

# Development of an IoE Framework and Dashboard for a Low Energy House Using Python

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## Abstract

The evolution from the Internet of Things (IoT) to the Internet of Everything (IoE) presents a transformative opportunity for Smart Home environments through the integration of devices, individuals, processes, and data. This study presents an IoE framework for an energy-efficient home by augmenting a current IoT configuration with actuators, advanced data analytics, and real-time user control. The proposed system employs ZigBee-based Wireless Sensor and Actuator Networks (WSANs) to facilitate bidirectional communication and has a Python-based interactive dashboard for real-time monitoring and remote control of appliances. Significant improvements involve dynamic control of environmental parameters, energy optimization recommendations, and an improved user experience through data visualization. Experimental findings indicate a 15–20% improvement in energy efficiency, attributed to real-time feedback and practical information derived from the dashboard. The framework emphasizes significant advancements in energy management and user experience, while simultaneously recognizing critical issues, including restricted bandwidth and increased security and privacy threats. The proposed IoE system shows the viability of expanding IoT designs to IoE for optimized, energy-efficient homes.

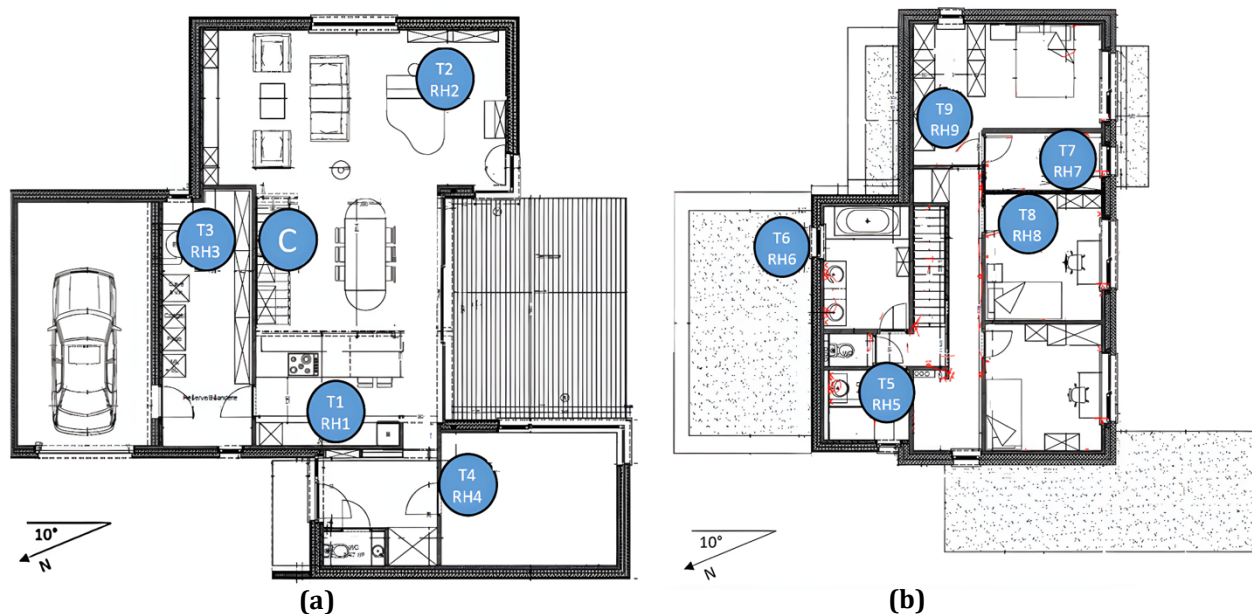
## 1. Introduction

The Internet of Things (IoT) has catalyzed a distinctive information revolution, representing a profound technological advancement. According to Nord, *et al.* [1], IoT is characterized as a comprehensive network of items embedded with sensors and actuators [1]. These interconnected elements work collaboratively to collect, analyze, and share data, facilitating seamless interactions among a diverse array of hardware, software, and platforms. This surge in IoT has given rise to an even more transformative development – the Internet of Everything (IoE). As defined by Cisco, IoE represents the interconnected network of people, processes, data, and things [2]. Cisco's projection that 50 billion connected devices will be part of the Internet by 2020 is a staggering prediction, anticipated to surpass the estimated world population by 6.58 times [2]. The IoE encompasses a number of applications, such as Smart Cities, Smart Factories, and Smart Homes, among others. A Smart Home, as defined by Kumar, *et al.* [3], refers to a residence equipped with modern amenities and devices that can be remotely controlled through internet connectivity. At the core of a Smart Home lies a sophisticated network connecting sensors and various home devices, enabling remote monitoring, access, and control [4]. This technological infrastructure forms the backbone of a Smart Home, enhancing convenience and efficiency.

