# INTELLIGENT TRANSPORTATION SYSTEMS (ITS) WITH IOT AND AUTONOMOUS VEHICLES

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**Abstract—**In This paper we introduce a transformative approach to urban parking, leveraging cutting-edge technologies for heightened efficiency. The parking infrastructure is meticulously organized into a 3x3 grid, comprising 9 blocks, each accommodating 6 slots, resulting in a total of 54 slots. A singular entry and exit point streamlines traffic flow, while the hierarchical arrangement minimizes parking distances and optimizes energy consumption. A dedicated mobile application empowers users with real-time information on the overall, allocated, and vacant parking slots. When a new vehicle enters or a parking request is received, the system dynamically computes the parking slot with the shortest distance, promptly displaying the corresponding block and slot numbers in the mobile app. Rejected slot selections are immediately released for other vehicles, while accepted requests update the occupancy status and decrement the available slot count. This innovative approach ensures a seamless experience for Full Self-Driving Vehicles. Parking requests are processed only when suitable slots are available, and slots promptly become vacant upon vehicle departure. The system's responsiveness, energy efficiency, and real-time visibility through the mobile app collectively redefine urban parking for the autonomous future.

**Keywords—** Internet of Things, Smart Parking, Real time information, Mobile application

## I. INTRODUCTION

Urban parking systems are facing unprecedented challenges in accommodating the growing number of vehicles in modern cities. Traditional setups often struggle with inefficiencies, leading to congestion, longer wait times, and increased energy consumption[1]. In response to these drawbacks, a transformative approach is necessary to revolutionize urban parking infrastructure. The proposed "IoT-Powered Smart Parking for Full Self-Driving Vehicles" offers a promising solution to address the limitations of conventional parking systems. By leveraging cutting-edge Internet of Things technologies, this innovative system introduces intelligence and adaptability into parking infrastructure. This paper introduces a meticulous organization of parking spaces into a 3x3 grid, comprising 9 blocks with 6 slots each, resulting in a total of 54 slots. This grid-based system optimizes parking hierarchy, minimizes parking distances, and reduces energy consumption. A singular entry and exit point streamline traffic flow, enhancing overall efficiency. Moreover, a dedicated mobile application provides real-time updates on total and available parking slots, empowering users with seamless access to parking information. When a new vehicle enters or a parking request is received, the system dynamically computes the nearest available parking slot, ensuring prompt allocation and minimal wait times. Furthermore, this innovative approach not only meets the demands of today's urban landscape but also prepares for the autonomous future of Full Self-Driving Vehicles. Parking requests are processed efficiently, and slots promptly become vacant upon vehicle departure, ensuring optimal utilization of parking resources. Through its responsiveness, energy efficiency, and real-time visibility features, the proposed system redefines urban parking for the autonomous era, offering a sustainable and user-friendly solution to the challenges of modern city parking.The mobile application used is MIT App Inventor[2], and Firebase Cloud is used for storing the database[3].

## II. Related Work

### *A. GRID MAP IN PARKING LOT*

One useful tool for efficiently schematizing an area is a grid map. Different routes or hazards can be represented by creating an area within the identical squares grid. In [4], form the grid map is particularly popular for indoor robot or moving object driving because it is easier to convey in a straightforward manner without making a differentiation between interior and exterior locations. Even in an environment it is unfamiliar with, a robot or object that moves can utilize detectors to track what is around it in a grid and estimate its location.

In [5], a grid map may have been generated beforehand to be employed if an object in motion travels toward a target or guesses its location if the person using it is already familiar with the interior structure. A grid map can be made of an indoor or subterranean parking lot because the entry point, departure, traveling guidance, and parking spots are all fixed. The mobile edge can also move to its target and predict its precise position via a grid map because it is outfitted with multiple sensors and networking modules.

### *B. RASPBERRY PI AND EDGE CLUSTER*

One of the most popular edges for a wide range of projects is theRaspberry Pi. It has Wi-Fi, Bluetooth, and GB of RAM installed.Additionally, Raspberry Pi OS running on Linux and Windows Ubuntu is an option as well. Also, a number of Raspberry Pi software extensions have been made available. Edge clusters are clusters made up of Raspberry Pi and other edges [6]. The edge is often low-power focused. As a result, Raspberry Pi struggles to deliver a service which necessitates it to analyze large amounts of data on its own due to the restricted computational capacity. To make up for this deficiency, edge cluster distributes the data and aggregates the neighboring edges into a single group. This approach makes rapid data analysis possible via restricting the quantity of data handled by each edge.

