



Centralized Power Optimized Monitoring And Automated System For Industry Using Cloud Computed Technology

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Abstract- The constant developments in mobile technology and the rapid advancements in embedded systems have made it possible to integrate mobile technology into the design of home automation systems. Home automation allows the controlling and monitoring of various home appliances by a single system and brings greater convenience better security, as well as higher energy-efficiency to home users. The integration of home automation systems into the future smart grids will give consumers the ability to control their house system and save energy efficiently.

This project presents a centralized energy-optimized industrial monitoring and automation system using cloud-based computing technology. With increasing energy demands, industries require intelligent solutions to monitor and control loads in real-time. The proposed system uses Arduino UNO, temperature and light sensors, current sensors, IoT modules, RFID access control, and wired charging features to automate operations and improve energy efficiency. Sensor data is continuously monitored and uploaded to the cloud for analysis. Automated load control using environmental sensors, IoT-based remote switching, and RFID-enabled gate control increase convenience, ensure safety, and reduce human intervention. A regulated power supply ensures reliable operation of all modules. The system aims to create a smart industrial environment with enhanced monitoring, security, and energy optimization capabilities.

Keywords: Embedded System, IOT, RFID, Arduino, Automation System, Gate Control

1. INTRODUCTION

The rapid advancement in embedded systems, IoT, and mobile communication has transformed the way

industrial and home automation systems are developed. Modern industries require centralized automated systems capable of monitoring environmental conditions, optimizing energy usage, and remotely controlling electrical loads. This project focuses on developing an advanced automation and monitoring system using Arduino, sensors, IoT technology, and smart power management techniques. By integrating cloud computing and mobile-based control, the system enables efficient energy utilization, real-time monitoring, and automated load handling suitable for industries, parking zones, and smart infrastructures.

The **Internet of things (IoT)** is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other-items

embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as "the infrastructure of the information society." The IoT allows objects to be sensed or controlled remotely across existing network infrastructure,^[4] creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

Typically, IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications

and covers a variety of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects), is expected to usher in automation in nearly all fields, while also enabling advanced applications like a smart grid,^[13] and expanding to areas such as smart cities.

"Things," in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, electric clams in coastal waters,^[16] automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring^[17] or field operation devices that assist firefighters in search and rescue operations.^[18] Legal scholars suggest to look at "Things" as an "inextricable mixture of hardware, software, data and service" .These devices collect useful data with the help of various existing technologies and focuses on integrating live video streaming to provide real-time visual feedback for improved situational awareness. Additionally, machine learning techniques are incorporated to analyze collected data, detect anomalies, and predict future environmental trends. The overall goal is to create a scalable, cost-effective, and intelligent monitoring solution suitable for smart cities, agriculture, industrial safety, and disaster management application.

PROBLEM STATEMENT

In many industrial environments, monitoring and control of electrical loads are still performed using manual or semi-automated systems. Lighting systems, ventilation units, and other electrical equipment often operate without considering real-time environmental conditions such as temperature and ambient light intensity. This leads to unnecessary energy consumption, increased operational costs, and reduced overall efficiency. Additionally, the absence of intelligent monitoring mechanisms makes it difficult to track real-time power usage and identify areas of energy wastage.

Traditional industrial setups also lack a centralized platform that integrates environmental sensing, energy monitoring, remote access, and automated load control into a single system. Data related to temperature, power consumption, and system status is either not recorded or not accessible remotely, limiting effective decision-making and performance analysis. Furthermore, industrial access control systems are frequently managed manually, which can compromise security and increase dependency on human supervision

then autonomously flow the data between other devices. Current market examples include home automation (also known as smart home devices) such as the control and automation of lighting, heating (like smart thermostat), ventilation, air conditioning (HVAC) systems, and appliances such as washer/dryers, robotic vacuums, air purifiers, ovens or refrigerators/freezers that use Wi-Fi for remote monitoring.

As well as the expansion of Internet-connected automation into a plethora of new application areas, IoT is also expected to generate large amounts of data from diverse locations, with the consequent necessity for quick aggregation of the data, and an increase in the need to index, store, and process such data more effectively. IoT is one of the platforms of today's Smart City, and Smart Energy Management Systems.

