# IOT based Smart City management using ESP-32

**Prateek S P[1]**

Department of electronics and Communication,

Jawaharlal Nehru New College of Engineering,

Karnataka, 577201

pratheeksp7@gmail.com

**Rakesh R H[2]**

Department of electronics and Communication,

Jawaharlal Nehru New College of Engineering,

Karnataka, 577201

rakeshhulihalli91@gmail.com

**Varsha Vasanth Akkasali[3]**

Department of electronics and Communication,

Jawaharlal Nehru New College of Engineering,

Karnataka, 577201

varshavasanth247@gmail.com

**Varun Kumar P B[4]**

Department of electronics and Communication,

Jawaharlal Nehru New College of Engineering,

Karnataka, 577201

varunkumarpb07@gmail.com

**Sunil M D[5]**

Department of electronics and Communication,

Jawaharlal Nehru New College of Engineering,

Karnataka, 577201

mdsunil.dev@jnnce.ac.in

**Abstract:** ***Rapid urbanization has increased the demand for efficient management of city resources such as waste collection, parking facilities, and street lighting. This paper presents the design and implementation of an IoT-based smart city model using the ESP32 microcontroller. The proposed system integrates three key applications: a smart waste bin that monitors and displays the fill level percentage in real time, a smart parking system that detects available parking slots, and an intelligent street lighting system that automatically controls lighting based on environmental conditions and occupancy. Sensor data is collected and processed by the ESP32 and transmitted wirelessly for monitoring and control. The system aims to reduce human intervention, optimize resource utilization, and improve energy efficiency in urban environments. Experimental results demonstrate reliable performance, real-time monitoring capability, and suitability of the proposed model for scalable smart city applications***.

## I. INTRODUCTION

The rapid growth of urban populations has created significant challenges in managing city infrastructure efficiently. Conventional methods of waste management, parking control, and street lighting often rely on manual monitoring, leading to increased operational costs, energy wastage, and delayed responses. To overcome these limitations, smart city concepts based on Internet of Things (IoT) technology have gained considerable attention in recent years.IoT enables the interconnection of physical devices equipped with sensors, controllers, and communication modules to collect and exchange data in real time. By integrating IoT with embedded systems, city services can be automated, monitored remotely, and optimized for better performance. The ESP32 microcontroller is widely used in smart city applications due to its low power consumption, built-in Wi-Fi and Bluetooth capabilities, and cost-effective design.This project focuses on the development of an IoT-based smart city model that addresses three critical urban services: smart waste management, smart parking, and smart street lighting. The smart bin system measures the fill level of waste and displays the percentage to enable timely collection. The smart parking module identifies available parking spaces to reduce traffic congestion and time spent searching for parking. The smart street lighting system automatically controls lighting based on ambient conditions and human presence, thereby reducing unnecessary energy consumption.

## II. LITERATURE REVIEW

The ESP32-powered smart bin revolutionizes waste management with its cutting-edge IoT technology. By continuously monitoring waste levels, it enables optimized collection routes and schedules. Real-time data facilitates datadriven decision-making, improving waste management services. Automated alerts prevent overflow and littering, contributing to a cleaner environment. This innovative system is essential for smart cities seeking to upgrade their waste management infrastructure. The smart bin's scalability and adaptability make it suitable for various urban settings. Cities adopting this technology can achieve sustainability goals while enhancing citizens' quality of life. IoT integration in waste management opens opportunities for further innovation and development. The ESP32-powered smart bin represents a forward-thinking approach to urban waste management. It combines technology and sustainability to create a better future for cities. Implementing this system can lead to improved public health and reduced environmental footprint. Enhanced urban livability is another significant benefit of this smart technology. Cities can pave the way for a more sustainable and efficient future by embracing such innovative solutions. The smart bin's impact extends beyond waste management, contributing to broader smart city development goals. By leveraging IoT technology, cities can create a more responsive and sustainable urban environment[1].