### *C. WSN-BASED SMART PARKING LOT*

Drivers can locate accessible parking lots with the use of WSN-BASED SMART PARKING LOT [7], which makes use of a web server, a WSN, and multiple smartphone applications. Applications that are updated by sensors placed in the parking area allow drivers to verify the status of a spot.

A master web server and an internal WSN web server make up the web server. Through the driver application, the internal and central web servers are updated simultaneously.The driver was advised about the count and direction of available parking places in [8], likewise, the framework in concern makes vehicle governance and surveillance easier.

### *D. IoT-BASED SMART PARKING LOT*

Within [9], a sensor module named SPIN-V—which is composed of up of a Raspberry Pi, an ultrasonic sensor, a camera, and other components—was used to determine whether a car was present in a parking place. In this study, the parking lot owner monitored the entire area through a monitoring center, while the user could reserve and manage a spot using a smartphone app. Additionally, the study uses three scenarios to show how beneficial an innovative parking system may be.

In [10], infrared and ultrasonic sensors were used to detect the appearance of a vehicle in the parking lot, and the LED lighting was adjusted based on the detection outcome. In order to reduce parking lot management costs and parking time, the system subsequently updated the parking lot status by transferring the discovered information to the edge and cloud servers via a software architecture made up of sensor, network, cognitive, and application layers.

In [11], the current parking lot status was sent to a LoRa receiver via an ultrasonic sensor and a long-range (LoRa)-based transmitter module. The IBM Watson cloud and the client's mobile application received data from the receiver over Wi-Fi. Users could use the cloud or a LoRa receiver to check their parking spot data.In [12], the current parking lot information was sent to a LoRa receiver via an ultrasonic sensor and a long-term (LoRa)-based transmitter module. subsequently the person to whom it was provided data to the IBM Watson cloud and a user's mobile application via Wi-Fi. Users could use the cloud or a LoRa receiver to check their parking spot data [13].

## III. Methodology

### *A. PARKING LOT DESIGN*

Smart parking systems are revolutionizing urban parking management by leveraging advanced technologies to optimize efficiency and convenience. In this document, we present a cutting-edge smart parking slot design consisting of 9 blocks, each containing 6 parking slots, for a total of 54 slots “Fig.1”. Each block operates as an independent IoT system, equipped with sensors and a microcontroller connected to the internet via Wi-Fi. However, in our proposed system, we utilize a simulation software implemented in an Android application to replicate the functionality of sensors and microcontrollers, with smartphones acting as microcontrollers. This document outlines the key features and functionality of our smart parking slot design. Operationdata flow is shown in “Fig.2”.

a) Android Application Interface: The smart parking system is accessible through a user-friendly Android application interface. Users can interact with the system to book parking slots, park, leave, and access navigation features.
b) Manual Sensor Status Update: Instead of physical sensors, the status of parking slots is updated manually through the Android application. Users can indicate whether a slot is vacant or occupied, enabling real-time monitoring of parking availability.
c) Booking and Navigation: Users have the option to book parking slots in advance through the Android application. Upon booking, the application provides navigation guidance to the reserved parking slot, optimizing the parking experience for users.
d) Total and Vacant Slot Display: The Android application displays real-time information on the total number of parking slots and the number of vacant slots. This feature enables users to make informed decisions when searching for parking.
e) Closest Energy-Efficient Parking Slot: The smart parking system utilizes energy-efficient algorithms to identify the closest available parking slot to the user's location. This promotes efficient resource utilization and reduces energy consumption.
f) A* Algorithm for Navigation: The navigation feature in the Android application utilizes the A* algorithm to compute the optimal route to the booked parking slot and the exit. This algorithm considers factors such as distance and traffic conditions to provide efficient navigation guidance.
g) Enhanced User Experience: The smart parking slot design offers a seamless and user-friendly parking experience through intuitive mobile application features.
h) Efficient Resource Utilization: By leveraging energy-efficient algorithms, the system optimizes parking slot allocation and reduces energy consumption.
i) Real-Time Monitoring: Users can monitor parking availability in real-time, minimizing the time spent searching for parking and reducing traffic congestion.
j) Optimized Navigation: The use of the A* algorithm for navigation ensures efficient route planning, leading to faster and more convenient parking slot access.
k) Scalability and Flexibility: The modular design of the smart parking system allows for scalability and flexibility, making it adaptable to varying parking requirements and environments.

