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IOT BASED SMART LOAD MANAGEMENT

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Abstract- This research paper has a primary objective of developing standardized descriptions and practices for smart home devices that are employed in demand response and load management applications within residential or light commercial settings. The initial version of the research paper specifically concentrates on control application domains like sensing device control, pricing and demand response, as well as load control. The paper also introduces smart home interfaces and device definitions that play a crucial role in promoting interoperability among various manufacturers of electrical equipment, meters, and smart energy enabling products. By establishing these standardized descriptions and practices, the research paper aims to enhance the compatibility and seamless integration of smart home devices, ultimately leading to more efficient and effective demand response and load management in the context of smart homes.

INTRODUCTION

IoT-Based Smart Load Management is a sophisticated system that harnesses the power of the IoT (Internet of Things) to effectively control and monitor energy load within a specific area. Its primary objective is to enhance energy efficiency, reduce energy costs, ensure higher reliability, and promote overall safety. By leveraging an interconnected network of sensors, actuators, and other intelligent devices, this system can actively detect, analyze, and regulate energy consumption patterns, leading to optimized energy usage and minimized wastage. Moreover, it enables real-time data acquisition and analysis for efficient energy management and optimization. In industrial applications, the proposed system showcases its capabilities by seamlessly integrating IoT technologies, advanced sensor mechanisms, and data analytics to continuously monitor and manage power consumption. It proactively identifies any anomalies or irregularities in power usage, allowing for timely notifications and alerts to the concerned user or operator. Through its comprehensive approach to load management, the IoT-Based Smart Load Management system promises to revolutionize energy utilization practices and pave the way for a more sustainable and resource-efficient future.

BLOCK DIAGRAM

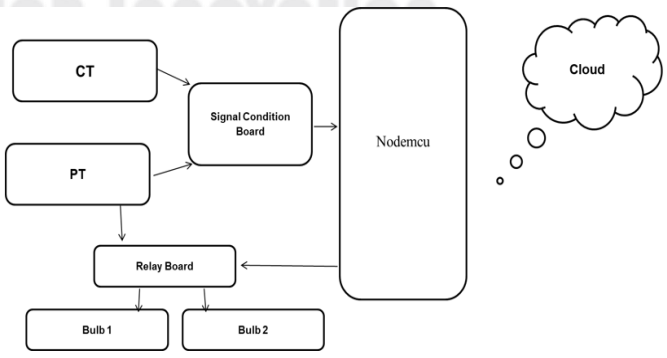

Fig: Block Diagram of IOT Based smart load management

EXISTING SYSTEM

The current system for smart load management heavily relies on manual processes, where users are responsible for manually monitoring and controlling their power consumption. This manual approach is not only inefficient but also susceptible to human errors, leading to suboptimal energy management. Moreover, the lack of automated monitoring and analysis means that users have no means to detect irregularities in power usage or receive valuable insights and recommendations on how to optimize their energy consumption. This limitation further hinders the ability to achieve energy efficiency goals and make informed decisions regarding power usage. A more advanced and automated smart load management system is needed to address these drawbacks and enable users to efficiently monitor, control, and optimize their power usage while minimizing human error and gaining valuable insights for energy optimization.

DISADVANTAGES:

- The system is employed with a wired connection.
- The reason for using wired communication is to replace existing wired systems.
- Implementing a wired system requires careful planning and construction work to ensure efficiency and a clean design.
- The use of a wired connection introduces hardware complexity into the system.

PROPOSED SYSTEM

The proposed smart load management system is an IoT-based solution that leverages sensors and data analytics to effectively monitor and control power usage specifically in industrial applications. By utilizing a network of sensors, the system can accurately detect any anomalies or deviations in power consumption, promptly alerting the user or operator to potential issues. Additionally, the system goes beyond anomaly detection and offers valuable insights and recommendations on how to optimize power usage. This enables users to make informed decisions and implement energy-efficient practices, ultimately improving energy management and reducing costs. With its advanced capabilities, the proposed system aims to enhance operational efficiency and sustainability in industrial settings by providing real-time monitoring, proactive alerts, and actionable recommendations for optimizing power usage.

