



Digital Parking Management System using IoT

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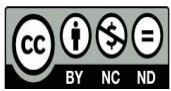
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Abstract: Finding a vacant space in a busy parking area is time-consuming, and conventional parking systems that depend on security personnel and manual observation often give inaccurate or delayed information. This paper proposes a Digital Parking Management System using IoT, an automated parking solution that combines IoT-based hardware with a web-based reservation platform. Sensors installed at individual parking slots detect vehicle presence, and a microcontroller such as the ESP32 converts the readings into a slot status shown by a traffic-signal-type indicator: green for empty, red for occupied and yellow for reserved. The status is sent over an IoT network to a central database, which drives an entrance display board showing the total, empty, occupied and reserved slots, and a website on which users can check availability and reserve a slot in advance. If an unauthorized vehicle occupies a reserved slot, the system generates a buzzer alert. The design is organized into five modules: slot detection and status indication, central display and IoT communication, database and parking management, web-based reservation, and reserved-slot monitoring with alert. This paper presents the architecture, methodology and planned evaluation of the system; the prototype is yet to be tested, and no experimental results are claimed.

Key Word: Smart Parking, Internet of Things (IoT), ESP32, Vehicle Detection Sensor, Slot Reservation, Real-Time Monitoring, Database Management, Smart City.

I. INTRODUCTION

The number of vehicles in cities, commercial areas, offices, hospitals, educational institutes and residential complexes is increasing continuously, and parking management has become an important problem as a result. Traditional parking systems depend on security personnel and manual observation to find vacant spaces. This consumes time, may give incorrect information about the available spaces, and makes drivers move around the parking area searching for a slot, which wastes fuel and increases traffic inside the area.

The Internet of Things (IoT) allows physical devices such as sensors and controllers to communicate with a server or database. In a smart parking system, sensors detect whether a slot is occupied and transmit the information to a central system, so that the current parking status can be monitored and shared with users [1], [2]. Web-based reservation extends this idea by letting users view availability and book a slot before they reach the parking area.

This paper proposes a Digital Parking Management System using IoT. Each parking slot is provided with a sensor that detects whether the slot is empty or occupied, and a traffic-signal-type indicator near the slot shows its status: green for empty, red for occupied and yellow for reserved. A display board at the entrance shows the total, empty, occupied and reserved slots, and a website allows users to check availability and reserve a slot. A database links the physical parking system with the website, and a buzzer alert is generated when an unauthorized vehicle occupies a reserved slot. The system is intended for shopping malls, offices, hospitals, railway stations, airports, residential societies, educational institutes and other large parking facilities.

The main contributions of this work are: (i) a proposed modular architecture that connects slot-level detection, visual indication, an entrance display, a database and a reservation website; (ii) a three-state slot model (empty, occupied, reserved) that is kept consistent across the slot indicator, entrance display, database and website; (iii) a reserved-slot protection mechanism that raises a buzzer alert for unauthorized parking; and (iv) a planned evaluation covering detection accuracy, status-update accuracy, reservation success rate and alert accuracy. The scope is a working prototype for a small parking area, which can later be extended to larger facilities.

The rest of the paper is organized as follows. Section II reviews the literature. Section III describes the methodology as five modules. Section IV discusses the expected benefits, planned evaluation and feasibility. Section V concludes.

II. LITERATURE REVIEW

Traditional parking systems use security personnel to control vehicle entry and to identify available spaces. Such systems are simple but need continuous human involvement. Modern systems use sensors, communication networks and software applications to automate parking management. The following studies form the basis of the proposed work.

Kanan and Arbess [1] proposed an IoT-based system for real-time parking monitoring with automatic billing. Their work shows that real-time monitoring can be combined with additional parking services through IoT. Khanna and Anand [2] presented an IoT-based smart parking system in which sensors report the occupancy of parking slots so that availability can be checked remotely. This is the basic concept followed by the proposed system.

