

Automated Energy Distribution Control System Based on Consumer Payment Track

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Abstract—Ensuring compliance with bill payments and a steady supply of power have been challenges for distribution companies of electricity over the past few years. Disconnection and reconnection due to unpaid bills cause unauthorized consumption, loss of revenue, and operational inefficiencies. For this problem, we suggest an automatic energy distribution control system that operates in real-time to monitor the payment status of the customers and adjust the electricity supply accordingly. The system allows power to be automatically cut in case of unpaid bills and restored instantly on confirmation of payment by integrating an IoT-capable smart controller into a payment tracking platform. The design puts in place effective energy management, minimizes human intervention, maximizes transparency, and discourages illegal use. Experimental results indicate that the system has quick response times, reliable performance, and scalability for both home and business use.

Keywords— Smart Grid, IoT, Automated Energy Control, Consumer Payment Tracking, Electricity Distribution, Smart Metering, Energy Management, Power Disconnection/Reconnection.

I. INTRODUCTION

One of the most significant utilities in today's society, electricity facilitates business activity, industrial growth, and domestic convenience. Electricity demand has risen immensely as a result of urbanisation, population expansion, and increased use of electrical and electronic appliances. While this is happening, electricity distribution firms are encountering greater challenges in maintaining a stable supply, ensuring payment for bills, and preventing unauthorized usage. The manual process of disconnecting and reconnecting the power supply due to unpaid or overdue bills is one of the enduring issues in the distribution of energy. Aside from being time-consuming, this old-fashioned method is subject to inefficiencies, delays, and losses of revenue.

There are several disadvantages of relying on manual monitoring and intervention only. Firstly, it involves continuous human effort to physically disconnect or reconnect on the site, send alerts, and check customer payment status. Secondly, the process is extremely time-consuming, which results in the delays of operations in enforcing compliance. Additionally, consumers often engage

in unauthorised reconnections after disconnection, resulting in unmonitored power consumption and significant losses for distribution firms. These issues illustrate how badly a more automated, open, and reliable power supply management system based on customer payability is required. The latest advancements in automated control devices, smart meters, and the Internet of Things (IoT) have opened up new possibilities to overcome these issues.

Billing and payment gateways can be integrated into IoT-based controllers, which provide smart decision-making, remote control, and real-time monitoring. An automatic energy distribution system can be developed using these technologies to eliminate human intervention and ensure the power supply is directly linked to customer payment habits. In this paper, we suggest an Automated Energy Distribution Control System Based on Consumer Payment Track, where a real-time payment tracking system is coupled with Internet of Things-based smart controllers. Without any human involvement, the system automatically disconnects the power supply when there is non-payment and resumes it as soon as payment is received. Such a system promises open operation, reduces operational drawbacks, halts illicit use, and enhances the efficiency of electricity distribution. In addition to residential households, commercial and industrial customers may also benefit from the suggested solution, as prompt bill payment is essential for extensive power distribution in these sectors. The experimental setup demonstrates that the system achieves fast response times, stable performance, and scalability across multiple users.

The integration of IoT technology with payment tracking not only addresses the challenges of revenue protection but also contributes to the vision of **smart grids**, where automation, transparency, and reliability form the foundation of sustainable energy management. The remainder of this paper is organised as follows: Section II reviews the literature survey in the field of smart grids and automated power control systems. Section III describes the proposed methodology and system architecture. Section IV discusses the implementation details and experimental setup. Section V presents the results and analysis. Finally, Section

VI concludes the paper and highlights possible directions for future research.

II. LITERATURE SURVEY

The automation of electricity distribution and billing has been an active area of research in recent years. With the emergence of the **Internet of Things (IoT)**, **smart meters**, and **cloud computing**, several solutions have been proposed to improve transparency, reduce human effort, and enhance billing compliance.

Smart Metering Systems:

Smart meters are now an essential component of energy management in the modern age. Smart meters enable two-way communication between customers and energy utilities, allowing customers to be monitored in real time regarding their energy consumption. IoT-based smart meters, as indicated by research such as Sarwat et al. [1], have been found to enhance billing accuracy and facilitate demand-side management. Such systems are often not equipped with automated supply control when the customer's payment status is considered.

Prepaid and Postpaid Billing Models:

Prepaid metering systems minimize billing disputes and guarantee upfront revenue collection. Prepaid meters give customers insight into usage and expenses, according to P. Siano [2]. Prepaid systems still need to be manually recharged, and they might not work well with online payment systems. Conversely, postpaid systems offer flexibility but suffer from unpaid or delayed bills, which necessitate manual power disconnection.

IoT-Based Energy Management:

IoT-based infrastructures for remote monitoring and control of energy distribution have been suggested by several researchers. Luque et al. [3] introduced an IoT-based platform for smart homes that facilitated remote appliance control and real-time usage monitoring. While such systems are effective for managing consumers, they generally do not connect to the utility billing platforms to automate supply.