2. HARDWARE IMPLEMENTATION Proposed Block Diagram

The proposed system introduces a centralized, energy-optimized automation platform designed using Arduino UNO, multiple sensors, IoT connectivity, and RFID technology. The system automatically controls loads such as lights and fans based on real-time temperature and ambient light conditions, ensuring efficient energy usage. A current sensor continuously measures power consumption and uploads the data to a cloud server for remote monitoring and analysis. Wireless mobile charging and an IoT app provide convenient remote control of loads, while an RFID module enables automated parking gate operation for vehicles and industrial lorries, enhancing security and reducing manual involvement. The LCD module displays live system information including sensor readings and load status. A regulated power supply with rectification and voltage control ensures stable and reliable operation of all components. Overall, the proposed system integrates automation, monitoring, and cloud computing into a single intelligent industrial solution.

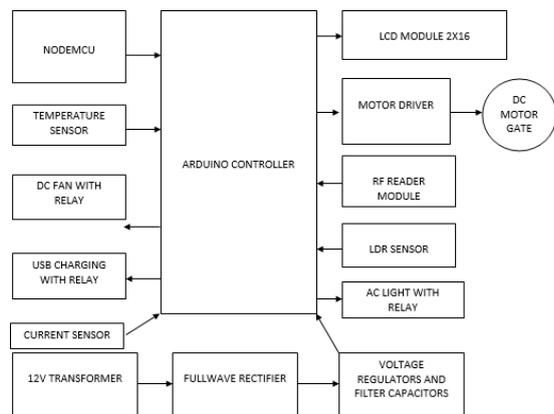


Figure 1 Proposed Block Diagram

HARDWARE COMPONENTS

ARDUINO UNO BOARD

The Arduino UNO serves as the primary controller of the system. It is based on the ATmega328P microcontroller and provides multiple digital and analog input/output pins for interfacing with sensors and peripheral devices. The Arduino continuously reads environmental data from the connected sensors, processes the information based on programmed logic, and controls the connected loads through relay modules. Its ease of programming, low cost, and flexibility make it suitable for industrial automation applications.



Figure 2 Arduino uno

TRANSFORMER

A transformer is an electrical device used to transfer electrical energy between two or more circuits through electromagnetic induction. It plays an essential role in power supply design by stepping up or stepping down voltage levels according to system requirements. In the proposed centralized energy optimized monitoring and automation system, a step-down transformer is used to reduce the high AC mains voltage to a lower and safer voltage suitable for electronic circuits.

LCD 2X 16 MODULES

A motor driver is an essential electronic interface used to control the direction, speed, and operation of DC motors by providing sufficient current and voltage that a microcontroller cannot supply directly. Since microcontrollers like the ESP32 operate at low power levels, a motor driver acts as an intermediary between the control unit and the motors, enabling safe and efficient motor operation.



Figure 3 Lcd 2x16 Module

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

RELAY

A **relay** is an electrically operated switch. Many relays use an electromagnet to mechanically Operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.



Figure 4 Relay

The gears operate in accordance with the law of conservation of angular momentum. A smaller gear will turn faster but will have less torque; a larger gear turns slower and produces more torque. If more than one gear is attached, the devices determine the velocity and torque of the final shaft. In DC motors RPM/Torque is inversely proportional that mean if more torque required to motor speed will get slow.

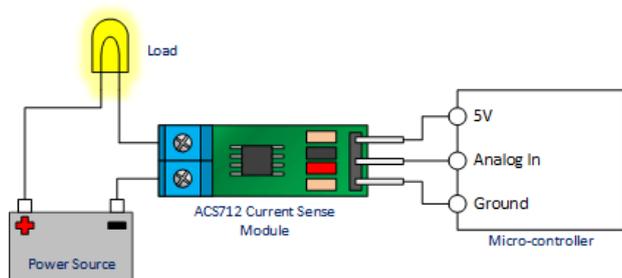
CURRENT AND TEMPERATURE SENSOR

A **current sensor** is a device that detects electric current (AC or DC) in a wire, and generates a signal proportional to it. The generated signal could be analog voltage or current or even digital output. It can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purpose.



Figure 5 ACS712 Current Sensor

ACS712 current sensor operates from 5V and outputs analog voltage proportional to current measured on the sensing terminals. You can simple use a microcontroller ADC to read the values.



The DS18B20 temperature sensor is used to measure ambient temperature in the industrial environment. It is a digital temperature sensor that communicates using the One-Wire protocol, allowing accurate and reliable temperature measurement with minimal wiring. The sensed temperature data is processed by the controller to automatically regulate the DC fan and maintain suitable operating conditions.



