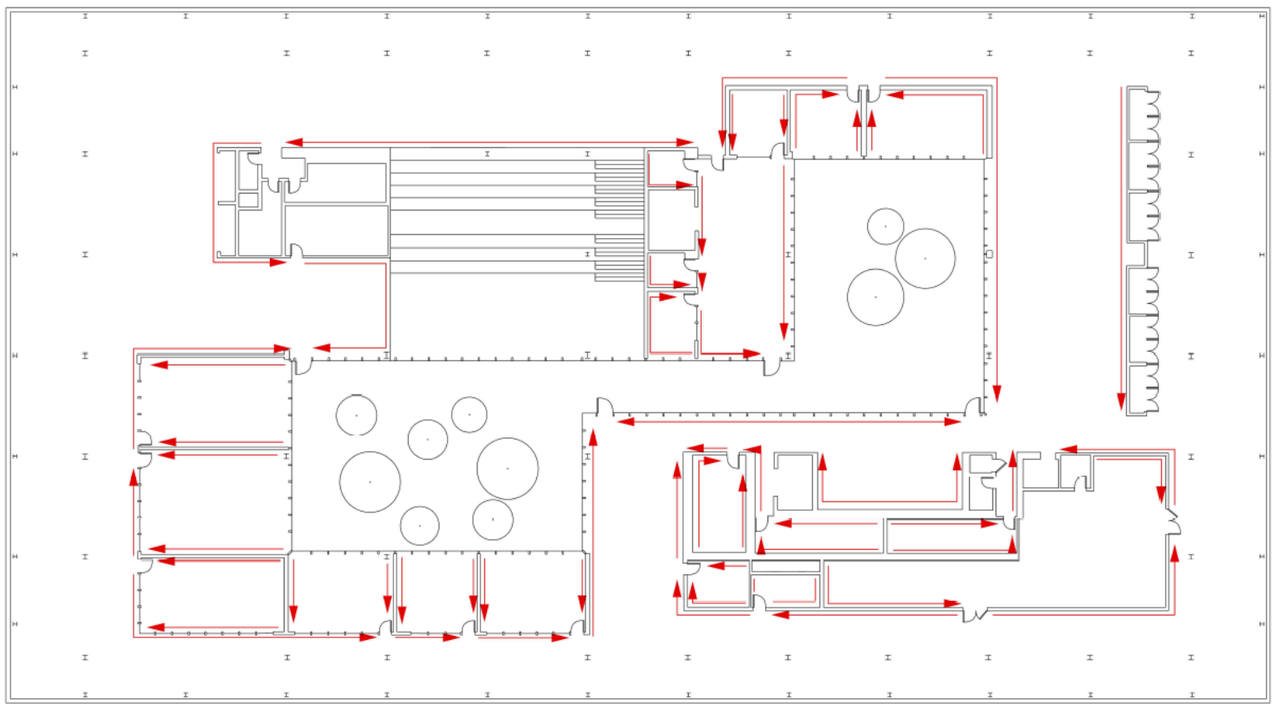
- ESP32 Microcontroller
- Breadboard
- Jumper Wires
- HLK-LD2410C Human Presence Radar Sensor
- DHT22 Temperature & Humidity Sensor
- MQ135 Air Quality Sensor
- WS2812B LED Strip

Key Benefits

- Guides people to safety in real time using LED lights that respond to room occupancy
- Saves energy with smart lighting that only turns on when needed, powered by PoE
- Easily expands to fit schools, hospitals, offices, and other buildings

How It Works





Team Responsibilities

- **Hardware Team:** Component selection, physical build, wiring design
- **Software Team:** Python programming, data handling, server integration, UI creation
- **Marketing Team:** Poster & business proposal

Soteria

Smart Occupancy & Emergency Response System

IPRO-497-615: Power Over Ethernet

Illinois Institute of Technology

05/02/2025

Project Overview

Soteria is designed to enhance emergency safety through automated, real-time evacuation guidance. At its core, Soteria uses a network of sensors that feed info into a central microcontroller that processes the data and triggers LED lighting patterns based on the real-time status of each room. What makes Soteria stand out is its wave-based LED guidance system. Lights activate only in occupied spaces, and use color-coded signals—such as green for occupied rooms needing help—to guide evacuations and focus responder attention where it's needed most. Rooms without lights are assumed to be empty, which helps reduce response times and confusion. The system is powered entirely through Power over Ethernet (PoE), which means both electricity and data travel through a single cable. This keeps installation simple and allows for centralized control.