Advantages

- Energy Efficiency is improved
- Lower Energy Costs
- Increased Reliability
- Increased Safety

HARDWARE COMPONENTS

- Nodemcu
- CT (Current Transformer)
- PT(Potential Transformer)
- Relay Board
- Bulbs(2)

Software Requirement

- Arduino IDE
- Embedded-C
- IOT

LITERATURE SURVEY

“A survey on smart metering and smart grid communication, Renewable and Sustainable Energy Reviews”:

This research focuses on the extensive study of smart communication and metering methods within the context of smart grids. It highlights that while control and monitoring processes are commonly used in industrial systems. The evolution of smart grids is driven by energy management requirements of both service providers and consumers. The paper aims to provide a clear understanding of what smart grids are and the various communication methods utilized within them.

"Hybrid nanogrids development to improve residential reliability and resiliency supply: Testing and implementation, Tropical Renewable Energy Center, Universitas Indonesia":

This paper proposes a novel concept called "Dual Power Nanogrids" as a solution improving the reliability and resiliency of power supply for residential sectors, particularly relevant during the COVID-19 pandemic when most activities are conducted at home. It divides the voltage into two parts: DC voltage and AC voltage, supplied through a 230 VAC inverter for motor/inductive loads.

"A survey on smart grid technologies and applications, Journal of King Saud University - Computer and Information Sciences":

This survey paper explores various aspects of smart grid technologies and applications. It highlights that a smart-grid, an advanced digital power system capable of two-

way power flow, self-healing, adaptability, resilience, and sustainability. The paper covers topics such as enabling smart grid metering and communication in technologies, cloud computing in smart grids, and smart grid applications.

"Grid-Tied Distributed Generation Systems to Sustain the Smart Grid Transformation: Tariff Analysis and Generation Sharing, Frontiers in Energy Research - Electrical Applications":

This paper introduces a novel model that has been proposed and analyzed by ENEL, the largest electric utility in Chile. The model specifically addresses electric power control and energy management for a residential building comprising 60 apartments. This case study serves as an exemplification of ENEL's green energy program, which is an integral part of their Smart Grid Transformation plan. The plan entails the implementation of grid-tied distributed generation (DG) systems, particularly microgrids, equipped with solar generation and energy storage technologies in Santiago, Chile. By presenting this model and case study, the paper highlights the utility's commitment to sustainable energy practices and showcases the potential of smart grid technologies in optimizing energy management at the residential level.

Hardware module

Nodemcu

The ESP32s module is a versatile and affordable device designed to facilitate internet connectivity for various projects. It offers the flexibility of operating as either an access point, enabling the creation of a local network, or as a station, allowing connection to existing Wi-Fi networks. This functionality enables the module to fetch data from the internet and upload data from connected devices, making it a valuable component in Internet of Things (IoT) applications. Additionally, the module supports communication with APIs, enabling access to a wide range of information available on the internet. Notably, the ESP32s module can be conveniently programmed using the Arduino IDE, providing a user-friendly development environment. It is worth mentioning that while this version of the module has two GPIO pins (expandable to four with certain modifications), it can be used in conjunction with other microcontrollers, such as Arduino, or standalone versions of the ESP-12 or ESP-32 for projects requiring more GPIO pins. Overall, the ESP32s module offers an accessible and efficient solution for initiating IoT projects or adding internet connectivity to existing projects. This versatility enables easy data retrieval and uploading to the internet, making it ideal for Internet of Things (IoT) applications. The module can also fetch data from the internet using APIs, expanding the range of available information for your project. Another notable feature is its compatibility with the Arduino IDE, simplifying the programming process. However, it is important to note that this version of the module has only 2 GPIO pins, although it can be modified to utilize up to 4 pins. If more GPIO pins are required, alternative versions such as ESP-12 or ESP-32 may be considered. Overall, the ESP32s module is a suitable choice for beginners in IoT or projects requiring internet connectivity.

Current Transformer

A current transformer (CT) is an electrical transformer used for measuring or monitoring electric current flowing through a conductor. It plays a crucial role in electrical power systems, serving various applications including protection, control, metering, and monitoring. CTs are designed for specific current ratings and accuracy classes based on their intended purpose. They are commonly employed in high-voltage electrical systems, such as power substations and distribution networks, to provide precise current measurements for protection relays, energy meters, and other monitoring devices. Additionally, CTs find application in industrial and commercial settings to measure current in motor control circuits, HVAC systems, and other electrical equipment. Key characteristics of current transformers include accuracy, burden rating (indicating the maximum load connected to the secondary winding without affecting measurement accuracy), and saturation characteristics (the point at which nonlinear behavior occurs due to excessive current). They are engineered to operate safely and efficiently under normal and fault conditions, adhering to industry standards and regulations to ensure reliability and performance