*B. Application development and operations*

The Android application is a comprehensive solution for efficient parking management, featuring dual login functionalities for administrators and users “Fig.3”. Upon accessing the application, administrators can utilize the admin login with predefined credentials: username "admin" and password "admin123". Once logged in, administrators gain access to essential configuration options, including setting entry and exit directions. With a selection of 8 available directions for both entry and exit, administrators can tailor the traffic flow within the parking facility to optimize efficiency and convenience for users “Fig.4”.

Another crucial feature available to administrators is slot prioritization. The application encompasses a total of 54 parking slots, each with its unique position within thefacility. Utilizing a manual editing interface, administrators can adjust the priority of these slots based on the minimum distance calculation. This calculation incorporates both the distance from the entry point to the parking slot and the distance from the parking slot to the exit. By prioritizing slots in this manner, administrators ensure that users are directed to parking spaces that offer the most convenient access to entry and exit points, minimizing congestion and enhancing overall user experience.

Upon logging in with the user login, users are prompted to enter their phone number as the username and their chosen password. Once authenticated, users are presented with a comprehensive dashboard displaying relevant information about the parking facility. This includes details such as the user's name, total number of slots available, number of slots currently occupied, number of slots booked, and the status of each slot (whether it is vacant, booked, or occupied) “Fig.5”.

The user interface further provides interactive functionality through buttons such as "Book Slot" and "Slots Status". Upon selecting the "Slots Status" button, users are presented with a visual representation of the parking facility, with each slot color-coded to indicate its status. Green signifies a vacant slot, blue denotes a slot that has been booked, and red indicates a slot that is currently occupied.

When a user decides to book a slot, they can do so by selecting the "Book Slot" button. This action triggers the display of additional options, including "Park", "Cancel Booking", and "Navigate". If the user opts to navigate to the booked slot, the application employs a yellow-colored navigation feature, guiding the user from the entry side to the designated slot. This navigation functionality is facilitated by the A* algorithm, ensuring optimal routing and efficiency.

In the event that a user wishes to cancel their booking, selecting the "Cancel Booking" button prompts a pop-up dialogue allowing the user to confirm their decision. Conversely, selecting the "Park" option opens a pop-up prompting the user to confirm their intention to park at the designated slot. Once parked, the user interface dynamically updates to display new options, including "Leave" and "Navigate". If the user chooses to navigate from the parked slot to the exit, selecting the "Navigate" button triggers the display of directional guidance from the parked slot to the exit point. Similarly, if the user decides to leave the parking slot, selecting the "Leave" option prompts a pop-up dialogue allowing the user to confirm their departure “Fig.6”.

Overall, the Android application serves as a comprehensive tool for parking management, offering intuitive functionalities for both administrators and users. By leveraging features such as slot prioritization and dynamic navigation “Fig.7”, the application enhances the efficiency and convenience of parking operations within the facility. With the incorporation of the A* algorithm for navigation, users can navigate seamlessly throughout the parking facility, optimizing their parking experience “Fig.8”and “Fig.9”.

