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IoT Based Smart Parking System

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Abstract A smart parking system based on the Internet of Things (IoT) can assist users in locating parking spaces in crowded regions by offering real-time availability updates online. This technology streamlines the car parking procedure, encompassing the entire process from vehicle entry to payment and subsequent leave. The system utilises NodeMCU, a set of five IR sensors, and a pair of servo motors to accurately detect the presence of cars and determine the availability of parking slots. Two infrared sensors are used to detect cars at the entry and exit gates, while three sensors are employed to detect the availability of parking slots. Servo motors operate gates by responding to sensor readings to initiate opening and closing actions. The data is made available on the Adafruit IO platform, enabling worldwide monitoring. The system utilises a total of five infrared sensors and two servo motors that are linked to the NodeMCU. The NodeMCU is responsible for overseeing the entire operation and transmitting data regarding parking availability and time to Adafruit IO.

Crossref 10.36371/port.2024.3.1

Keywords: *Internet of Things (IoT), Parking System, NodeMCU, Adafruit IO*.

1. INTRODUCTION

Parking in contemporary urban areas is a significant concern. There are an excessive number of automobiles on the route and an insufficient number of parking spots. The team recognised the necessity for effective parking management systems. In order to illustrate the idea, they employ infrared sensors to detect the occupancy of parking slots, in addition to a direct current motor to imitate the motors used for opening gates. Currently, a Wi-Fi modem facilitates their internet communication, and a microcontroller controls the system. They provide a website for designing graphical user interfaces (GUIs) for online connectivity and Internet of Things (IoT) management. The system employs infrared (IR) sensors to identify the occupancy status of the parking spots. The system retrieves the count of parking slots that are either available or occupied and synchronises the data with the cloud server, enabling online monitoring of parking slot availability [1]. Users may conveniently access real-time parking availability information online from any location, ensuring a seamless parking experience. Therefore, the system effectively resolves the problem of parking in urban areas and provides customers with a streamlined parking management system based on the Internet of Things (IoT). The inception of the Internet of Things (IoT) may be traced back to the utilisation of communication devices that have distinct identities. The gadgets can be remotely tracked, controlled, or monitored via Internet-connected computers. The Internet of Things (IoT) expands the utilisation of the Internet by enabling communication and inter-networking between devices and physical objects, sometimes known as "things." The two important terms in IoT are "internet" and "things." The Internet is an extensive worldwide network of interconnected servers, computers, tablets, and mobile devices that utilise universally recognised protocols to establish connections between systems. The Internet facilitates the transmission, reception, and exchange of information. The vision entails the transformation of various objects, such as wearables, watches, alarm clocks, household devices, and surrounding objects, into intelligent entities. This is achieved through the use of small embedded devices that possess the ability to sense, compute, and communicate. These devices are capable of interacting with remote objects or individuals through connectivity. Developers are able to design and host their apps on cloud computing due to its scalable and robust nature. The cloud serves as an ideal companion for IoT, functioning as a platform for storing and retrieving sensor data from distant locations. These reasons resulted in the combination of both technologies, resulting in the creation of a new technology known as the Cloud of Things (CoT). Within the context of CoT, the nodes can be remotely accessed, monitored, and controlled through the utilisation of cloud technology. Thanks to the cloud's tremendous scalability, the IoT system can have nodes added or withdrawn in real-time, regardless of the number. The Internet of Things (IoT) can be

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defined as the combination of a physical object with controllers, sensors, and actuators connected to the internet [2]. Work [3] introduces an Internet of Things (IoT)-enabled intelligent parking system designed for large parking lots. The system aims to alleviate traffic congestion by offering real-time information on available parking spaces using a mobile application. The device utilises Internet of Things technologies to direct people to the closest accessible parking space.

Work [4] introduces a smart parking energy management solution designed specifically for a multi-story business parking space. The parking system utilises IoT technology and employs Honeywell sensors to establish a methodical approach. Luminous devices identify vacant areas and guide individuals towards them. Occupied areas are kept on a remote server, and the light intensity is automatically adjusted to save energy. The system enhances user convenience and optimises time efficiency in parking.