Potential transformer:

Potential transformers (PTs) are indeed used to step down high voltage levels to a lower, measurable level that is safe for use with standard metering or monitoring equipment. Here are some additional points regarding potential transformers: PTs are commonly utilized in high-voltage electrical systems, such as power substations and distribution networks, where accurate voltage measurements are essential for protection relays, energy meters, and other monitoring devices.They also find application in industrial and commercial settings to measure voltage in various electrical equipment and systems.Similar to current transformers, potential transformers are designed for specific voltage ratings and accuracy classes, depending on their intended

purpose.PTs are engineered to provide accurate voltage measurements with minimal phase shift, ensuring the reliability and precision of the measured values even under varying load conditions.They comply with industry standards and regulations to guarantee their performance, safety, and compatibility with other electrical components and systems.By employing potential transformers in electrical power systems, high voltage levels can be safely and accurately measured, enabling effective monitoring, protection, and metering operations.

Relay

Relays operate by utilizing the principles of electromagnetic attraction. When a fault current is detected in a circuit, the relay's electromagnetic field is activated, producing a temporary magnetic field. This magnetic field exerts a force on the relay's armature, causing it to move and either establish or break the electrical connections within the relay. In the case of a small power relay, it typically consists of a single contact that is responsible for opening or closing the switch. On the other hand, high-power relays often feature two contacts for enhanced switching capabilities. Internally, the relay comprises an iron core that is wound with a control coil. The control coil receives power through the contacts of the load and the control switch. When an electric current passes through the control coil, it generates a magnetic field around the coil. As a result of this magnetic field, the upper arm of the relay's magnet attracts the lower arm, bringing them together and closing the circuit. This allows the current to flow through the load, enabling the intended operation. Conversely, if the contacts are already closed, the magnetic field causes the armature to move in the opposite direction, opening the contacts and interrupting the current flow. By utilizing this electromagnetic attraction principle, relays provide a reliable means of controlling electrical circuits and enabling or disabling the flow of current based on specific conditions or signals.

Software module

Arduino Software (IDE)

The Arduino Integrated Development Environment (IDE), also known as Arduino Software (IDE), is a powerful software platform designed for writing and uploading code to Arduino and Genuino boards. It offers a range of tools and features that facilitate the entire development process. In previous versions of the Arduino IDE, sketches were saved with the .pde file extension. However, starting from version 1.0, sketches are saved with the .ino extension. If you open a .pde file using version 1.0 or later, the IDE will prompt you to save the sketch with the .ino extension when you save the file. The Arduino IDE provides a user-friendly and intuitive interface that simplifies the coding experience. It includes a text editor for writing code, a message area for displaying feedback and error messages, a text console for displaying program output, a toolbar with common functions, and a series of menus for accessing various features. One of the key features of the Arduino IDE is its ability to compile and upload code to Arduino boards. It supports a wide range of Arduino and Genuino boards, allowing you to select the appropriate board from the Tools menu. Additionally, you can choose the correct port from the Tools menu to establish a connection between the IDE and the board. The Arduino IDE is designed to be beginner-friendly while still providing advanced functionality for experienced users. It offers a simplified programming language based on C/C++, making it accessible to those who are new to programming. Furthermore, it provides a vast library of pre-written code examples and tutorials, enabling users to learn and experiment with different functionalities. Overall, the Arduino IDE serves as a comprehensive and efficient platform for writing, compiling, and uploading code to Arduino boards. Its user-friendly interface and extensive features make it a popular choice among both beginners and experienced Arduino enthusiasts.

Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The Arduino Software (IDE) implements the concept of a sketchbook, which serves as a designated location for storing your Arduino programs or sketches. This allows for easy organization and management of your projects. When you launch the Arduino IDE for the first time, it automatically creates a directory on your computer to serve as your sketchbook. This directory acts as a container for all your sketches. By default, the sketchbook directory is located in the user's Documents folder. To access the sketches within your sketchbook, you can go to the File menu and select Sketchbook. This will display a list of all the sketches present in your sketchbook directory. Additionally, you can use the Open button on the toolbar to browse and open sketches directly from your sketchbook. If you wish to change the location of your sketchbook directory, you can do so by accessing the Preferences dialog. In the Arduino IDE, go to File > Preferences. This will open the Preferences dialog where you can view and modify various settings related to the IDE. Within the Preferences dialog, you will find an option to specify the location of your sketchbook. By default, it points to the previously mentioned sketchbook directory. Changing the sketchbook location can be useful

if you prefer to store your sketches in a different directory or if you want to keep your sketches synchronized across multiple devices. By providing a dedicated sketchbook, the Arduino IDE makes it easy to manage and organize your projects, allowing for convenient access to your sketches and providing a streamlined workflow for Arduino development.