This study proposes a smart garbage monitoring system leveraging the Internet of Things (IoT) to optimize waste management. The system enables real-time monitoring of garbage levels in bins, sending alerts to authorities when the bins are full. This approach reduces unnecessary waste collection trips, minimizing operational costs and environmental impact. The system's automated monitoring and alert features contribute to a cleaner and healthier environment. By utilizing IoT technology, the smart garbage monitoring system provides a practical solution to the challenges of waste management in urban areas. The system's real-time data facilitates efficient waste collection, reducing the risk of overflow and littering. This innovative approach to waste management has the potential to significantly improve the quality of life for citizens. The authors' work demonstrates the effectiveness of IoT-based solutions in addressing urban waste management challenges. By adopting such smart technologies, cities can move towards more sustainable and efficient waste management practices. The system's scalability and adaptability make it suitable for various urban settings. The smart garbage monitoring system is a significant step towards achieving sustainable and efficient waste management. It combines technology and sustainability to create a better future for cities. The system's impact extends beyond waste management, contributing to broader smart city development goals. By leveraging IoT technology, cities can create a more responsive and sustainable urban environment. This approach can lead to improved public health, reduced environmental footprint, and enhanced urban livability[2].

This study present an IoT-based smart parking management system using the ESP32 microcontroller, designed to alleviate parking congestion and improve urban mobility. The system utilizes ultrasonic sensors to detect parking slot occupancy, providing real-time data to a web-based platform. This enables drivers to view and reserve parking slots efficiently, reducing search time and traffic congestion. The system's accuracy and reliability are enhanced by the ESP32 microcontroller's capabilities. By leveraging IoT technology, the smart parking management system offers a practical solution to urban parking challenges, contributing to improved traffic flow and reduced driver frustration. The system's real-time data and automated features make it an essential tool for smart city initiatives. With its potential to transform urban parking management, this innovative approach can lead to more efficient, sustainable, and livable cities. The system's impact extends beyond parking management, supporting broader smart city development goals. By adopting such smart technologies, cities can create a more responsive and sustainable urban environment. This approach can lead to improved public satisfaction, reduced environmental footprint, and enhanced urban livability. The system's scalability and adaptability make it suitable for various urban settings. Overall, the IoT-based smart parking management system is a significant step towards achieving efficient and sustainable urban mobility[3]

The study proposes an intelligent street lighting system for smart cities, leveraging the Internet of Things (IoT) to optimize energy consumption and enhance public safety. The system uses infrared (IR) transmitter and receiver pairs to detect the presence of vehicles or obstacles on the street, automatically switching on the street lights when movement is detected and turning them off when the object is no longer present. This approach eliminates the need for manual operation and reduces energy wastage. Additionally, the system's ON/OFF status can be monitored remotely in real-time via the internet, enabling smart control from anywhere, anytime. By employing IoT-based sensing, automated control, and remote monitoring, the proposed system offers a more efficient, sustainable, and intelligent approach to street lighting in smart cities[4].

The integration of Internet of Things (IoT) technology in smart cities has revolutionized urban development by providing advanced services, improving infrastructure, and enhancing the quality of life for citizens. IoT services, combined with big data analytics, drive global smart city initiatives by optimizing resource allocation, improving public services, and promoting sustainability. For instance, IoT sensors can monitor traffic flow, air quality, and waste management, providing real-time data that can be analyzed to identify areas of improvement. However, challenges such as data security, privacy, and standardization need to be addressed to realize the full potential of IoT-based smart cities. By leveraging IoT technologies, cities can create a more efficient, sustainable, and livable environment for their citizens[5].

## III. OBJECTIVES AND METHODOLOGY

1.To develop a smart garbage system using an ultrasonic sensor and ESP32 to continuously monitor the fill level of dustbins and display real-time percentage updates on a mobile app for efficient waste management.