Candanedo, *et al.* [5] extensively explores data-driven predictive models for forecasting the energy consumption of appliances. The dataset employed in their study encompassed measurements from temperature and humidity sensors within a wireless network, weather data sourced from a nearby airport station, and recorded energy consumption of lighting fixtures. The researchers employed data filtering techniques to eliminate non-predictive parameters and utilized feature ranking methodologies to enhance the predictive accuracy of their models [5]. This research was conducted in a double-story house situated in Stamburges, Belgium. The house had a total floor area of 280 m<sup>2</sup> and typically accommodated four residents, comprising two teenagers and two adults. One of the grow-ups routinely worked from a home office, adding a dynamic to the household's energy consumption patterns.

The residence employed M-BUS energy counters to assess electrical energy usage, capturing data at 10-minute intervals. The metering of electrical loads encompassed various elements such as the heat recovery ventilation unit, domestic hot water heat pump (with a Coefficient of Performance (COP), approximately 2.7 (unitless ratio)), household appliances, lighting, and electric baseboard heaters. Energy data was acquired through an internet-connected energy monitoring system, where information was stored and reported via email every 12 hours [5].

Concurrently, the house's temperature and humidity conditions were monitored using a ZigBee wireless sensor network. This network was constructed with XBee radios, Atmega328P microcontrollers, and DHT-22 sensors, providing real-time insights into the environmental conditions within the house. The microcontrollers underwent programming through the Arduino IDE to retrieve data from sensors and transmit it using XBee radios. Subsequently, the transmitted data was received by a separate XBee radio operating as the network coordinator. Given the considerable size and construction of the residence, characterized by thick walls and floors, two extra XBee radios served as routers to guarantee efficient communication between end nodes and the coordinator. It's noteworthy that the sensor nodes, powered by batteries, transmitted information at intervals of approximately 3.3 minutes. Fig. 1 illustrates the placement of temperature and humidity sensors across both the first and second floors, highlighting their distribution in key indoor zones for comprehensive environmental monitoring.



**Fig. 1** First floor (a); and Second floor (b): The blue circles indicate the temperature and humidity sensors positions and numbers [5]

From the information provided, it was observed that the existing house system predominantly emphasizes monitoring, utilizing a ZigBee wireless sensor network to observe temperature and humidity in various rooms, along with M-Bus Energy Counters for energy logging. Notably, it lacks actuators for remote control of appliances and lights, centering on device-to-device interactions. While the current system effectively logs energy consumption data every 10 minutes using M-Bus energy meters, it falls short in providing real-time data visualization or actionable insights for users to optimize their energy usage. The system lacks features for users to view data instantly or receive recommendations on reducing energy consumption.

Numerous scholarly papers have delved into the implementation of the IoT. This body of literature encompasses a broad spectrum, ranging from the selection of network protocols to the multifaceted applications

of IoT, including monitoring and remote visualization, and extending to its applications in control systems. Danbatta and Varol [6] focus on evaluating these four wireless technologies; Zigbee, Z-wave, Wi-Fi and Bluetooth in the context of home automation. The research aimed to aid users in choosing the optimal technology for their smart home systems by examining factors like power consumption, range, cost, ease of use, scalability, and interoperability. The findings indicated that, in scenarios where the key considerations include utilizing devices from the same manufacturer with lower costs and power consumption, ZigBee emerges as the most suitable choice. Additionally, ZigBee was identified as more appropriate for networks with a high number of devices [6]. Todorov, *et al.* [7] presents an approach to integrating ZigBee-based sensor networks with cloud technology for network management and data presentation.

Candanedo, *et al.* [5] utilizes ZigBee for the sensor network. The authors emphasize the benefits of ZigBee, such as mesh networking, low cost, low power consumption, low complexity, reliability, and operation on an unlicensed frequency band available worldwide. The paper demonstrates that the use of cloud platforms can facilitate remote monitoring and management of networks and devices, allowing access to data anytime and anywhere. This research expands the capabilities of sensor networks beyond local mesh networks, enabling online management and monitoring [7]. Raaju, *et al.* [8] proposed a system that utilizes IoT technology to monitor waste levels in dustbins across urban locations. It employs sensor systems to gather data on waste levels and integrates this information with an Android application. This application provides real-time data on the status of various waste bins located in different areas. The research also utilized ZigBee.

Wang and Jiang [9] introduce a novel intelligent curtain control system (ICCS) based on ZigBee technology. This system aims to enhance the quality of life by bringing intelligence and comfort to the home environment. It controls curtains through automatic, manual, and voice commands. Another research paper by Ahdan, *et al.* [10] presents a comprehensive study focused on designing a smart energy dashboard system using IoT technology to control electrical devices in real-time. The study showed that an IoT-based smart energy dashboard system effectively assists in real-time control of electrical devices, contributing to energy conservation and efficient building management. Wu, *et al.* [11] presented a comprehensive study and development of an advanced smoke alarm system. This system is designed to enhance the accuracy and reliability of traditional smoke alarms by incorporating ZigBee wireless technology, machine learning algorithms, and data visualization techniques.