Zheng et al. [3] studied parking availability prediction for sensor-enabled car parks in smart cities. Their work shows that occupancy data collected by sensors can be used to forecast availability and not only to display the current state, which we treat as a future extension. Pham et al. [4] described a cloud-based smart-parking system built on IoT technologies for finding, allocating and reserving parking spaces, which is close to the combination of monitoring and reservation proposed here.

Paidi et al. [5] reviewed sensors, technologies and applications for smart parking in open parking lots, and their review is useful for selecting a suitable vehicle-detection sensor for the prototype. Rico et al. [6] used context information of a smart city to enable fast search and management of parking resources, which supports the idea of giving users parking information before they reach the parking area. Karthi and Harris [7] proposed smart parking with reservation in a cloud-based environment, which supports the reservation feature of the proposed system. Abdullah et al. [8] studied license plate recognition using a support vector machine. Number-plate identification is one possible way of checking whether a vehicle is authorized for a reserved slot. *Research gap:* The reviewed studies show that IoT-based parking monitoring and reservation are feasible, but they differ in what they provide: some concentrate on monitoring or billing, some on prediction or reservation, and some on sensing technologies or vehicle identification. The proposed work does not claim a new sensing or recognition technique. Its aim is a complete, low-cost and modular prototype that joins slot detection, per-slot visual indication, an entrance display, a database, a reservation website and an unauthorized-parking alert in one system, and that is planned to be tested at module level and as an integrated system.

III. METHODOLOGY

The proposed system follows a modular design in which hardware, software and communication functions are developed and tested separately and then integrated. It is organized into five modules (Table I and Fig. 1). The sensors, controller and indicators form the physical layer, while the IoT network, database, display board and website form the software layer through which parking information reaches users and administrators.

Module	Function	Key components
M1	Slot detection and status indication	Sensors, microcontroller, LEDs
M2	Central display and IoT communication	Display board, IoT network
M3	Database and parking management	Server, database
M4	Web-based booking and reservation	Web application
M5	Reserved-slot monitoring and alert	Identification unit, buzzer

Table I. summary of the modules

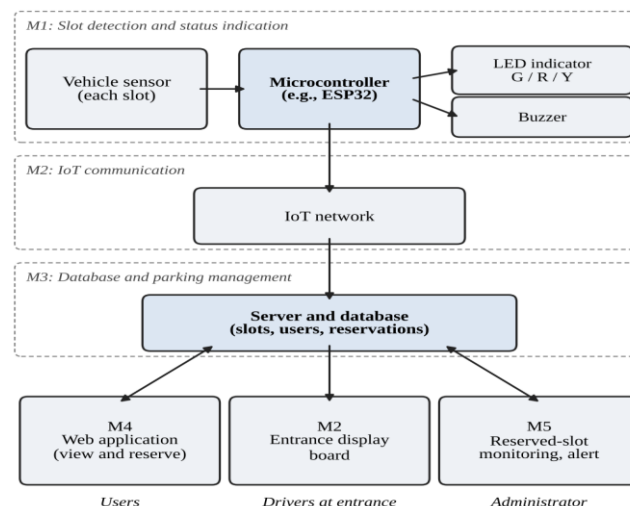


Fig. 1. Block diagram of the proposed Digital Parking Management System and its five modules (M1–M5). Sensor data flows from the slots to the database, which drives the display board, the website and the alert function.

A. Module 1: Parking-Slot Detection and Status Indication

A sensor is placed at every parking space to detect whether a vehicle is present. The microcontroller reads the sensor signal, determines the slot status and drives the status indicator. When no vehicle is detected, the slot is considered available and the green indicator is activated. When a vehicle occupies the slot, the status changes to occupied and the red indicator is activated. When the slot is reserved through the website, the indicator changes to yellow (Table II). After every change, the status is sent to the central system and the database is updated.