The Internet of Things (IoT) [5] is a rapidly growing area of research and implementation, offering numerous benefits and reducing manpower. As the population grows, transportation dependency increases, resulting in increased parking difficulties in urban areas. Traditional indoor parking systems are outdated and burdensome, causing traffic and accidents. Smart outdoor parking systems using weighbridge load sensors can provide organised, flexible, convenient, and safe parking in public spaces.

The paper [6] introduces a smart parking system that uses IoT technology to tackle the challenges associated with conventional parking lots. The system utilises a smartphone application, infrared sensors, radio-frequency identification (RFID), and Arduino technology to accurately determine the availability of parking spaces and prevent unnecessary travel. Users can conveniently locate local parking lots, reserve them, and make payments using an integrated in-app wallet. This technology enhances efficacy, dependability, and convenience while diminishing resource consumption and pollution.

The Internet of Things (IoT) is gaining popularity in smart cities to improve urban infrastructure and productivity [7]. However, in these cities, limited parking facilities and traffic congestion lead to wasted time and delays in payment processes. This paper proposes an IoT-based smart parking system with e-ticketing, using Arduino UNO as the processing unit and RFID cards to identify vehicles and deduct parking charges. If sufficient funds are available, a message is sent to the owner's mobile phone, and the system opens parking gates, minimizing time spent on finding vacant parking slots.

The aim of this study is to analyze the characteristics of COVID-19 in a group of Iraqi patients and comorbidities to aid the development of strategies to better manage SARS-CoV-2-infected patients and to update our information on the influence of comorbidities on the exacerbation of COVID-19 so identifying the patients at higher risk for critical conditions helps to manage the disaster .

2. PROBLEM STATEMENT

Difficulty in locating available spaces in a multilevel parking garage is highly problematic, especially during weekends or public holidays. For around two-thirds of visitors, finding parking spaces during weekends or public holidays can take more than 10 minutes . During peak hours, stadiums and retail centres are heavily crowded, and customers may have significant difficulties finding available spaces at these locations. Insufficient car parking spots lead to congestion and frustration among drivers [8].

The objective of the study is to develop and execute an intelligent system that will be utilised in intelligent parking garages to facilitate the identification of available parking spots.

3. PROPOSED DESIGN

The project is essentially divided into two primary components: hardware architecture and software details. The circuit design was implemented in the hardware architecture, and a prototype of the project was developed. Throughout the software development process, the entire prototype was controlled exclusively through programming code

3.1 Hardware

There are a wide variety of Arduino boards available, each possessing unique characteristics and capabilities. The project utilises several highly sought-after boards, including:

3.1.1 ESP8266 NodeMCU

NodeMCU (shown in Figure 1) is a cost-effective platform that utilises the ESP8266 WiFi-enabled chip and is available as an open-source solution. The device utilises an on-module flash-based SPIFFS file system, which is built on top of the Espressif Non-OS SDK. NodeMCU is a microcontroller board that resembles Arduino and has pins that can be programmed, as well as built-in WiFi and a micro-USB connection. The device can be programmed using several software platforms and is equipped with a built-in WiFi module, which helps to minimise power usage and save space. NodeMCU can be readily connected to any suitable USB port [9].

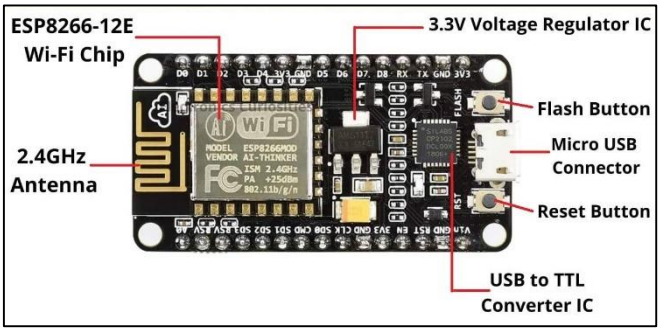

Fig. 1: *Layout of NodeMCU*

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3.1.2 IR Sensor

An infrared sensor, often known as an IR sensor, is an optoelectronic component that detects and responds to radiation in the infrared wavelength range of 780 nm to 50 µm. In contemporary applications, infrared sensors have become extensively employed in motion detectors. These detectors are used in building services to activate lighting systems and in alarm systems to identify intruders. The sensor components detect variations in heat radiation, specifically infrared radiation, brought about by people's movement in both time and space within a given range of angles. Infrared sensors of this kind merely need to fulfil modest specifications and are inexpensive, mass-produced commodities [10].