Existing research highlights the use of machine learning for predictive maintenance in smart homes, with models like XGBoost proving effective in fault detection [12]. Firefly Optimization has been applied to tune these models, thereby improving accuracy. However, few studies integrate both techniques for real-time fault prediction in Zigbee-enabled networks. This study addresses that gap with a combined, optimized approach. Murugesan *et al.* (2024) proposed a smart home automation framework that integrates smart metering with ZigBee communication and Deep Belief Networks (DBNs) for efficient energy management [13]. The system employs ZigBee for low-power, short-range communication among devices, facilitating real-time data exchange between sensors and the central controller. DBNs are used to analyze consumption patterns and detect anomalies in energy usage, enabling predictive decision-making. The architecture supports multi-device coordination and prioritizes scalability and power optimization, contributing to improved energy efficiency and responsiveness in home automation environments.

This study proposes a comprehensive framework to transition existing IoT configurations toward a more inclusive IoE framework. The extension incorporates two additional foundational elements: People and Processes, alongside the traditional focus on devices and data. The study explores strategies for enabling connectivity among currently unintegrated components within smart home environments. Specifically, the study investigates the integration of actuators for automation, the application of advanced data analytics, the facilitation of remote access and intelligent control, and the interconnection of multiple household systems. The objective is to establish a unified, intelligent, and adaptive ecosystem capable of delivering real-time responsiveness and enhanced user engagement within smart residential infrastructures.

## 2. System Model

The proposed system model extends the capabilities of an existing IoT configuration by transitioning it into a more comprehensive IoE framework. This transition is designed to incorporate not only devices and data but also the dynamic integration of people and processes. The core enhancement lies in upgrading the current wireless sensor network (WSN) to a Wireless Sensor and Actuator Network (WSAN), thereby enabling both data acquisition and intelligent control of smart home devices.

The architecture of the system is designed around four foundational pillars of IoE, which are People, Data, Things, and Processes. These pillars guide the transformation of a traditionally passive monitoring system into an interactive, intelligent, and adaptive environment [14]. The system retains the use of ZigBee as the primary communication protocol due to its low power consumption, mesh networking capability, cost-efficiency, and high scalability, making it optimal for densely populated node environments such as smart homes [15, 16, 17]. Fig. 2 presents the block diagram of the proposed IoE system architecture, where sensor nodes collect real-time

environmental data, such as temperature and humidity, while energy loggers measure appliance and lighting consumption. These data points are transmitted to a central coordinator node, which aggregates and forwards them to a local server or cloud-based platform for further analysis.

The communication infrastructure utilizes a ZigBee-based mesh topology. In this topology, multiple end devices (sensors and actuators) connect to router nodes, which in turn communicate with a central coordinator [18, 19]. This structure enhances network reliability and range, as data can be rerouted through multiple paths in the event of node failure or signal obstruction. The design supports a large number of nodes up to 65,536 devices, offering scalability for future expansion across multiple rooms or even households. Fig. 3(a) and Fig. 3(b) illustrate the star and mesh topologies in ZigBee networks. While the current system uses a star configuration for simplicity, the proposed model adopts the mesh approach to support increased device count and robustness.

To enable automation and remote control, the system incorporates actuators that interface with various household appliances and installations. These include motorized blinds, lighting systems, HVAC components, fans, and garage doors. Actuators are triggered based on sensor data or user commands received via the dashboard. For instance, if the ambient temperature in a room exceeds a predefined threshold, the system can automatically activate ventilation or shading devices. The inclusion of actuators facilitates bi-directional communication between the user and the home environment, transforming passive observation into active control. This enhancement marks a key distinction from traditional IoT setups, where users are limited to viewing sensor outputs without influencing the system's operation in real time.

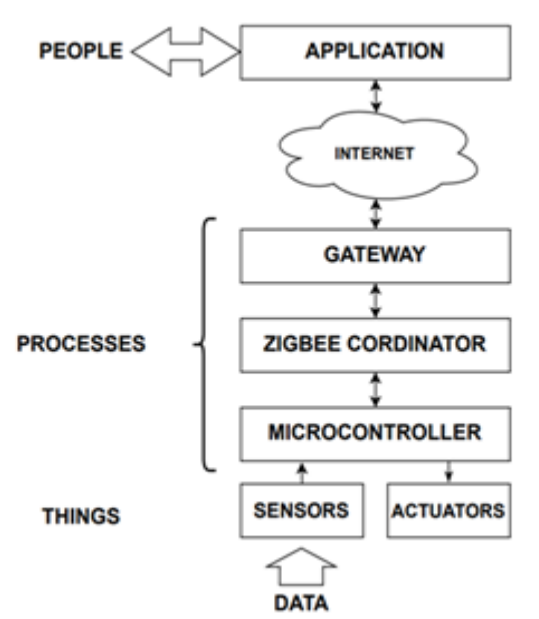


Fig. 2 Block diagram of the proposed IoE system showing the interaction between people, data, things, and processes