Indicator	Slot status	Condition
Green	Empty	No vehicle detected in the slot
Red	Occupied	Vehicle detected in the slot
Yellow	Reserved	Slot reserved through the website

Table 2. Slot status indication

B. Module 2: Central Display and IoT Communication

This module manages communication between the slot sensors and the central display system. The controller collects information from multiple slots, processes it and transmits it to the central system. The display board at the entrance shows the total number of slots, the number of empty, occupied and reserved slots, and the relevant slot numbers. For example, in a parking area of 20 slots with 8 vehicles parked and 2 slots reserved, the display shows TOTAL: 20, OCCUPIED: 8, AVAILABLE: 10 and RESERVED: 2, and the counts are updated whenever a vehicle enters or exits.

IoT communication connects the hardware with the software and the database. The basic flow is sensor, controller, IoT network, server/database, and display/website, so that a change in the physical parking area is reflected in the digital system.

C. Module 3: Database and Parking Management

The database stores information about parking slots and slot numbers, slot status, user details, reservation details, vehicle information, and entry and exit information. A basic parking-slot table contains the fields Slot_ID (unique slot number), Vehicle_Type (two-wheeler or four-wheeler), Status (empty, occupied or reserved), User_ID (user associated with a reservation), Vehicle_No (registration number) and Reservation_Time (date and time of reservation). The database keeps the physical parking system and the web application consistent and gives administrators a central location for managing parking records.

D. Module 4: Web-Based Booking and Reservation

The website lets users view parking availability and available slot numbers, select a suitable slot, enter the required user information, reserve the slot and view the reservation details. When a user reserves a slot, the reservation is stored in the database, the slot status changes from empty to reserved, and the corresponding indicator turns yellow (Fig. 2, left). The interface is kept simple and understandable for users.

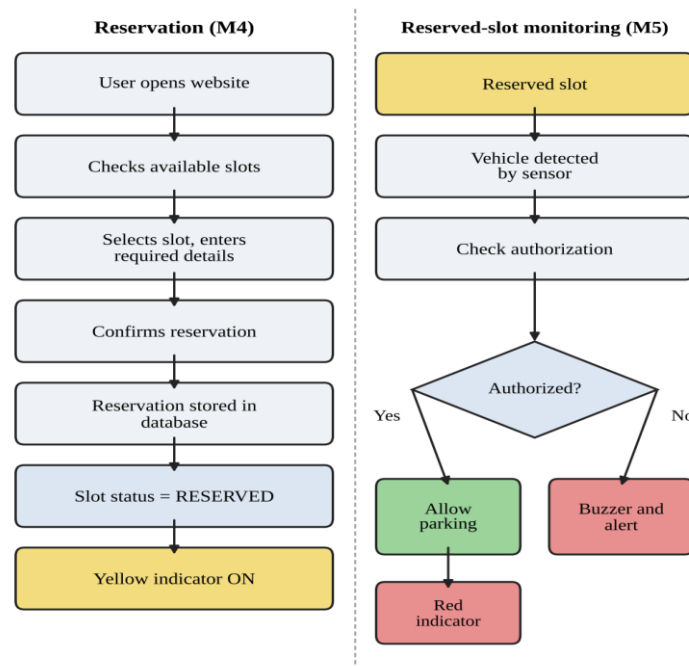


Fig. 2. Reservation process (left) and reserved-slot monitoring process (right) of the proposed system.

E. Module 5: Reserved-Slot Monitoring and Alert

This module protects reserved slots. When a vehicle occupies a reserved slot, the system checks whether the vehicle is authorized for that reservation. Depending on the hardware and identification method chosen for the final prototype, authorization can be checked using a scanner, RFID, camera-based number-plate identification [8] or another identification mechanism. If the vehicle is authorized, parking is allowed and the slot is shown as occupied; if not, the buzzer is activated and an alert is generated (Fig. 2, right). This improves parking discipline and reduces unauthorized use of reserved spaces.