Figure 6 DS18B20 Temperature Sensor

LDR – Light Dependent Resistor

A photoresistor or light-dependent resistor (LDR) or photocell is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor can be applied in light-sensitive detector circuits, and light- and dark-activated switching circuits.



Figure 7 LDR

RFID READER

Radio-Frequency Identification (RFID) is the use of radio waves to read and capture information stored on a tag attached to an object. A tag can be read from up to several feet away and does not need to be within direct line-of-sight of the reader to be tracked.

A RFID system is made up of two parts: a tag or label and a reader. RFID tags or labels are embedded with a transmitter and a receiver. The RFID component on the tags have two parts: a microchip that stores and processes information, and an antenna to receive and transmit a signal. The tag contains the specific serial number for one specific object.



Figure 8 (RFID READER)

SERVO MOTOR

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.^[1] It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing



Figure 9 SERVO MOTOR

Battery & Power Management

A rechargeable battery supplies power to the entire system. A battery management module ensures safe charging, voltage regulation, and protection against overcurrent and deep discharge, supporting stable and long-duration operation.

3. SOFTWARE IMPLEMENTATION Embedded C Programming

Embedded C is an extension to the traditional C, and is used in programming for embedded systems. It provides several features not normally available in standard C, such as fixed-point arithmetic, named address spaces and I/O hardware access, making it ideal for devices with limited memory or custom hardware peripherals. These extensions aside, Embedded C retains the standard C syntax such as functions may use local variables and can have loops, conditional statements, arrays, structures etc. and various other distinctions that make it suitable for run or processing efficient programs to be deployed on hardware devices.

It is essentially developed in embedded C, since it has basic functionality and implemented using less number of lines and has ease to understand, increased reliability, Portability for any processor & Scalability for any application. The coordinator, mobile phones, washing machines, digital cameras — most of the electronic devices that we use on a daily basis embed microcontrollers programmed using such Embedded C; it's all code-implement-compile-as-hex and program-to-microcontroller.

Microcontroller programming process varies across operating system such as Windows, Linux or RTOS, but the concept is same. The aim is to write, compile and upload structured Embedded C code in order for the micro controller to control hardware in a way that will perform some task or full fill functionalities of an embedded system.

Programming of Arduino-based microcontrollers (such as the Nano used in Duino Kits) requires installation of the Arduino IDE. The software is freely available at the Arduino site. cc by using the Windows, Mac or Linux version as appropriate. Prerequisites You need the computer and an Arduino-compatible board, as well as a USB cable to plug the board in for program loading (upload). The Installer (.exe) version is preferable since it allows USB driver installation, and zip-based installation need to manually install drivers. \

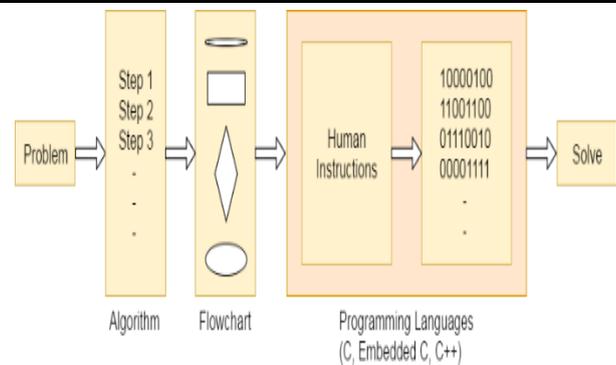


Figure 10 Flow of Embedded C

When you install it will ask where you want to install, you can just choose C:\Program Files\Arduino. This is the default place, and it is OK for most users, who will have IDE files, libraries, drivers and examples in a single convenient place. But advanced users may prefer custom locations, particularly when working with limited storage or multiple projects

Once the directory is selected, the installation process begins. The installer copies program files, examples, and libraries, installs essential USB drivers, and registers Arduino settings with the operating system. A progress bar indicates installation status. After completing the process, shortcuts are created, file associations are set, and the IDE becomes ready for uploading sketches to the Arduino board.

Arduino IDE

You can use the Arduino IDE for writing, editing and uploading programs to your Arduino. Clean design, easy to understand and use for beginners in embedded systems. The interface has important areas like Menu Bar, Toolbar, Sketch Editor, Message Area and Serial Monitor. Functions useful for file management, compiling and uploading are available on the menus of the Menu Bar: File, Sketch, Tools. Quick-access buttons such as Verify, Upload, New, Open and Save are located in the toolbar.