## IV. RESULT AND ANALYSIS

### *A. Project diagrams and screenshots*

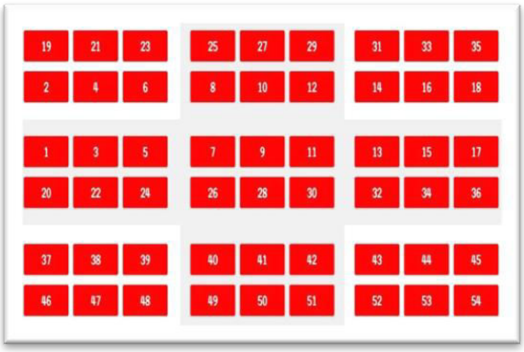

*Fig. 1:Parking lot layout*

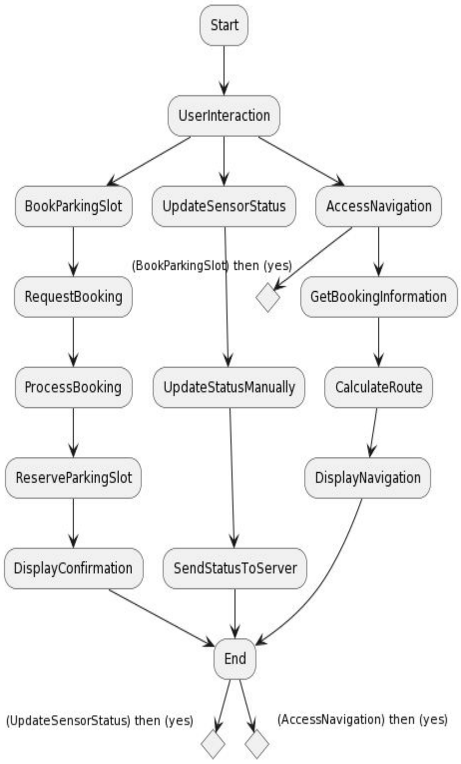


*Fig. 2:Operation data flow*

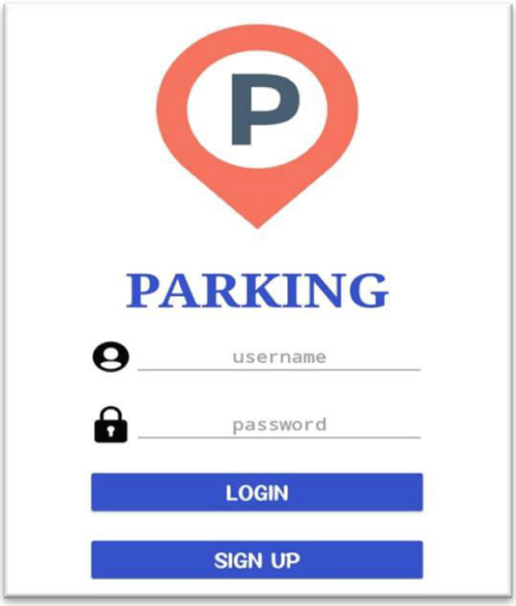


*Fig. 3:Dual login functionality interface*

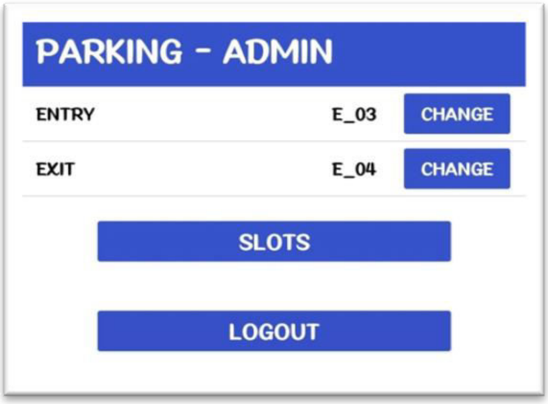


*Fig. 4:Entry and exit interface*

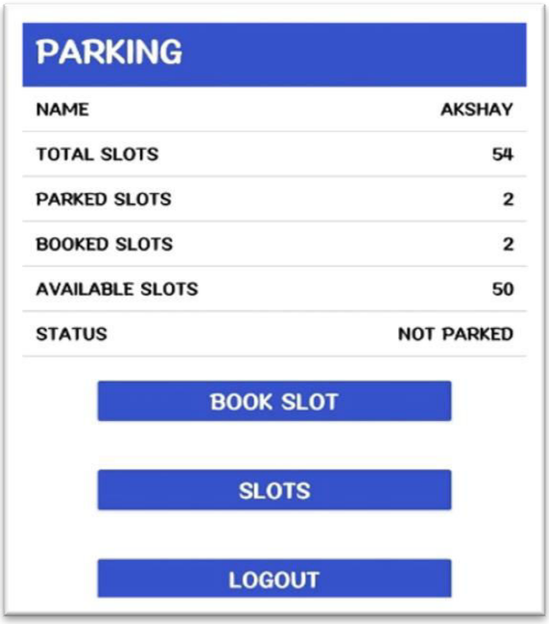


*Fig. 5:parking information*

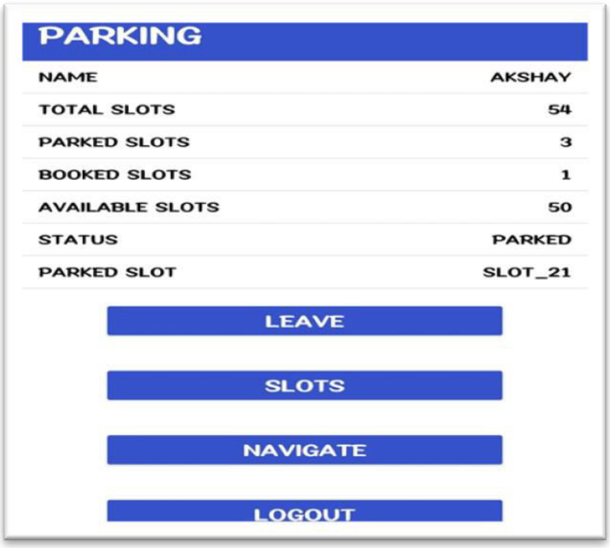


*Fig. 6:Interface after parked*