2.To monitor a smart garbage system that requires a user password to open the dustbin using a servo motor, detects wet waste using a soil sensor, imposes a fine for incorrect waste disposal, and automatically records the violation in an Excel sheet.

3. To develop an intelligent streetlight system using IR sensors and LDR, where streetlights automatically turn on when a vehicle is detected and sequentially turn off after a delay, optimizing energy consumption.

4.To develop a smart parking system using IR sensors and a microcontroller to detect vehicle presence, send real-time data to the cloud, and allow users to monitor parking slot availability through a mobile application.

## METHODOLOGIES:

**1. Smart Garbage Monitoring System**

- An ultrasonic sensor is mounted inside the dustbin. It continuously monitor the dustbin level and sense the remaining empty space by calculating the distance to the waste surface.
- The ESP32 converts this distance into a percentage value and updates the dustbin status on a mobile application or desktop application through wireless communication.

---

**2. Smart Garbage System with Fine Management**

- The system validates a user-entered password before activating the servo motor to open the dustbin lid.
- A moisture sensor analyzes the disposed waste; if incorrect waste is detected, the system applies a penalty and logs the incident automatically in an Excel record.

---

**3. Smart Streetlight System**

- IR sensors are positioned along the roadway to identify the movement of vehicles, while an LDR measures surrounding light intensity.
- Streetlights are switched ON only when motion is detected at night and are turned OFF one by one after a time delay to minimize power usage.

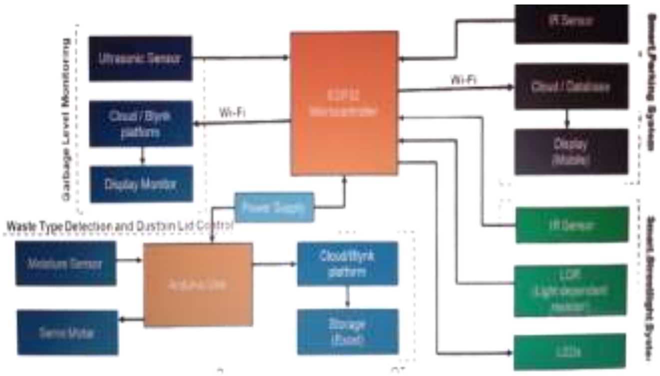
---

**4. Smart Parking System**

- Each parking slot is equipped with an IR sensor to monitor vehicle entry and exit.
- The controller sends updated slot information to a cloud platform, allowing users to check parking availability in real time via a mobile app.

---

## IV. BLOCK DIAGRAM




The block diagram illustrates a comprehensive smart city system utilizing Internet of Things (IoT) technology, integrating three primary components: smart garbage monitoring, intelligent streetlight control, and smart parking management. The smart garbage monitoring system employs an ultrasonic sensor to continuously monitor the fill level of dustbins, transmitting real-time data to the ESP32 microcontroller, which then updates the information on the Blynk mobile app. This enables efficient waste management by allowing municipal staff to remotely monitor dustbins and optimize waste collection routes.

The intelligent streetlight control and smart parking management systems also utilize IoT technology to optimize energy consumption and improve traffic flow. The streetlight control system uses IR sensors and LDR to detect vehicle presence and ambient light conditions, automatically turning on and off the streetlights as needed. The smart parking management system uses IR sensors to detect vehicle presence in parking slots, transmitting real-time data to a mobile application, enabling users to monitor parking slot availability. By leveraging real-time data and automated controls, the system can significantly improve waste management, reduce energy consumption, and enhance traffic flow, ultimately contributing to a smarter and more response city infrastructure.