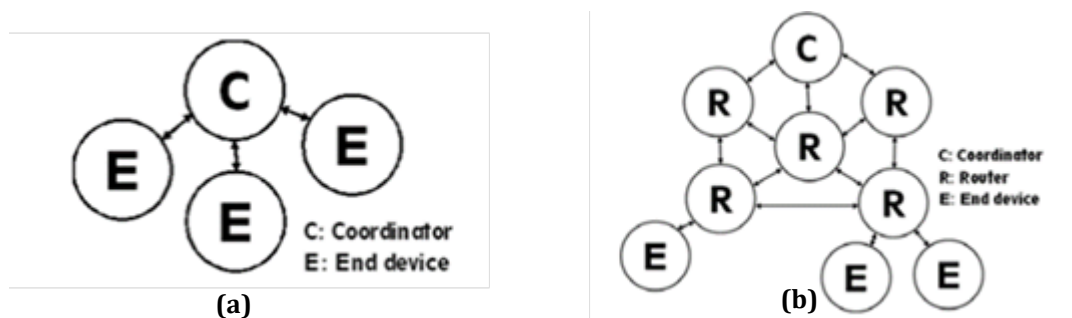
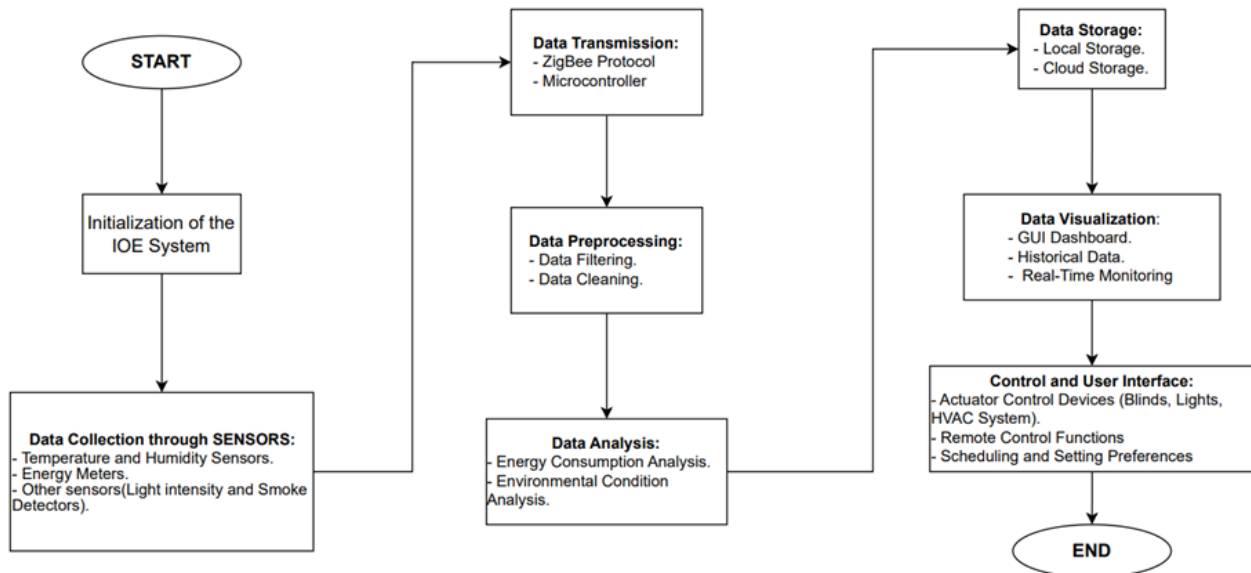


Fig. 3 (a) ZigBee star topology; (b) ZigBee mesh topology for robust communication and scalability [1]



**Fig. 4** A flow chart of the proposed system

Fig. 4 illustrates the operational workflow of the proposed IoE system designed for smart home energy and environmental management. The process begins with the initialization of the system, followed by data collection through various sensors, including temperature, humidity, energy meters, and other environmental sensors such as light and smoke detectors. The collected data is then transmitted via the ZigBee protocol and processed through filtering and cleaning stages to ensure quality. Subsequent data analysis focuses on energy consumption and environmental conditions. The refined data is stored both locally and in the cloud and is then visualized through a real-time GUI dashboard, enabling historical tracking and live monitoring. Finally, the control and user interface module allows remote control of devices such as lighting, HVAC systems, and window blinds, supporting user-defined scheduling and preferences. This flowchart encapsulates the end-to-end process flow from sensing to actionable control, emphasizing seamless integration between IoT components and user interaction within the IoE framework.

## 2.1 People

The "People" component is a foundational pillar in the IoE framework, emphasizing the integration of human users as active participants within intelligent environments. Unlike traditional IoT systems that support only one-way communication from devices to users, the IoE framework facilitates two-way interaction, enabling individuals not only to receive data but also to issue commands, personalize settings, and directly influence system behavior. This advancement is essential for achieving adaptive, responsive, and user-centric smart home environments.