But, it's really the Sketch Editor that is your primary coding workspace (where you will write code with syntax highlighting and error underlining). The area Message below shows the compilation result, when there is warning or if upload fails, it would help you to easily debug the errors. By opening up the Serial Monitor, you can communicate with the board in real time and view sensor data as well as debug messages.

For IDE users can find these options in \[Tools> Board\] > and their corresponding port. Beginners are able to grasp how the sensors are used through reference on Examples menu for sensor use, communication examples, and sample coding structure. IDE output area: The Message Area and Serial Monitor provide vital program feedback and are both part of the IDE. Together, these elements make the Arduino IDE an efficient tool

for learning, testing and developing microcontroller-based applications.

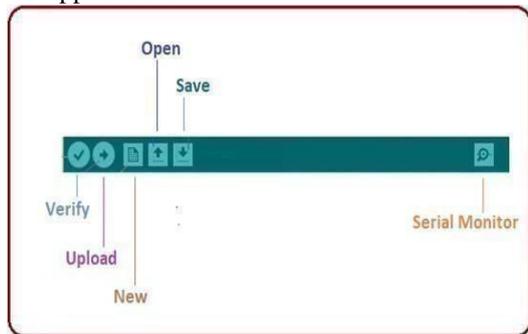


Figure 11 Arduino Uno Interface

CONFIGURING THE ARDUINO IDE

The next thing to do is to make sure the software is set up for your particular Arduino board. Go to the “Tools” drop-down menu, and find “Board”. Another menu will appear, where you can select from a list of Arduino models. I have the Arduino Uno R3, so I chose “Arduino Uno”.

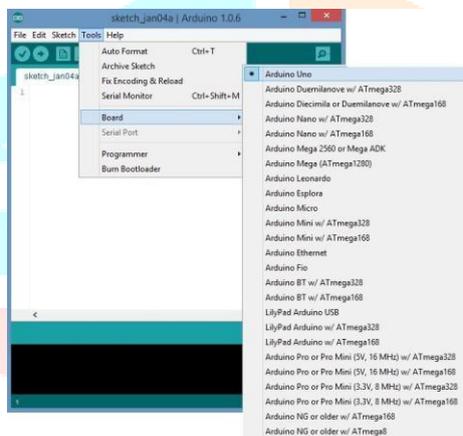


Figure 12 Install Board

EXPLORING THE ARDUINO IDE

After the installation of the tool and rebooting the IDE, ESP32 boards shows up in Tools → Board again beside the board under ESP32 Boards that I can choose models such as NodeMCU 1.0 among others. Once the right board and COM port has been selected, Arduino IDE is entirely prepared to compile and flash IoT applications into ESP32 modules.

IOT INTERFACE AND CLOUD MONITORING

The system integrates IoT functionality through the NodeMCU module, enabling cloud-based monitoring of industrial parameters. The IoT platform provides a web-based interface where real-time data such as temperature, light intensity, current consumption, and load status are displayed.

The web dashboard presents sensor values in a clear and organized manner, allowing users to remotely monitor industrial conditions. Historical data analysis and trend observation can also be performed using graphical representations available on the cloud platform. This remote accessibility enhances centralized supervision and improves decision-making capabilities.

The integration of Embedded C programming with the Arduino IDE and IoT interface forms the software backbone of the proposed system, ensuring intelligent monitoring, automated control, and efficient energy management.



Figure 13 Web Dashboard

In addition to real-time monitoring, the cloud system enables remote supervisory control. Authorized users can observe system performance and make informed decisions based on current environmental conditions. This centralized access reduces dependency on manual inspections and improves overall operational transparency.

The integration of IoT and cloud computing also enhances scalability. Additional sensors or load units can be incorporated into the system with minimal modification to the cloud architecture. The centralized nature of the platform allows multiple industrial units to be monitored under a single interface, thereby improving management efficiency.

4. RESULTS

The centralized energy optimized monitoring and automated system was successfully designed, implemented, and tested under practical operating conditions. The system effectively monitored environmental parameters such as temperature and ambient light intensity, along with electrical parameters including real-time current consumption. Sensor readings were accurately acquired by the Arduino UNO microcontroller and displayed locally on the LCD

module while being simultaneously transmitted to the cloud platform through the IoT module.