## IMPLEMENTATION

The IoT-based Smart City project integrates various sensors with the ESP32 microcontroller to enhance urban services. For efficient waste management, ultrasonic sensors track dustbin fill levels, while a soil moisture sensor distinguishes between wet and dry waste. A servo motor controls the bin lid, ensuring secure access through password authentication, and logs any improper disposal for automated penalty imposition. Meanwhile, the smart parking system utilizes IR sensors to detect vehicle occupancy in parking slots, transmitting real-time availability updates to a mobile app via ESP32 and Wi-Fi, thereby reducing traffic congestion. Additionally, the intelligent street lighting system leverages LDR sensors to monitor ambient light and PIR sensors to detect motion, enabling the ESP32 to dynamically adjust streetlight brightness, conserving energy by illuminating lights only when necessary.

## V.RESULTS

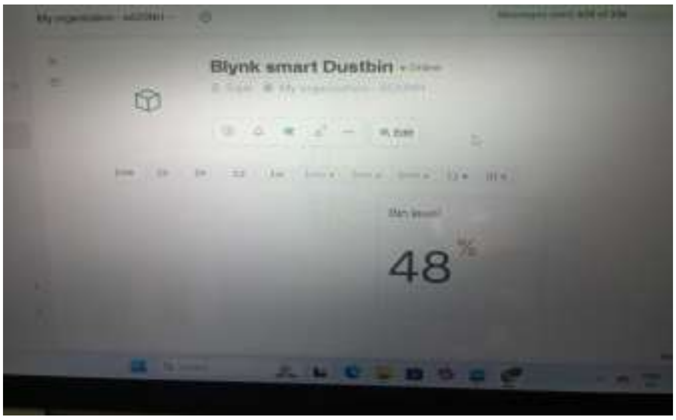



FIG-1: Dustbin level Monitor using Blynk Platform

The Blynk smart Dustbin application provides a user-friendly interface for monitoring waste levels, as shown in Figure 1. The screenshot displays a dustbin level reading of 48, highlighting the system's capability for real-time monitoring. This application is a key component of a smart waste management system, leveraging the Blynk platform to optimize waste .


FIG-2: Smart Dustbin

The figure 2 shows the smart bin which we have used for the implementation of our project and the results are shown below.

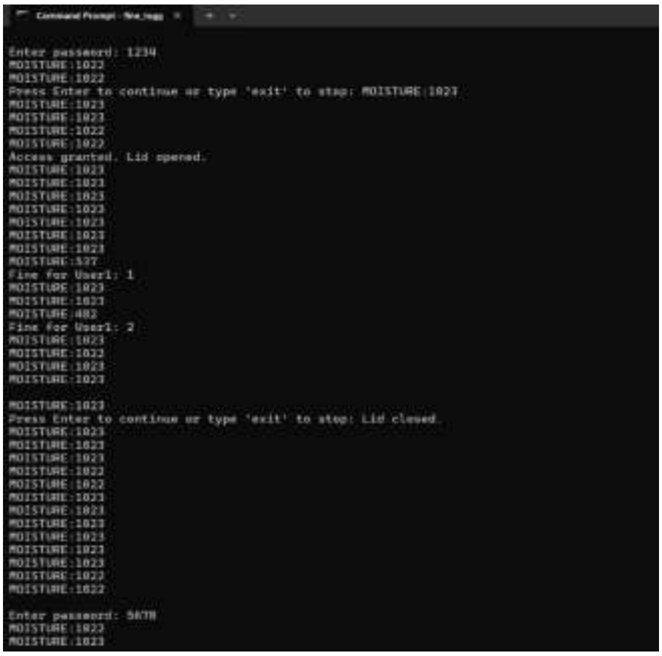



FIG-3: Output Window

It shows the user to put the specified password to open the lid of a bin if the user entered wrong password thye bin will be closed otherwise it will be opened and used by the user.