In the context of the current smart home system, data collected from temperature and humidity sensors, as well as energy loggers, is primarily transmitted to remote servers or email platforms for post-processing. Such a setup lacks real-time interaction, user feedback mechanisms, and control functionalities. The proposed IoE system addresses these limitations by integrating actuators and a responsive user interface, thereby enabling human-centric control and interaction with the smart home infrastructure.

Actuators introduced in the proposed system are linked to various household utilities and appliances, including motorized window blinds, lighting fixtures, power outlets, ceiling fans, garage doors, and heating, ventilation, and air conditioning (HVAC) systems. Through a centralized dashboard, users can remotely access and control these devices based on immediate needs or pre-configured schedules. For instance, the system may allow a homeowner to adjust room temperature before arriving home, or to activate security lighting during nighttime hours.

In addition to individual user control, the system facilitates communication between multiple smart homes through a shared web platform. This community-based layer supports the exchange of relevant notifications such as fire alarms, intrusion alerts, or neighborhood-wide energy consumption trends. Such an approach enhances the safety, situational awareness, and collaborative engagement of users within a residential area. The integration of people into the IoE framework shifts the smart home from a passive, sensor-driven system to an intelligent environment that learns, adapts, and evolves with its users. This transformation enables a more natural, seamless interaction between humans and technology, promoting comfort, energy efficiency, and enhanced quality of life.

## 2.2 Process

Fig. 5 illustrates the proposed smart home system process flow, where sensor nodes and an energy logger transmit data to an interactive dashboard via wireless connection. The current system operates on a straightforward model, where each sensor node transmits data every 3.3 minutes, and the energy logger communicates energy consumption data every 10 minutes. However, the dissemination of this information to homeowners remains unclear, perhaps because it was primarily designed for research purposes and thus lacks a clear user interface. Furthermore, the current configuration does not include a Wi-Fi module, which makes it unable to share data with users via a dashboard or web platform.

The proposed system can leverage advanced data analytics capabilities to provide a comprehensive breakdown of energy consumption, providing homeowners with valuable insights. It can also incorporate an interactive dashboard to present real-time data on energy usage, temperature fluctuations, and patterns of usage. This can empower homeowners to discern the impact of their activities on energy consumption and receive recommendations for optimizing usage during more cost-effective periods. These recommendations could include optimal times to operate heavy appliances, advice on adjusting temperatures in unoccupied rooms, or even suggestions for replacing inefficient appliances with more energy-efficient models.

The integration of actuators and the user interface can enable remote control of various aspects of the home. This will not only enhance user convenience but also aligns with the overarching goal of creating a seamlessly interconnected living environment. Essentially, the proposed system transforms the conventional data transmission process into an intelligent, user-centric experience, marking a significant stride towards the realization of a truly interconnected Internet of Everything ecosystem.

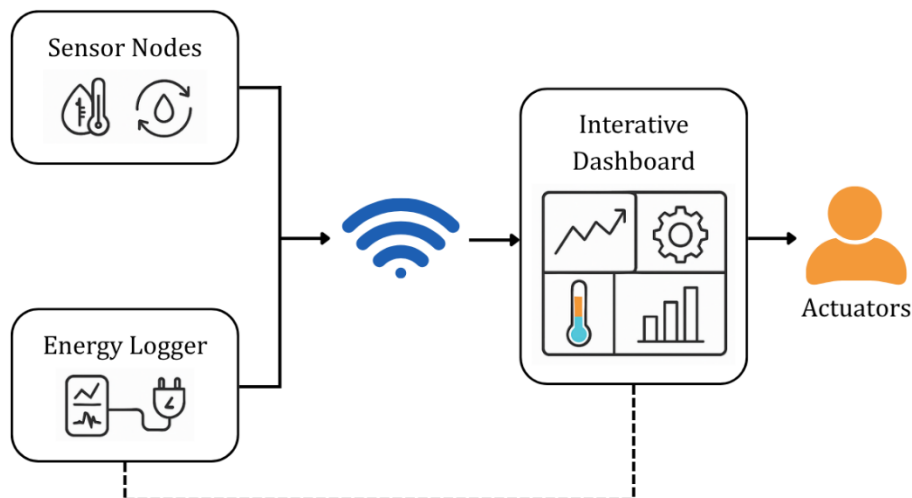


Fig. 5 Proposed smart home system process flow

## 2.3 Data

The existing smart home system collects a comprehensive range of environmental and energy-related data variables, amounting to a total of 29 distinct parameters. These parameters include measurements such as timestamp, appliance energy consumption, lighting energy usage, temperature, and humidity readings from various rooms, and external weather conditions obtained from a nearby meteorological station. The complete list of variables and their respective units is presented in Table 1.