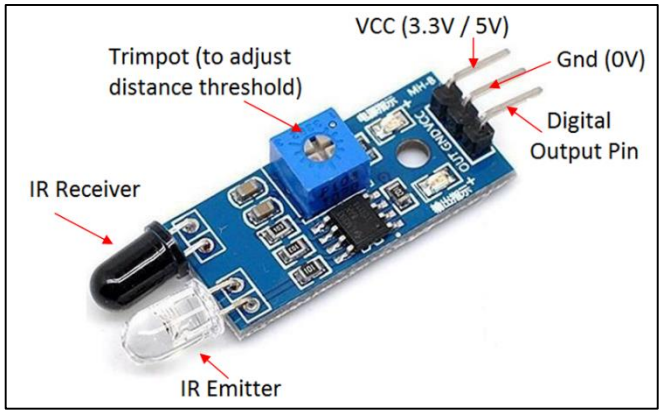

Fig. 2: *IR Sensor*

3.1.3 Servo Motor

A servo motor is a motor with great precision that rotates at particular angles or distances. The device has a gear system that enables the production of potent rotational force in small, lightweight units, and it can run on either a direct current (DC) or alternating current (AC) power source. These motors are used in a multitude of applications, including toy automobiles, RC helicopters, planes, and robotics. The system employs two servo motors as entry and exit gates, which autonomously rotate from 45° to 140° upon detection of an automobile by an IR sensor. After a period of time, the motor reverts back to its original position. Servo motors can be classified into different categories depending on their gear arrangement and operational characteristics [10].

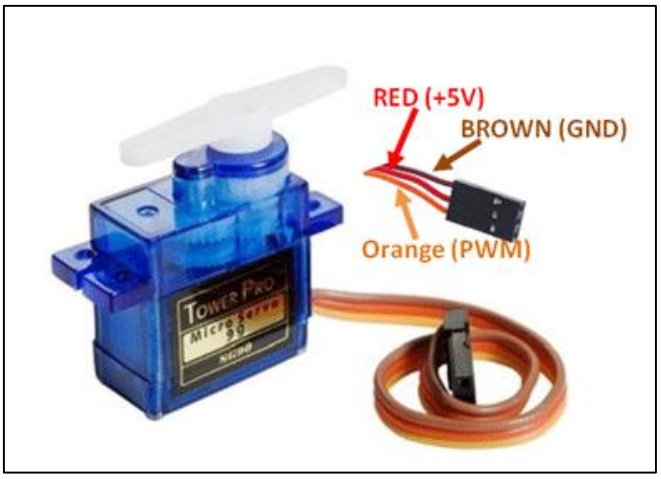

Fig. 3: *Servo Motor*

3.1.4 Breadboards

A breadboard is a plastic block with electrical sockets suitable for gripping thin connecting wires, component wires, or pins of transistors and integrated circuits (ICs). It allows easy removal and replacement of components, demonstrating their action and allowing reuse in another circuit. The sockets are spaced 2.54 mm apart, ensuring proper spacing for IC pins [11].

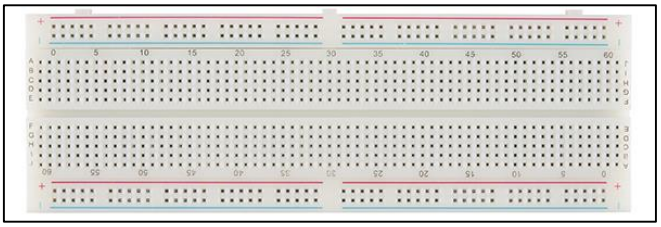

Fig. 4: *Breadboards*

3.1.5 Jumper Wires

Jumper wires are connector pins used to connect two points without soldering, commonly used with breadboards and prototyping tools. They come in male-to-male and male-to-female types, with square and round head shapes. Male ends have a pin for plugging, while female ends do not [11].