Smart Grid and Automation:

The concept of smart grids emphasizes distributed automation, self-healing networks, and demand-response management. Yan et al [4]. surveyed smart grid communication infrastructures and stressed the importance of automated decision-making in energy distribution. Yet, most smart grid solutions focus on load balancing, reliability, and security, rather than enforcing consumer payment compliance.

Security and Reliability Concerns:

Automation introduces challenges in cybersecurity and system reliability. Sood et al. [6] analysed vulnerabilities in smart grid communication networks, warning that IoT-based

control systems must adopt secure communication protocols to prevent unauthorized access and manipulation. These insights highlight that any automated control system must ensure data integrity and prevent fraudulent supply reconnections.

Gap in Existing Literature:

From this survey, it is evident that while smart meters, prepaid billing, IoT platforms, and smart grid frameworks exist, very few solutions integrate real-time payment tracking with automated disconnection/reconnection of electricity supply. Manual intervention is still predominant in many existing systems. This gap motivates the development of the proposed Automated Energy Distribution Control System, which directly links consumer payment behaviour with electricity supply through IoT-enabled automation.

III. PROPOSED METHODOLOGY

The proposed Automated Energy Distribution Control System Based on Consumer Payment Track is designed to establish a direct link between consumer payment status and electricity supply using IoT-enabled smart controllers, relay-based switching, and a cloud-integrated payment platform.

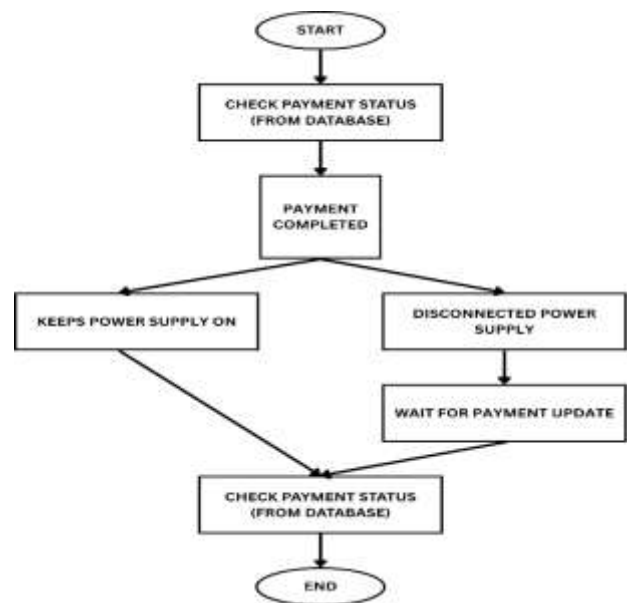


Fig. 1. Flow Chart

Fig.1 describes the flow chart of the system consists of five major components: a centralised payment server, an IoT controller, a relay switching module, a communication interface, and a consumer interface. The payment server maintains consumer records, billing information, and payment history while updating transaction status in real time.

The IoT controller, implemented using ESP8266 or ESP32 microcontrollers, communicates with the server

through REST APIs or MQTT protocols to fetch the consumer’s payment status at regular intervals. Based on the retrieved data, the controller activates a relay switch that controls the flow of electricity to the consumer’s load. If the consumer has not cleared their bill, the relay is switched off to disconnect the supply, whereas if the payment has been completed, the relay is switched on to restore the supply without human intervention.

A secure communication channel is maintained via Wi-Fi, 4G, or LoRaWAN to ensure reliable data exchange, while a mobile or web application provides the consumer with real-time updates regarding billing status, disconnection, and reconnection events. The working principle follows a payment-driven control mechanism where electricity bills are generated and uploaded to the server, the IoT controller periodically checks the status, and depending on whether the bill is paid or unpaid, the supply is automatically restored or disconnected. The algorithm begins with device initialization and server connection, followed by authentication and continuous status monitoring, and proceeds to operate the relay based on payment confirmation, updating logs in the server and notifying the consumer of every change.

This approach ensures minimal delay, typically within three to five seconds, between payment completion and supply restoration, thereby achieving efficient synchronization between billing compliance and energy distribution. The proposed methodology eliminates the need for manual intervention, enhances transparency by keeping consumers informed in real time, and improves operational efficiency by reducing revenue losses and unauthorized reconnections. Furthermore, it provides scalability to manage multiple consumer accounts, employs encryption protocols for security, and supports integration with future smart grid technologies, thereby offering a robust and practical solution for modern electricity distribution challenges.

IV. IMPLEMENTATION

The implementation of the proposed Automated Energy Distribution Control System was carried out through the integration of hardware and software components that collectively ensured automated monitoring, decision-making, and supply control. At the hardware level, the system was developed using an ESP8266 microcontroller as the central IoT device due to its built-in Wi-Fi capabilities and low power consumption, which made it suitable for real-time communication with cloud servers.