F. Facilities and Development Environment

The system will be developed and tested in the Computer Engineering Department laboratory with the support of the project guide and the project sponsor, Narwade and Associates, Miraj. The hardware requirement comprises an IoT-enabled

microcontroller such as the ESP32, vehicle-detection sensors for the slots, LED indicators in the form of traffic-signal poles, the main display board, a buzzer, and basic electronic components such as a breadboard, jumper wires, resistors and a power supply. A computer with internet connectivity and suitable programming, web-development, database and microcontroller-programming tools is needed for the web application, the database, documentation and testing. Each module will be developed and tested separately before final integration.

IV. EXPECTED BENEFITS AND EVALUATION PLAN

A. Expected Benefits

Based on the design, the system is expected to detect the availability of individual slots in real time, give clear visual information about each slot through the indicators, show the total, empty, occupied and reserved slots at the entrance, allow users to check availability and reserve a slot before arriving, reduce unauthorized use of reserved slots through an alert, and reduce manual monitoring. Together these features should shorten the time spent searching for parking, improve the utilization of parking spaces and reduce unnecessary vehicle movement, congestion and fuel consumption inside the parking area. Because the design is modular and database-driven, it can be scaled from a small prototype to malls, hospitals, offices, railway stations and multi-level parking facilities, and it can act as a base for smart-city applications. These are design goals, not measured results.

B. Planned Evaluation

After implementation, the system will be evaluated by testing its major functions against the targets in Table III.

Parameter	Expected result / target
Vehicle detection	Vehicle presence in a slot is detected correctly
Slot indication	Green = empty, red = occupied, yellow = reserved
Real-time update	Status updates automatically after vehicle entry or exit
Main display	Total, empty, occupied and reserved counts are correct
Reservation	User can reserve an available slot
Reserved-slot protection	Unauthorized parking generates an alert
Database update	Reservation and slot status are stored correctly
Web application	Availability and reservation details are displayed properly
System response	Status changes are reflected with minimum delay
Reliability	System operates continuously under normal test conditions

Table3 performance parameters and expected targets

The following measurements will be recorded during testing:

$$A_d = (n_d / N_d) \times 100 \quad (1)$$

$$A_u = (n_u / N_u) \times 100 \quad (2)$$

$$R = (n_r / N_r) \times 100 \quad (3)$$

$$A_a = (n_a / N_a) \times 100 \quad (4)$$

where n is the number of correct outcomes and N is the total number of tests for detection (A_d), status update (A_u), reservation (R) and alert (A_a), giving the detection accuracy, status-update accuracy, reservation success rate and alert accuracy in percent. These measurements will help to determine the reliability and effectiveness of the system.

C. Feasibility and Scope

The project is technically feasible because it uses commonly available IoT components such as an ESP32-class microcontroller, sensors, LEDs, a buzzer and a display unit, together with standard web and database technologies. It is economically feasible because a prototype can be built from low-cost components and freely available or commonly used software tools, and the modular design allows gradual development within the available budget. It is operationally feasible because users can view and reserve slots through the website and staff can monitor the parking status through the main display and the management interface. It is schedule-feasible because the work divides into modules that can be developed and tested separately before integration, and user-feasible because the interface is simple for both users and administrators. The final performance will be confirmed through hardware, software and integration testing. The scope of this work is a working prototype; features such as mobile applications, online payment and AI-based parking prediction are left for future work.

V. CONCLUSION

This paper proposed a Digital Parking Management System using IoT that combines sensors, a microcontroller, slot indicators, an entrance display, a web-based reservation system and a database to monitor parking slots in real time. The display provides information about empty, occupied and reserved slots, and the individual indicators help users identify the status of each parking space. The reservation facility lets users check availability and reserve a suitable slot in advance, and the reserved-slot monitoring and alert mechanism can help prevent unauthorized vehicles from occupying reserved spaces. The five-module design allows each stage to be developed, tested and improved independently.

Future work includes completing the prototype, evaluating it as planned in Section IV, and extending it with mobile applications, automatic number-plate recognition, online payment, AI-based parking prediction, EV charging and integration with larger smart-city systems.

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