Fig. 5: *male to male & female to male wires*

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3.2 Software

3.2.1 Arduino IDE

The Arduino IDE is a freely available piece of software used for authoring and compiling code for Arduino modules. It may be used on MAC, Windows, and Linux operating systems. The software operates on the Java Platform and encompasses features for debugging, modifying, and compiling code. The Arduino modules consist of the Arduino Uno, Arduino Mega, Arduino Leonardo, and Arduino Micro. The IDE environment comprises a text editor and a compiler that provide support for the C and C++ programming languages. It enables novices to acquire and enhance their proficiency in Arduino.

3.2.2 Adafruit IO

Adafruit IO is an open data platform that enables the aggregation, visualisation, and analysis of live data on the cloud. It allows users to upload, display, and monitor data over the internet, enabling IoT projects. Adafruit IO is free for testing and experimenting and has been previously used with the Raspberry Pi. To use Adafruit IO, create an account on the Adafruit IO website and log in to obtain your username and AIO key. Copy these keys and usernames for future use in code [12].

4. DESIGN AND IMPLEMENTATION

The scheme illustrates the flow of inputs and outputs in the project's' work. For instance, when a car intends to park, the infrared (IR) sensor transmits a signal to the nodemcu, which in turn provides a signal to the servo motor. Additionally, the IR sensor for the output gate becomes operational. Additional infrared sensors are used to determine if a vehicle is positioned in a secure area. The outcomes are then showcased on Adafruit IO and a mobile application.

The following schematic represents the connection of the hardware components of the project, which is connection for programming, as the scheme shows the connection of each sensor and other piece with its respective ports.

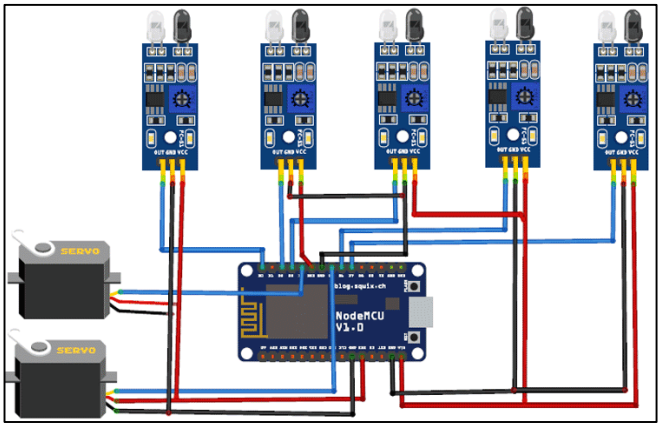

Fig. 6: *Schematic diagram of the proposed system*

The diagram illustrates the operational process of the programming code, wherein the initial IR sensors ascertain the presence of any vehicle at the input gate and determine whether the parking area is at maximum capacity or not. If the park reaches its maximum capacity, the entrance gate is closed, and the park is marked as full in the application.

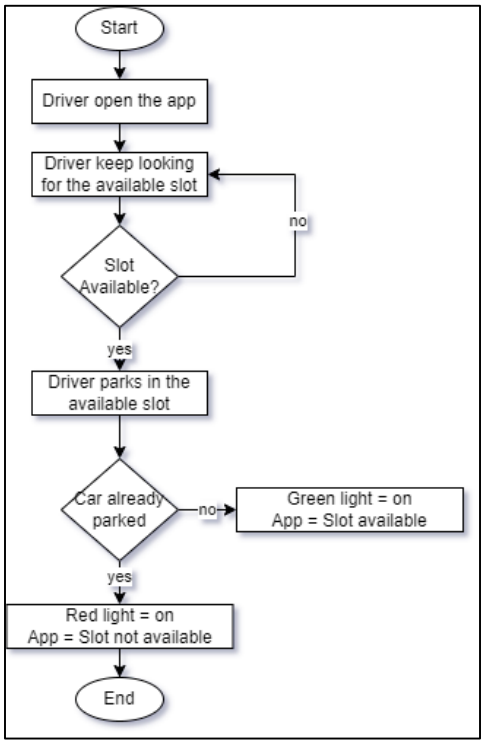

Fig. 7: Flowchart for the proposed algorithm

4. RESULTS

Based on the design schematic, the hardware level of the system has been introduced in this section.