The automatic load control mechanism functioned efficiently. When the temperature exceeded the predefined threshold, the DC fan was activated automatically and deactivated once the temperature returned to normal levels. Similarly, the lighting system responded appropriately to changes in ambient light intensity, ensuring energy-efficient operation. This confirmed the effectiveness of sensor-based automation in reducing unnecessary power consumption.

The RFID-based gate control system operated reliably by allowing access only to authorized RFID tags. The DC geared motor successfully opened and closed the gate upon verification, demonstrating secure and controlled entry management. Unauthorized access attempts were effectively restricted, validating the security functionality of the system.

Real-time energy consumption data collected from the current sensor was accurately monitored and uploaded to the cloud server. Remote monitoring through the IoT platform provided continuous visibility of system status, load conditions, and power usage patterns. The regulated power supply unit ensured stable system performance without voltage fluctuations during operation.

The experimental results confirm that the proposed system achieves centralized monitoring, energy optimization, secure access control, and reliable cloud-based supervision. The integration of embedded systems, IoT communication, and automated load management demonstrates the practical effectiveness of the developed industrial automation platform.

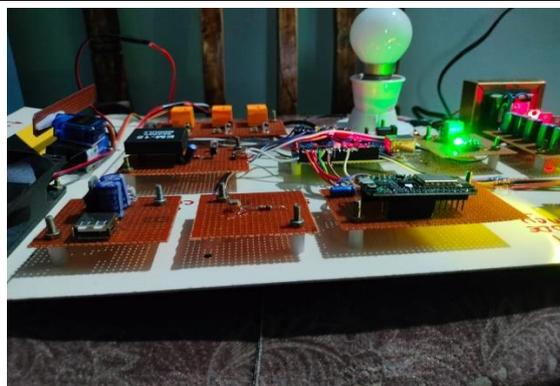


Figure 15 Back View



Figure 16 Side View



Figure 17 Top View



Figure 14 Front View

The results validate that the integration of embedded systems, sensor-based automation, RFID-based access control, and IoT-enabled cloud monitoring provides an effective and intelligent solution for centralized industrial energy management. The proposed system successfully demonstrates real-time environmental monitoring, automated load control, secure gate operation, and remote supervision through cloud connectivity. By combining energy optimization techniques with centralized monitoring architecture, the system offers a practical solution for smart industries, industrial automation facilities, warehouses, manufacturing units, and modern infrastructure environments where efficiency, security, and sustainability are essential.

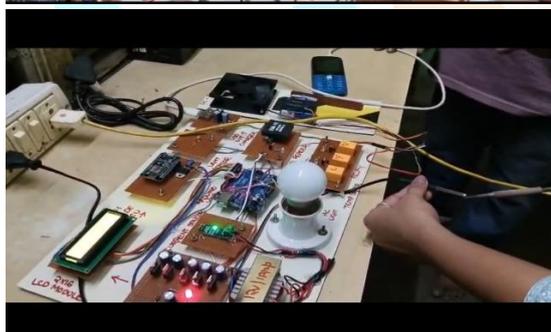
5. CONCLUSION



(a) Dashboard Predictive Analytics



(b) Sensors Outputs



The proposed centralized energy-optimized monitoring and automation system successfully integrates Arduino, IoT technology, sensors, and RFID control to build an efficient and intelligent industrial automation platform. The system automatically controls loads, monitors energy usage, supports wireless charging, and offers secure gate access. Cloud connectivity ensures real-time tracking and analytics, leading to improved decision-making and significant energy savings. This project demonstrates a scalable and cost-effective solution for modern industrial environments seeking automation, safety, and efficient power management.

FUTURE SCOPE

- Implementation of AI/ML for predictive energy optimization and automated scheduling.
- Integration of cloud dashboards for advanced analytics and long-term performance reporting.
- Migration to LoRa/ZigBee/Wi-Fi 6 for wider wireless communication coverage.
- Use of smart meters and dynamic tariff-based load management.
- Expansion into multi-industry centralized control platforms.
- Voice assistant connectivity for smart and hands-free operation.
- Integration of mobile notifications and fault-alert systems.
- Implementation of real-time energy consumption benchmarking to compare performance across efficiency.
- Integration of renewable energy sources such as solar panels with intelligent load balancing for sustainable and hybrid energy management.
- Deployment of edge computing modules for faster local decision-making and reduced dependency on continuous cloud connectivity.

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