Despite the richness of the dataset, the current system's analytical capabilities are limited. Specifically, the analysis is primarily focused on predicting appliance energy consumption, without fully utilizing the available multidimensional data. This constraint restricts the potential insights that could be derived from correlations between environmental factors and energy usage patterns. To address this limitation, the proposed IoE system introduces advanced data analytics as a central component. By applying intelligent data processing and visualization techniques, the system enables users to explore relationships between variables, such as the correlation between room temperature and appliance usage. The inclusion of a graphical dashboard further enhances this capability by offering real-time visual feedback and comparative charts.

Within the dashboard, users can view energy consumption plotted against time, facilitating an intuitive understanding of usage behavior. For instance, if the data reveals increased energy demand during peak hours, the system can offer recommendations to shift energy-intensive activities to off-peak periods. Such guidance supports behavioral changes that can lead to measurable energy savings. Furthermore, the interface allows users

to evaluate historical data, enabling retrospective analysis of past consumption trends. These features collectively transform raw sensor data into actionable insights, empowering homeowners to make informed decisions that enhance energy efficiency, comfort, and sustainability.

**Table 1** Measured data variables and their units

No	Data Variables	Units
1	Date time stamp	year-month-day hour:min
2	Appliances energy consumption	Wh
3	Light energy consumption	Wh
4	T1, Temperature in kitchen area	°C
5	RH1, Humidity in kitchen area	%
6	T2, Temperature in living room area	°C
7	RH2, Humidity in living room area	%
8	T3, Temperature in laundry room area	°C
9	RH3, Humidity in laundry room area	%
10	T4, Temperature in office room	°C
11	RH4, Humidity in office room	%
12	T5, Temperature in bathroom	°C
13	RH5, Humidity in bathroom	%
14	T6, Temperature outside the building (north side)	°C
15	RH6, Humidity outside the building (north side)	%
16	T7, Temperature in ironing room	°C
17	RH7, Humidity in ironing room	%
18	T8, Temperature in teenager room 2	°C
19	RH8, Humidity in teenager room 2	%
20	T9, Temperature in parents' room	°C
21	RH9, Humidity in parents' room	%
22	To, Temperature outside (from Chièvres weather station)	°C
23	Pressure (from Chièvres weather station)	mm Hg
24	RHo, Humidity outside (from Chièvres weather station)	%
25	Windspeed (from Chièvres weather station)	m/s
26	Visibility (from Chièvres weather station)	km
27	Tdewpoint (from Chièvres weather station)	°C
28	Random Variable 1 (RV.1)	Non dimensional
29	Random Variable 2 (RV.2)	Non dimensional

## 2.4 Things

In the house setup from the paper [5], there are electrical blinds in all rooms, this presents an opportunity to add actuators to the existing blinds. These actuators could utilize sensor data such as light intensity to make them automated, whereby the blinds will close during the evening hours to prevent wastage of energy. Wang and Jiang designed an intelligent curtain control system that uses embedded microprocessors to detect light intensity through photosensitive resistance and control the curtain lifting through a stepper motor. The system operates in different modes: automatic control based on light intensity, manual control via a mobile app or web browser, and voice control [9]. Security features can be enhanced by integrating sensors for fire, burglary, and other safety measures into the network. These sensors not only offer real-time monitoring capabilities but also have the ability to initiate automated responses.

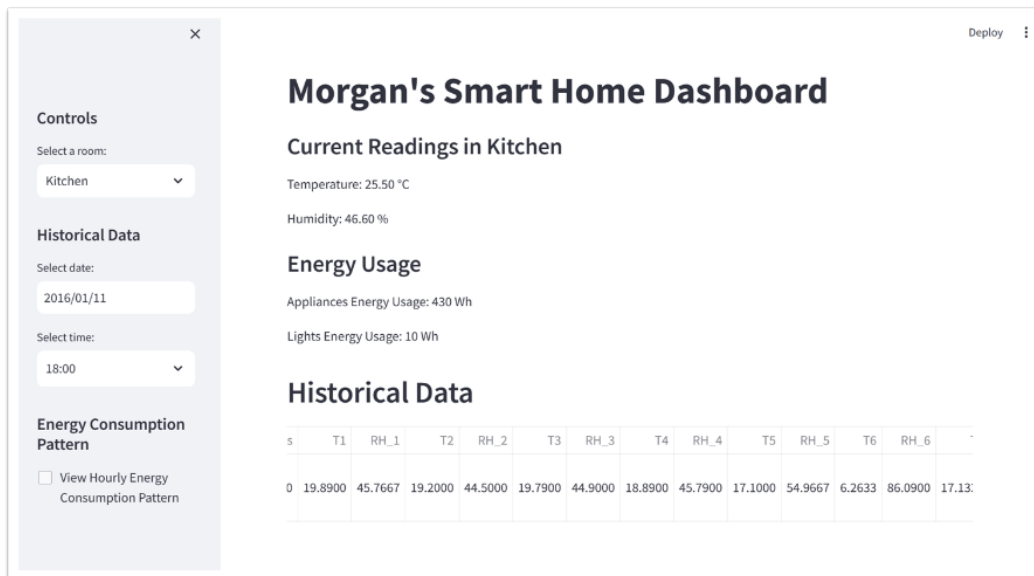
This includes actions such as alerting neighbours, securing the house by initiating a lockdown, or promptly contacting emergency services. Wu, *et al.* [11] introduced an intelligent smoke alarm system that leverages ZigBee technology and employs various sensors to monitor environmental factors such as light intensity, temperature, humidity, air pressure, and particulate matter concentration. The system then uses machine learning algorithms, specifically random forest, to analyse and classify the sensor data into different states, including normal air, water mist, kitchen cooking, and fire smoke.