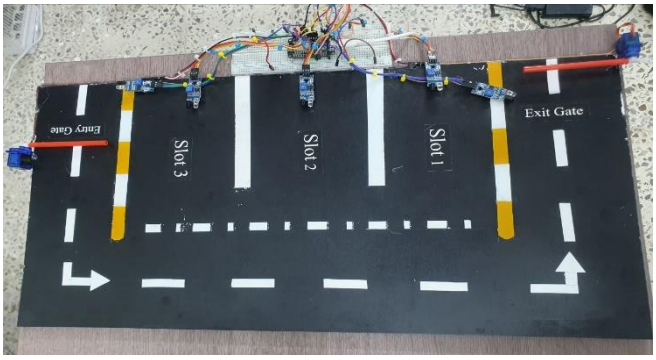

Fig. 8: Final Design

At the start of the project, the Internet of Things (IoT) will be depicted visually, as shown in Figure 9. According to the parking count, it can be deduced that there are zero cars parked at the location. Figure 10 presents a graphic depiction of a parking lot that is not currently being used.

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Fig. 9: *Start of IOT project*

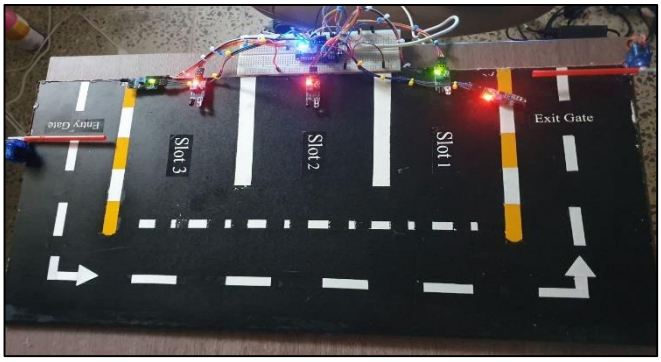

Fig. 10: Park is empty

When a vehicle enters the park, the sensor will be triggered, causing the car parked counter to increase by 1, as shown in Figure 11. In addition, a servo motor will operate the entry gate. Afterwards, the car moves towards an empty parking spot, such as the first available space. The infrared sensor enables the transfer of information on the duration of parking and the time of departure of a vehicle from a specific parking spot to the Internet of Things (IoT) platform, as shown in Figure 12.

Fig. 11: car parked and time details

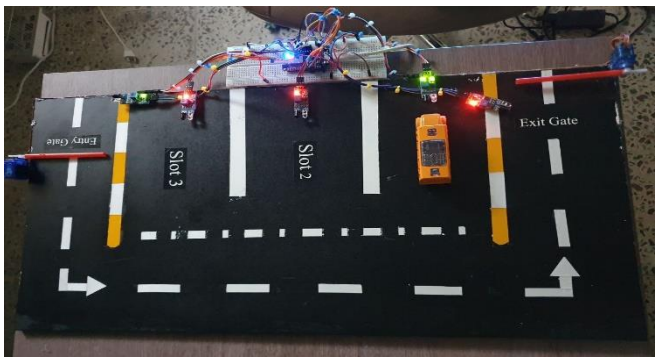

Fig. 12: car in the 1st slot

If the park reaches its maximum capacity, as shown in Figure 13, the website will indicate that three cars are parked and all sensors will continue to function, sending the respective entry times to the website as represented in Figure 14.