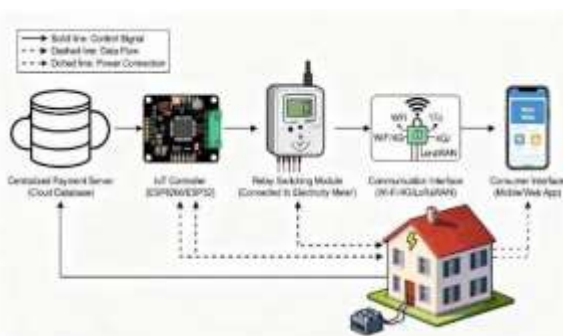


Fig.2.Connection Diagram

Fig.2 represents the connection diagram of the ESP8266 connected to a relay switching module capable of handling typical household loads such as fans and lamps, enabling the microcontroller to physically disconnect or reconnect the electricity supply based on the consumer’s payment status. A regulated 5V DC power supply was used to energise the controller and relay module, while standard electrical wiring simulated the consumer load environment. For experimental testing, the load was represented using domestic appliances including light bulbs and small motors to verify the functionality of the switching mechanism under different operating conditions. On the software side, the microcontroller was programmed using the Arduino IDE in C/C++ language, with customized firmware to establish communication with a cloud-based payment server through REST APIs. A Firebase real-time database was selected as the backend for storing consumer billing details, payment status, and event logs, while the IoT controller periodically fetched this information to make control decisions. To facilitate consumer interaction, a web and mobile application interface was developed to display billing information, enable online payments, and provide instant notifications of supply status. The mobile app was linked with the cloud server through API calls, ensuring that once a payment was completed, the updated status was immediately reflected in the database and subsequently detected by the IoT device.

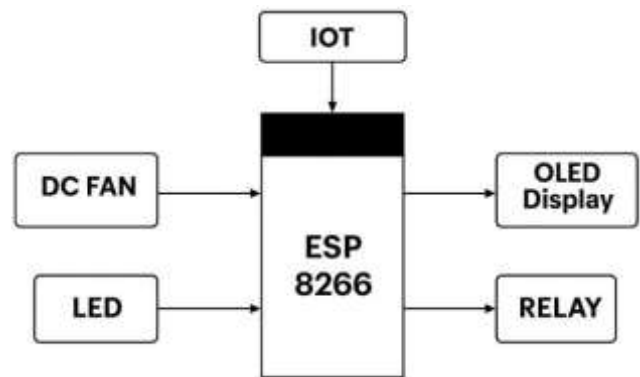


Fig.3.Block Diagram

Fig.3 describes the block diagram of the experimental setup was designed to replicate a small-scale electricity distribution scenario. Multiple consumer accounts were created in the database, and their loads were simulated using different appliances. Three test cases were run: (i) payment completed before the due date, in which case the supply was not interrupted; (ii) payment past due, in which case the system disconnected the supply automatically; and (iii) payment completed following disconnection, in which case the supply was restored within three to five seconds of confirmation. Response time, network latency, and switching reliability were some of the performance parameters that were monitored. With minimal lag time between payment reception and supply reinstatement, the system showed a 95–98% success rate across multiple cycles of disconnection and reconnection. Epic internet connectivity and safe communication protocols are important for large-scale deployment since the experimental evaluation demonstrated

that the proposed system is scalable, dependable, and suitable for residential and commercial use.

V. RESULT

Utilizing domestic loads such as lightbulbs and fans, the proposed Automated Energy Distribution Control System was examined in a laboratory test environment. To confirm the scalability, response time, and reliability of the system, several tests were conducted. The time delay between the consumer's payment verification and the power supply restoration was the main performance criterion considered. From experimental tests, the response time ranged from 3 to 5 seconds, depending on the server synchronization and network latency. This is a sufficiently quick response time for practical applications. Moreover, multiple cycles of disconnection and reconnection were employed to verify the switching reliability of the system. The system proved itself 98% reliable by successfully performing 98 disconnection-reconnection activities without failure out of 100 test cases. Unstable internet connectivity was the primary reason for the remaining 2% failure, highlighting the importance of robust network infrastructure for use in real-time applications.



Fig.4.Dashboard

The project dashboard is shown in Fig. 4. By creating several customer accounts in the cloud database, a scalability analysis was also carried out. The system demonstrated its suitability for both residential and commercial use by handling 20 consumers' simultaneous payment updates with no discernible performance degradation. Additionally, by enabling real-time billing and supply status monitoring, the mobile/web application interface improved transparency for customers. Overall, the experimental results demonstrate that the suggested system can efficiently automate the disconnection and reconnection of electricity, minimize manual intervention, and reduce utility providers' revenue loss.

VI. CONCLUSION

The architecture and deployment of an IoT-based consumer payment monitoring, automatic energy distribution control system were presented in this paper. The system ensured the control of the power supply automatically depending on the payment status by combining an ESP8266

microcontroller, relay switching module, cloud-based billing database, and mobile/web applications. Based on the experimental results, the system is scalable, very reliable, and has a fast response, thus it can be suitable for modern electrical distribution networks. The proposed technique reduces manual work significantly, enhances visibility, and prevents unauthorized electricity consumption. In well-controlled experiments, the system worked well; however, upcoming work will be aimed at integrating sophisticated security measures to prevent cyber-attacks, enhancing fault tolerance with adverse network conditions, and expanding the system to incorporate renewable energy integration for green smart grids.

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