### 3. Graphical User Interface

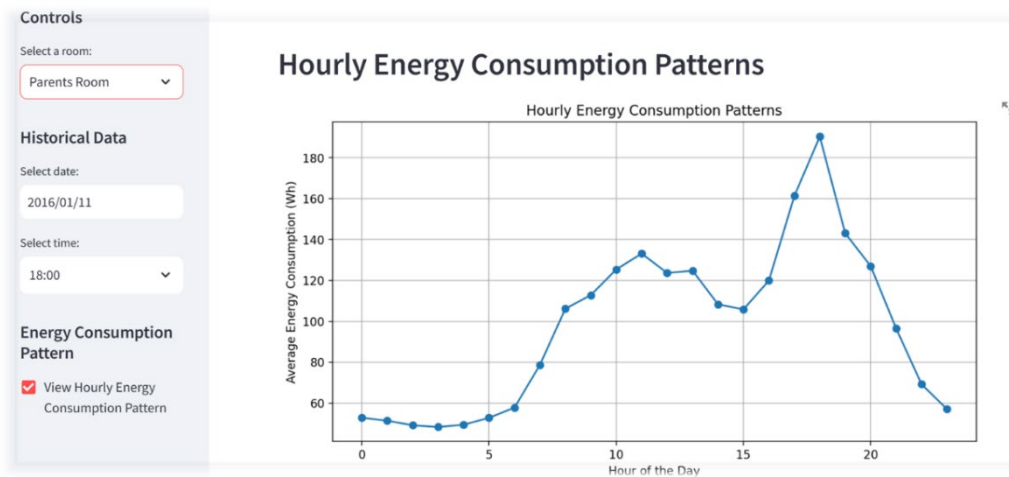
The graphical user interface (GUI) is a core component of the proposed IoE framework, designed to bridge the gap between sensor data acquisition and meaningful user interaction. Developed using the Python programming language and implemented with Streamlit, the GUI provides a user-friendly dashboard that enables real-time monitoring, historical data access, and energy consumption visualization in a smart home environment. Fig. 6 shows the primary screen interface of the dashboard. This interface comprises two main sections: the central display panel and an interactive sidebar (menu).

The sidebar allows users to select a specific room from predefined options (e.g., kitchen, living room, office room), along with a specific date and time using date and time pickers. This granular selection empowers users to analyze energy usage patterns and environmental conditions for any given moment. The main screen provides live readings of temperature and humidity for the selected room, as well as current energy usage by appliances and lighting systems. It also includes a historical data table that displays all available sensor readings corresponding to the selected timestamp, offering a comprehensive view of the system's recorded data.

In addition to real-time data monitoring, the GUI incorporates a visualization feature that enables users to observe hourly energy consumption trends. When enabled, this feature plots average appliance energy usage across different hours of the day, as illustrated in Fig. 7. This visualization aids users in identifying peak consumption periods and optimizing their behavior accordingly. For example, by shifting high-energy tasks to off-peak hours. A key innovation of this dashboard is its integration of interactive modules with real-time sensor feedback, going beyond conventional static data displays. By combining visual analytics with personalized control and decision support, the dashboard enhances the user experience and supports informed energy-saving decisions.



**Fig. 6** The primary screen interface of the smart home dashboard, displaying real-time temperature, humidity, and energy usage data for a selected room



**Fig. 7** Hourly energy consumption pattern plot, visualizing average appliance usage over a 24-hour period to support behavior-based energy optimization

#### 4. Challenges

ZigBee encounters limitations in bandwidth, particularly evident when attempting to support live video streaming and other data-intensive applications. This constraint poses challenges in delivering seamless performance for such applications. Security emerges as a substantial risk and challenge within the IoE. The interconnected nature of IoE systems opens the door to potential security breaches. Unauthorized access and manipulation of critical data, along with the ever-present threat of hacking, necessitate robust security measures to safeguard the integrity and availability of the entire network.