Soteria is also built for the long term. It's modular, scalable, and compatible with various environments like schools, hospitals, and office buildings. By combining sensor intelligence, efficient infrastructure, and real-time responsiveness, Soteria aims to improve safety outcomes, reduce infrastructure complexity, and support faster, smarter decisions during emergencies.

Project History

IPRO-497: Power over Ethernet (PoE) is a multidisciplinary, multi-semester course in which students from various fields collaborate to design and refine a long-term technical solution. Each cohort contributes to the ongoing development of the project, building upon the work of previous teams.

The current focus, Soteria, is a PoE-powered emergency evacuation system which was first initiated in 2019. The project has evolved over time with input from successive student groups. While many teams have made valuable contributions and proposed meaningful recommendations, continuity between semesters has historically been a challenge. In Spring 2024, the Soteria project received major recognition, earning top honors at Innovation Day. That

cohort’s software team made substantial progress by developing a comprehensive codebase from the ground up.

In Fall 2025, our team focused not only on improving the system’s hardware, software, and marketing components, but also on strengthening communication and documentation to support future teams. One of the key new features we introduced is the ability to detect where people are inside the building using presence sensors. This allows the system to activate lights only in occupied areas, helping guide responders directly to where help is needed, while avoiding unnecessary alerts in empty spaces. Alongside that, the software team developed a new UI, integrated environmental and occupancy sensors, and set up data reporting. They also created internal documentation to help the next team pick up where we left off. That said, without a formal handoff process in place, there's still a risk that valuable work could get lost between semesters. Moving forward, setting up a shared repository, better version tracking, and a simple onboarding process would make it much easier for future teams to continue building on what’s been done and help Soteria keep evolving.

Problem Statement

Current emergency systems lack real-time occupancy detection and dynamic visual guidance, relying heavily on manual intervention and static alerts. These limitations delay evacuation and reduce responder awareness.

Project Scope

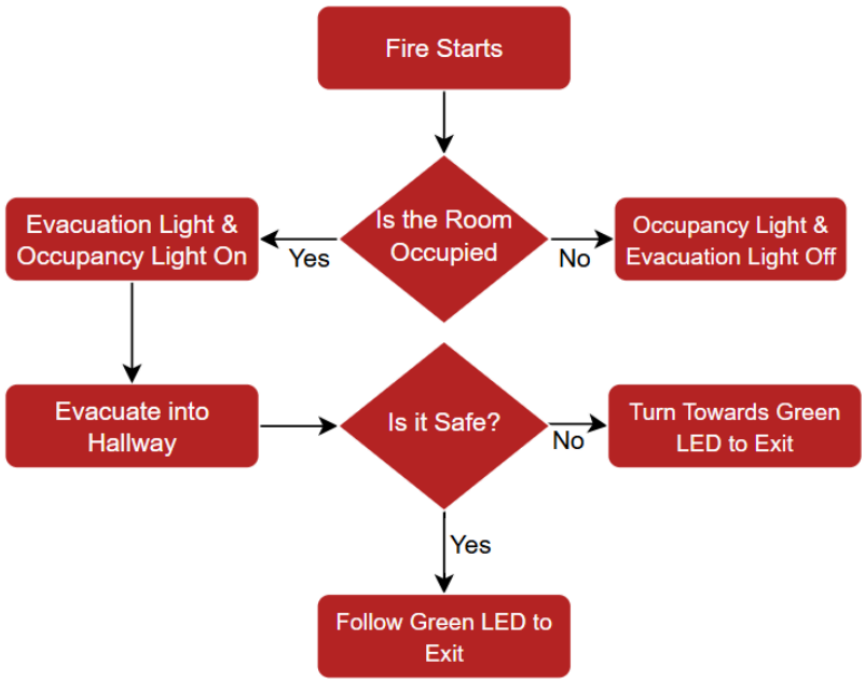
Create a scalable emergency response framework for schools, hospitals, and commercial buildings. The system will combine:

- Environmental and presence sensors
- PoE-powered LED lighting
- Microcontrollers and automation

- UI interface to view data

How the System Works

1. Sensors detect fire, poor air quality, and human presence.
2. ESP32 microcontroller collects sensor data and activates LED strip lighting via relay modules and sends it to a server.
3. If a hazard is detected and the room is occupied, LED strips activate in a wave-like pattern to guide occupants toward exits. Green lights indicate the room is occupied and assistance may be needed. If no lights are visible, it signals that the room is vacant and does not require immediate attention.
4. Once the room is vacated, lights automatically power down.
5. All components are powered via PoE, reducing infrastructure complexity and enabling centralized control.