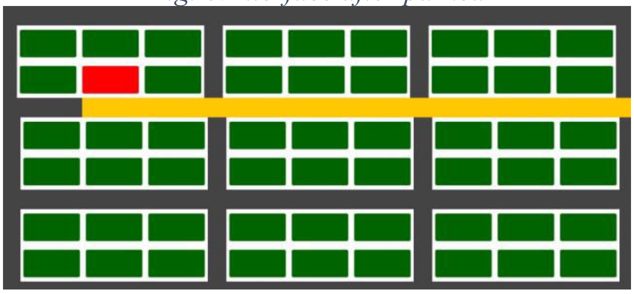

*Fig. 7:Navigation interface*

*B. Graph and analysis*

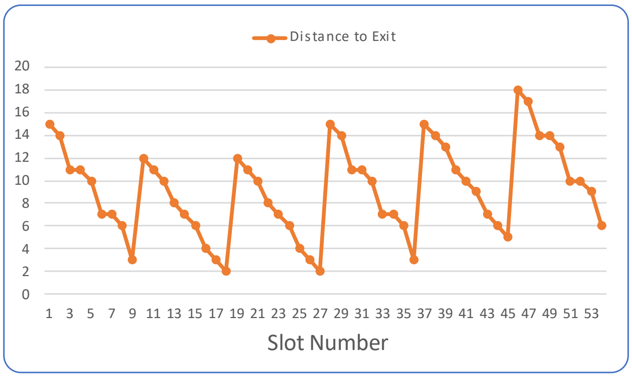


*Fig. 8:Distance from entry to slots*

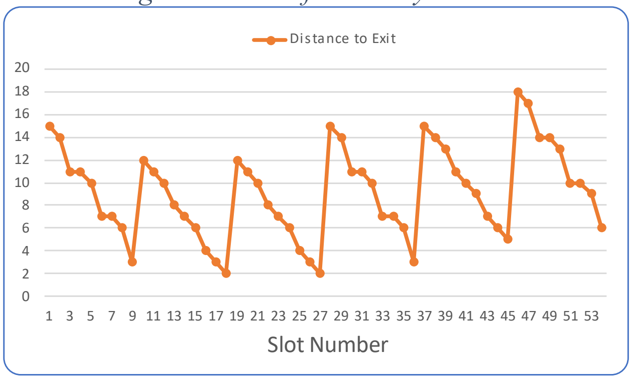


*Fig. 9:Distance from slots to exit*

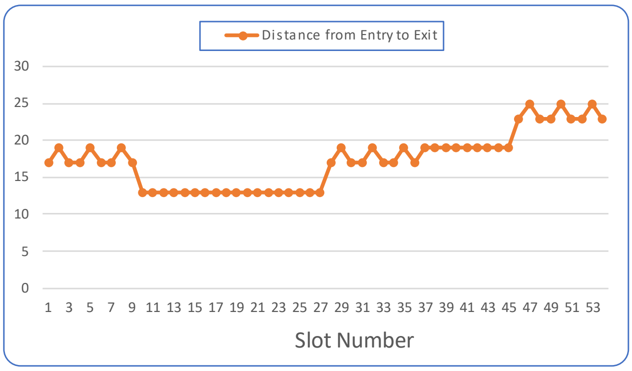


*Fig. 10:Distance between entry to exit through slots*

From the graph "Fig.10" we can analyse shortest path for parking the vehicle in the lot by combining entry to exit data collection using A* algorithm.