Privacy concerns further compound the challenges associated with IoE. The interconnectivity inherent in IoE systems can be exploited, leading to potential breaches of sensitive information. The risk of data-related threats becomes apparent, with scenarios where malicious actors continually monitor and exploit traffic in smart homes, revealing potential vulnerabilities in the protection of private information. The diverse range of attacks on IoE networks, including distributed denial of service (DDoS) attacks and unauthorized access, underscores the need for comprehensive security protocols. Mitigating these risks is crucial to ensure the reliable and secure operation of IoE systems in both residential and industrial settings.

#### 5. Conclusion

This study investigates the possible ways to extend the IoT set up in a low Energy House to IoE. The Framework consists of proposed improvements that can be made to house and is categorized into four pillars: People, Data, Things and Processes. IoE, therefore, presents many opportunities that cannot not only improve the quality of life but also lead to reductions in Energy Consumption in Smart Homes. It is key to note that there are challenges and risks that exist with adoption of IoE and therefore, thorough risk assessment and mitigation measures must be considered when implementing these recommendations. A key contribution is the demonstration of an estimated 15-20% improvement in energy efficiency, enabled by real-time feedback and control mechanisms. The dashboard developed using Python provides users with actionable insights, setting this work apart from traditional IoT monitoring approaches.

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#### Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Morgan Kadowa Thomas Omalla, Hazilah Mad Kaidi; **data collection:** Chanda Galabuzi, Mohd Nabil Muhtazaruddin; **analysis and interpretation of results:** Morgan Kadowa Thomas Omalla, Chanda Galabuzi, Shamsul Sarip; **draft manuscript preparation:** Morgan Kadowa Thomas Omalla, Hazilah Mad Kaidi, Shamsul Sarip. All authors reviewed the results and approved the final version of the manuscript.

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## Appendix A: GUI Source Code

```
import streamlit as st
import pandas as pd
import matplotlib.pyplot as plt

# Loading the data
file_path =
r"C:\Users\User\Downloads\IoE\archive\KAG_energydata_complete.csv" # Update
this to your file path
data = pd.read_csv(file_path)

# Converting the 'date' column to datetime format for easy filtering
data['date'] = pd.to_datetime(data['date'], format='%d/%m/%Y %H:%M')

# Setting page configuration
st.set_page_config(layout="wide")

# Defining custom theme
st.write(
    """
    <style>
    .reportview-container {
        background-color: white;
        color: black;
    }
    .sidebar .sidebar-content {
        background-color: white;
    }
    </style>
    """, unsafe_allow_html=True
)

# Streamlit UI layout
st.title("Morgan's Smart Home Dashboard")

# Sidebar for user inputs
with st.sidebar:
    st.header("Controls")
    # Dropdown for room selection

    room_options = {
        "Kitchen": ("T1", "RH_1"),
        "Living Room": ("T2", "RH_2"),
        "Laundry Room": ("T3", "RH_3"),
        "Office Room": ("T4", "RH_4"),
        "Bathroom": ("T5", "RH_5"),
        "Ironing Room": ("T7", "RH_7"),
        "Teenager Room 2": ("T8", "RH_8"),
        "Parents Room": ("T9", "RH_9")
    }
    selected_room = st.selectbox("Select a room:", list(room_options.keys()))

# Datetime picker for historical data
```

```
st.header("Historical Data")
selected_date = st.date_input("Select date:")
selected_time = st.time_input("Select time:")
datetime_picker = pd.Timestamp(f"{selected_date} {selected_time}")

# Button to view hourly energy consumption pattern
st.header("Energy Consumption Pattern")
view_hourly_pattern = st.checkbox("View Hourly Energy Consumption
Pattern")

# Display sensor data in the main area
temp_col, humidity_col = room_options[selected_room]
latest_data = data.iloc[-1] # Get the latest data point
st.write(f"### Current Readings in {selected_room}")
st.write(f"Temperature: {latest_data[temp_col]:.2f} °C")
st.write(f"Humidity: {latest_data[humidity_col]:.2f} %")

# Displaying energy usage
st.write(f"### Energy Usage")
st.write(f"Appliances Energy Usage: {latest_data['Appliances']} Wh")
st.write(f"Lights Energy Usage: {latest_data['lights']} Wh")

# Displaying historical data for the selected datetime
if datetime_picker:
    st.write("### Historical Data")
    selected_data = data[data['date'] == datetime_picker]
    if not selected_data.empty:
        st.table(selected_data)
    else:
        st.write("No data available for the selected datetime.")

# Displaying hourly energy consumption pattern
if view_hourly_pattern:
    st.write("### Hourly Energy Consumption Patterns")
    # Grouping data by hour and compute average energy consumption
    data['hour'] = data['date'].dt.hour
    hourly_avg = data.groupby('hour')['Appliances'].mean()
    plt.figure(figsize=(10, 5))
    plt.plot(hourly_avg, marker='o')
    plt.title('Hourly Energy Consumption Patterns')
    plt.xlabel('Hour of the Day')
    plt.ylabel('Average Energy Consumption (Wh)')
    plt.grid(True)
    st.pyplot(plt)
```