Uploading

To upload your sketch to the Arduino board using the Arduino IDE, you need to ensure that your Arduino board is connected to your computer via a USB cable. Once you have your sketch ready, open it in the Arduino IDE. From the toolbar, click on the upload button or go to the Sketch menu and select "Upload". The Arduino IDE will compile your sketch and initiate the upload process. If you're using a newer Arduino board, it will reset automatically before the upload begins, and you'll notice the RX and TX LEDs blinking on the board. However, for older boards without auto-reset, you'll need to manually press the reset button on the board just before starting the upload. The Arduino IDE will display the upload progress, and once it's complete, you'll see a "Upload complete" message. In case of any issues, such as connection problems or compilation errors, the Arduino IDE will display an error message for you to troubleshoot. By following these steps, you can easily upload your sketch to the Arduino board and begin running your code.

Embedded C

Embedded C is a highly versatile and robust programming language that is specifically designed for embedded systems development. It offers a wide range of features and capabilities that make it a popular choice among developers working on microcontrollers and other embedded devices. One of the key advantages of Embedded C is its ability to provide low-level access to hardware resources, allowing developers to directly control and interact with the underlying components of the system. This level of control enables efficient utilization of system resources and enables developers to implement custom functionalities tailored to the specific requirements of the embedded system. Another important feature of Embedded C is its emphasis on efficient code execution. Embedded systems often operate with limited processing power and memory resources, and the ability to write optimized code is crucial for achieving high performance and responsiveness. Embedded C provides various mechanisms and techniques for code optimization, such as inline assembly, register manipulation, and memory management, which contribute to the overall efficiency of the system. Furthermore, Embedded C offers a compact and concise syntax, resulting in smaller memory footprint and reduced code size. This is particularly valuable in embedded systems where space constraints are common. Despite its compactness, Embedded C provides rich functionality and supports various programming paradigms, allowing developers to implement complex algorithms and logic. As the demand for embedded systems continues to grow in industries such as automotive, aerospace, consumer electronics, and industrial automation, the significance of Embedded C as a powerful programming language for developing efficient and reliable embedded systems is expected to persist. Its unique combination of low-level access, efficient code execution, and compactness makes it a valuable tool in the ever-evolving field of embedded systems development.

ThingSpeak

ThingSpeak is an IoT platform that offers a range of features to connect, store, and analyze sensor data in the cloud, enabling the development of IoT applications. The platform provides a variety of tools and applications for data analysis and visualization, while also offering MATLAB support for advanced data processing. With ThingSpeak, sensor data can be easily integrated and transmitted from devices like Arduino, Raspberry Pi, or any other IoT gateway. Key features of ThingSpeak include the ability to collect data in private channels, allowing users to keep their data secure and accessible only to authorized individuals or systems. Additionally, data can be shared using public channels, enabling collaboration and data sharing with a wider audience. ThingSpeak supports both REST API and MQTT APIs, providing flexible options for data integration and communication with the platform. The REST API allows for programmatic access to ThingSpeak, facilitating data retrieval, storage, and manipulation. The MQTT API enables lightweight and efficient data exchange between IoT devices and the platform. The integration of MATLAB with ThingSpeak enhances the platform's capabilities by enabling advanced analytics and visualizations. MATLAB is a powerful programming and analysis environment that allows users to perform complex calculations, apply machine learning algorithms, and generate insightful visual representations of the data. ThingSpeak also benefits from its worldwide community,

which fosters collaboration, knowledge sharing, and the development of innovative IoT applications. The community provides a platform for users to exchange ideas, seek assistance, and share their experiences and projects. Overall, ThingSpeak offers a comprehensive IoT platform with features such as data collection, sharing, REST API and MQTT API support, MATLAB analytics, and a thriving worldwide community. These features make it a versatile and robust platform for connecting, analyzing, and acting upon sensor data in the context of IoT applications.