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Software Integration

The Software Team is using Python to:

- Collect and process data from the DHT22 and MQ135 sensors
- Trigger and control LED outputs (up to 102 LEDs)
- Connect the ESP32 to Wi-Fi and stream data to a backend server

UI Development

- The UI is designed to display real-time sensor data, including temperature, air quality, and occupancy status.

Team Responsibilities

- **Hardware Team**: Component selection, physical build, wiring design
- **Software Team**: Python programming, data handling, server integration, UI creation
- **Marketing Team**: Poster and business proposal

Key Benefits

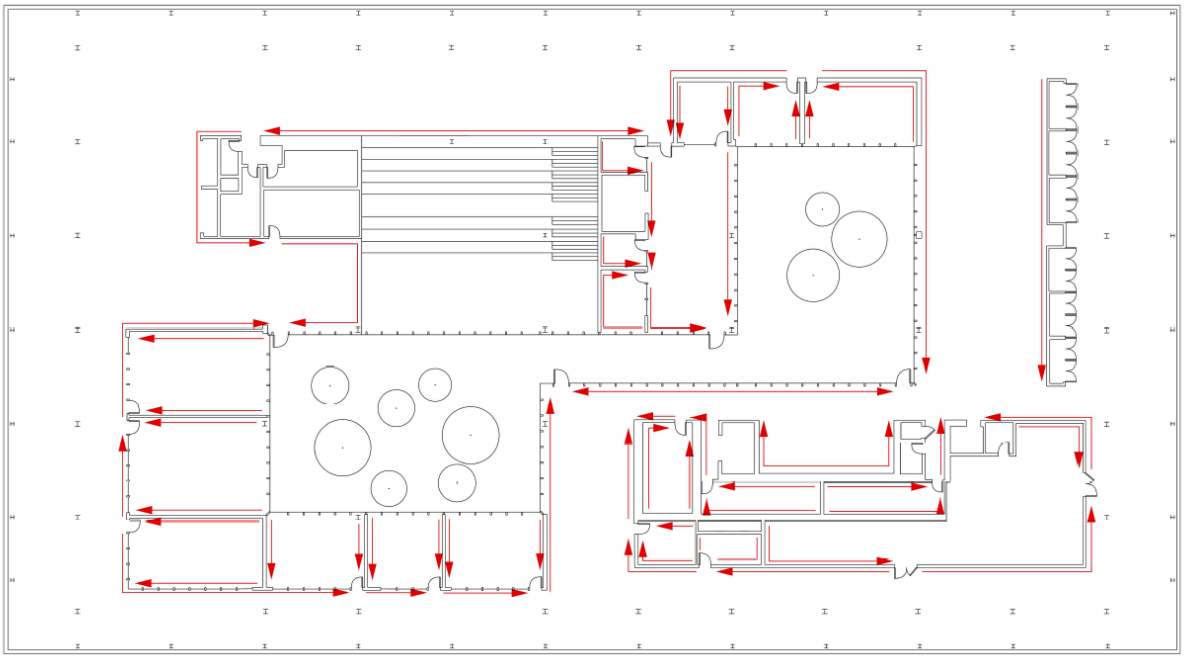
The system provides real-time evacuation guidance by activating LED lights based on room occupancy, ensuring that only necessary areas are illuminated during an emergency. It operates with high energy efficiency, using smart lighting logic and Power over Ethernet (PoE) to minimize power consumption. Designed for flexibility, the system is scalable and adaptable, making it suitable for a wide range of environments including schools, hospitals, offices, and other commercial spaces.

Future Expansion

In the future, the Soteria system aims to expand its capabilities by integrating AI for predictive alerts and intelligent evacuation patterns, allowing the system to anticipate hazards and respond even more efficiently. Plans also include developing a mobile app dashboard to enable real-time monitoring, control, and user notifications from any location. Additionally, the system is designed with scalability in mind, allowing for deployment in commercial and residential buildings, with enhanced features such as voice and sound-based indicators to further improve emergency communication and accessibility.

Visual Additions

LED Evacuation Floor Plan of Ed Kaplan at IIT



Hardware Model