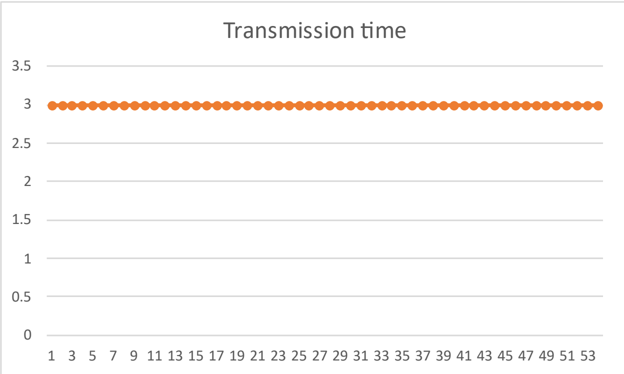


*Fig. 11:transmissiontimevs slots*

From the graph "Fig.11" we can analyse transmission time from the slots was constant.

*B. Tabulation*

| Resultobtained through A* algorithm | | | |
|---|---|---|---|
| Sl. no | Distance from Entry | Distance to Exit | Distance from Entry to Exit |
| 1 | 3 | 15 | 17 |
| 2 | 6 | 14 | 19 |
| 3 | 7 | 11 | 17 |
| 4 | 7 | 11 | 17 |
| 5 | 10 | 10 | 19 |
| 6 | 11 | 7 | 17 |
| 7 | 11 | 7 | 17 |
| 8 | 14 | 6 | 19 |
| 9 | 15 | 3 | 17 |
| 10 | 2 | 12 | 13 |
| 11 | 3 | 11 | 13 |
| 12 | 4 | 10 | 13 |
| 13 | 6 | 8 | 13 |
| 14 | 7 | 7 | 13 |
| 15 | 8 | 6 | 13 |
| 16 | 10 | 4 | 13 |
| 17 | 11 | 3 | 13 |
| 18 | 12 | 2 | 13 |
| 19 | 2 | 12 | 13 |

| | | | |
|---|---|---|---|
| 20 | 3 | 11 | 13 |
| 21 | 4 | 10 | 13 |
| 22 | 6 | 8 | 13 |
| 23 | 7 | 7 | 13 |
| 24 | 8 | 6 | 13 |
| 25 | 10 | 4 | 13 |
| 26 | 11 | 3 | 13 |
| 27 | 12 | 2 | 13 |
| 28 | 3 | 15 | 17 |
| 29 | 6 | 14 | 19 |
| 30 | 7 | 11 | 17 |
| 31 | 7 | 11 | 17 |
| 32 | 10 | 10 | 19 |
| 33 | 11 | 7 | 17 |
| 34 | 11 | 7 | 17 |
| 35 | 14 | 6 | 19 |
| 36 | 15 | 3 | 17 |
| 37 | 5 | 15 | 19 |
| 38 | 6 | 14 | 19 |
| 39 | 7 | 13 | 19 |
| 40 | 9 | 11 | 19 |
| 41 | 10 | 10 | 19 |
| 42 | 11 | 9 | 19 |
| 43 | 13 | 7 | 19 |
| 44 | 14 | 6 | 19 |
| 45 | 15 | 5 | 19 |
| 46 | 6 | 18 | 23 |
| 47 | 9 | 17 | 25 |
| 48 | 10 | 14 | 23 |
| 49 | 10 | 14 | 23 |
| 50 | 13 | 13 | 25 |
| 51 | 14 | 10 | 23 |
| 52 | 14 | 10 | 23 |
| 53 | 17 | 9 | 25 |
| 54 | 18 | 6 | 23 |

## V. CONCLUSION

The Android application streamlines parking management for both administrators and users. Through a dual-login system, administrators configure entry/exit settings and prioritize parking slots. Users access real-time information, book slots, and navigate seamlessly using the A* algorithm. This tech-driven solution optimizes efficiency, convenience, and satisfaction within the parking facility. Andanalyzed short distance parking and transmission time is constant.

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