RESULT

Fig: Thinkspeak with MATLAB

MQTT (Message Queuing Telemetry Transport)

MQTT (Message Queuing Telemetry Transport) is a widely adopted protocol in the realm of Internet of Things (IoT). It provides a lightweight and efficient communication mechanism for resource-constrained IoT devices. Here are some key points about MQTT:

Publish-Subscribe Model: MQTT follows a publish-subscribe model, where IoT devices publish information (messages) on specific topics, and other devices (clients) can subscribe to those topics to receive the published data.

MQTT Broker: A central component in MQTT is the MQTT broker, which acts as an intermediary between publishers and subscribers. It receives messages from publishers and forwards them to the appropriate subscribers based on their subscriptions.

Topics: Topics in MQTT represent a hierarchical structure, similar to file paths. Each topic acts as a channel or category to which messages can be published. Clients can subscribe to specific topics or use wildcards to subscribe to multiple levels of the topic hierarchy.

QoS (Quality of Service): MQTT supports different levels of Quality of Service for message delivery. QoS levels range from 0 to 2, offering varying degrees of reliability and guarantee of message delivery.

Lightweight and Efficient: MQTT is designed to be lightweight, making it suitable for resource-constrained devices with limited processing power, memory, and bandwidth. It uses a small network footprint, minimizing the impact on network traffic and conserving energy.

Scalability and Flexibility: MQTT enables seamless communication between a large number of devices, making it highly scalable. It also provides flexibility in terms of data exchange, allowing devices to communicate in a publish-subscribe manner rather than establishing direct connections.

Standardized Protocol: MQTT is an open and standardized protocol, maintained by the Organization for the Advancement of Structured Information Standards (OASIS). It has broad industry support and is implemented in various IoT platforms and devices.

With its simplicity, efficiency, and suitability for resource-constrained devices, MQTT has become a prevalent choice for IoT applications. It facilitates efficient data exchange, real-time communication, and effective management of IoT ecosystems, making it an integral part of the IoT landscape.

Broker

The MQTT broker plays a crucial role in the MQTT publish/subscribe protocol. It acts as a central hub that facilitates communication between MQTT clients. The broker receives messages from publishers and ensures that they are delivered to the intended subscribers. It handles the task of filtering messages based on

subscription topics and identifying which clients have subscribed to specific topics. This allows for efficient and targeted message distribution, enabling effective communication in large-scale MQTT deployments with numerous concurrently connected clients. With its ability to handle thousands of connected clients simultaneously, the MQTT broker provides scalability and flexibility in IoT applications. It serves as a reliable and robust intermediary, managing the flow of messages between publishers and subscribers. The broker's performance is crucial for ensuring real-time and reliable communication within an MQTT network. By efficiently routing and delivering messages, the broker enables seamless data exchange and synchronization between devices and applications. Furthermore, MQTT brokers often support advanced features such as message persistence, security mechanisms, and QoS (Quality of Service) levels. They can provide storage and buffering capabilities for messages, ensuring reliable delivery even in cases of temporary network disruptions. Security measures such as authentication and access control can be implemented at the broker level, ensuring secure and authenticated communication between clients. Additionally, brokers allow for different QoS levels to be configured, enabling trade-offs between message delivery guarantees and network bandwidth utilization. Overall, the MQTT broker is a critical component in MQTT-based IoT systems, enabling efficient and reliable communication between connected devices. Its ability to handle concurrent connections, filter messages, and route them to the appropriate subscribers ensures seamless data exchange and facilitates the development of scalable and robust IoT applications.

Advantages

- Efficient data transmission and quick implementation due to MQTT's lightweight nature.
- Low network usage thanks to minimized data packets, optimizing bandwidth utilization.
- Efficient distribution of data through MQTT's publish/subscribe model, ensuring selective delivery to subscribed clients.
- Successful implementation of remote sensing and control applications.
- Fast and efficient message delivery, enabling real-time communication between devices.
- Usage of small amounts of power, making it suitable for energy-constrained devices.
- Reduction of network bandwidth, enhancing overall system performance and scalability.

CONCLUSION

• The project concludes that IoT-based smart device management developed and used to monitor and control energy consumption.

• The system can detect anomalies in power consumption and alert the user.

• It can also provide insights and recommendations on how to improve energy efficiency.

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