Fig. 13: *IOT Park is full*

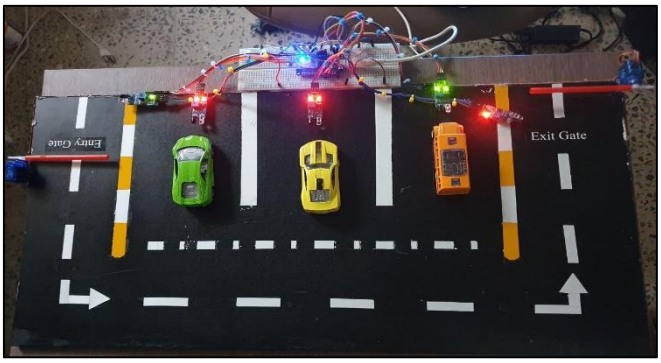

Fig. 14: Park is full

5. DISCUSSION AND FUTURE WORK

The concept of incorporating wavelet [13] and multiwavelet [14, 15, 16and 17] transforms into the system described here is an interesting proposition. Here's how these transforms could potentially improve parking availability prediction. Feature Extraction from Sensor Data: using Wavelet and multiwavelet transforms [18] can be used to analyze the data collected from IoT sensors in parking spaces. This data might include ultrasonic sensors where signal variations can reveal presence/absence of a vehicle and potentially information about vehicle size. Magnetic sensors usually change in magnetic field can indicate vehicle presence. Cameras (if used) will include image analysis using wavelets could extract features related to occupancy or parking space condition (e.g., blocked by cones).

Such techniques can lead in capturing temporal Variations since Wavelet transforms excel at analyzing signals over time [19]]. This allows for capturing how sensor readings change, potentially revealing patterns related to parking usage throughout the day. As well as such idea will improve feature representation by decomposing the sensor data into different frequency bands. Note that wavelets can potentially extract more informative features compared to using raw sensor readings alone. These features could then be used as inputs for the ensemble-based model. Multiwavelet transforms offer additional flexibility compared to single wavelets. Choosing appropriate wavelet bases could allow for better adaptation to the specific characteristics of the sensor data. Integration these transforms with Ensemble Model provide the following advantageous:

1- Feature Engineering: The features extracted using wavelets and multiwavelets can be combined with

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other relevant data points like time of day, weather, or upcoming events. This enriched feature set can then be fed into the ensemble model for training and prediction.

2- Potential for Improved Accuracy: By incorporating richer and more informative features, the ensemble model might learn more complex relationships between sensor data, parking availability, and other factors, potentially leading to improved prediction accuracy.

However, some challenges need to be addressed:

1- Increased Complexity: Introducing wavelet and multiwavelet transforms adds complexity to the system, requiring expertise in feature engineering and potentially increasing computational cost.

2- Data Volume: Wavelet transforms might generate a larger volume of features compared to raw sensor data. This can impact storage requirements and potentially training time for the ensemble model.

3- Hyperparameter Tuning: Selecting appropriate wavelet bases and parameters for the transforms requires careful optimization for optimal performance.

Overall, incorporating wavelets and multiwavelets holds potential for improving parking availability prediction by extracting more informative features from sensor data. However, the added complexity, potential increase in data volume, and need for careful hyperparameter tuning need to be weighed against the potential benefits.

Much better results can be achieved using some hybrid transforms [20] like Walidlet transforms [21, 22, 23 and 24], FAW and COW transforms [25]. Applications of these hybrid transforms can be found in several recent publications [20-25]. By the incorporation of Swin transformer with transformation techniques, the process of selecting, combining, generating or adapting several features to efficiently solve accuracy and computation time problems. One of the motivations for studying Swin transformer is to build systems which can handle classes of problems rather than solving just one problem [26, 27, 28 and 29].

6. CONCLUSIONS

The problem of car parking is a significant concern in numerous shopping centers and urban areas. In order to mitigate this issue, we have devised a concept for an Internet of Things (IoT)-enabled intelligent parking system utilising an Arduino microcontroller, a WIFI module, and a Node MCU. The cloud manages the parking system. Currently, urban areas are experiencing a high level of congestion in car parking facilities. We will utilize a simplified approach by employing the Internet of Things (IoT) parking system. Prior to commencing this endeavor, our intention is to locate a city that is experiencing parking difficulties and park the automobile there. This project simplifies the process of parking a car in any parking lot by implementing this system. Users may conveniently access and monitor parking space availability through an online platform, regardless of their location, ensuring a seamless parking experience. Therefore, the system effectively resolves the problem of parking in urban areas and provides customers with a streamlined parking management system that utilizes Internet of Things (IoT) technology.

One possible enhancement is the incorporation of an RFID card system that enables car access. Additionally, a camera can be installed to capture footage of the vehicle when it enters. Implementing the online booking and payment functionality.

Conflict of interest

The authors declare that they have no conflict of interest.

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