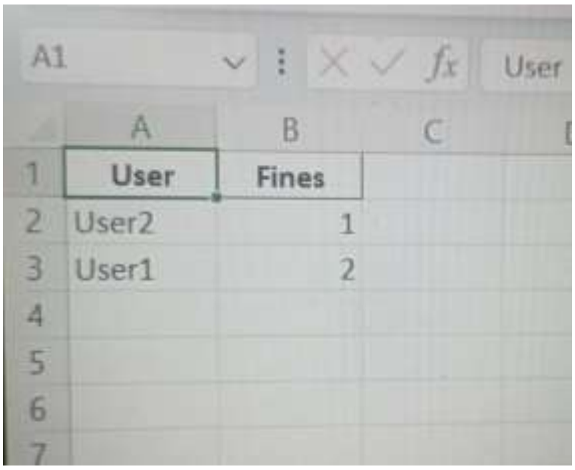



FIG-4: Fines Record

The Excel sheet shows the records of the user who puts the wet5 waste in dry waste bin and records the fine for particular user.

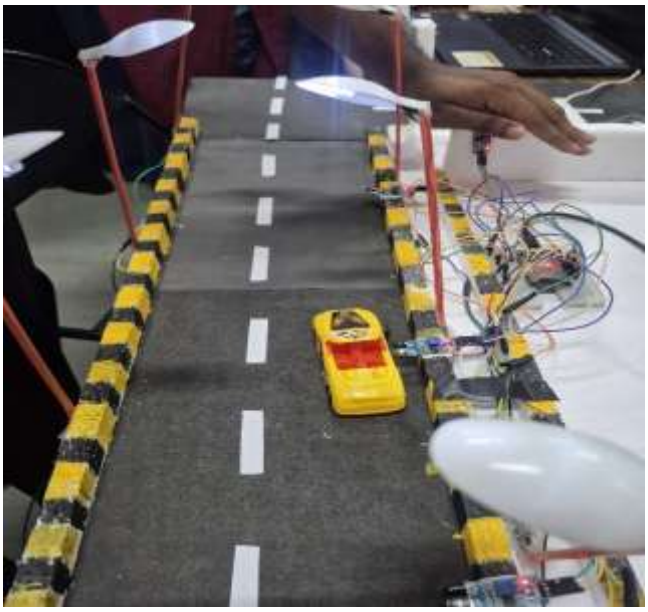


FIG-5: Street Light

The street light system where the light will be on if the car is present and detected by the IR sensors and it will remain off during the day time with the help of LDR sensor.

FIG-6:Smart Parking

It includes 3 slots and it shows which is available and slots which is not available and it also shows that In-time and pout-time of the car which will be helped for the citizens.

VI.CONCLUSION

In this paper, we presented an approach how the smart city can be developed using a prototype and it includes the three areas how the waste can be managed and it this paper gives an idea that how to implement a smart car parking which will be helpful for the users and citizens of the country and the smart street light system that will be helpful in energy conservation.

VI.REFERENCE

[1] Gajula, Ramesh, Madhavi Karanam, Dinesh Chandra Vakkapatla, Kranthi Raj Enrapu, Vegesna Vijaya Rama Raju, Sadda Bharath Reddy, Saif Obayd Aljanabi, SakshiKoli, and Shriya Mahajan. ”Sustainable waste management solution: ESP32-powered smart bin.” In AIP Conference Proceedings. AIP Publishing LLC, 2023.

[2] Chaware, Sandeep M., Shriram Dighe, Akshay Joshi, Namrata Bajare, and Rohini Korke. ”Smart garbage monitoring system using internet of things (IoT).” International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering 5, (2024).

[3] Simatupang, Joni Welman, and Aida Mahdalena Lubis. ”IoT-based smart parking management system using esp32 microcontroller.” In 2022 9th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), pp. 305-310. IEEE, 2022.

[4] Parkash, Prabu V., and Dandu Rajendra. ”Internet of things based intelligent street lighting system for smart city.” International journal of innovative research in science, engineering and technology 5, no. 5 (2016).

[5] Mehmood, Yasir, Farhan Ahmad, Ibrar Yaquob, Asma Adnane, Muhammad Imran, and Sghaier Guizani. ”Internet-of-things-based smart cities: Recent advances and challenges.” IEEE Communications Magazine 55, no. 9 (2017