

## Design And Verification of Car Parking Management System Using Verilog and System Verilog.

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### ABSTRACT

*The main aim of this work is to implement a design and verification of car parking management system using Verilog and system Verilog . The system is divided into two major parts. The first part involves the design of a counter that continuously monitors and indicates the number of occupied and vacant parking slots, also using water level sensor, smoke sensor, fire sensor for safety and security focuses on improving safety by detecting fire, smoke, and water conditions. The second part focuses on the design of a display and indication unit, where the slot status (filled or vacant) is shown on an LCD to assist drivers and prevent forward collision between vehicles inside the parking area.*

*The system operation is based on sensor detection, where the presence or absence of a vehicle is identified using sensors installed at*

*each parking slot. The LED indications depend on the sensor outputs and visually represent vehicle entry and exit from the parking slots. These LED signals help in identifying the availability of slots and also indicate the presence of vehicles approaching from the opposite direction at the slot entrance, thereby enhancing safety and traffic coordination within the cellar parking area. The system provides real-time information through LCD display and LEDs, and alerts users using a buzzer during emergency conditions*

*The complete system is designed using Verilog and functionally verified using System Verilog with simulation performed in Questa Sim. The proposed design improves parking efficiency, enhances safety, and minimizes human intervention, making it suitable for modern*

*automated parking applications.*

**KEYWORDS:** *Questa Sim, Verilog: System Verilog, IR sensors, fire sensor, smoke sensor, soil moisture sensor, LED, LCD display, motors*

## INTRDOCTION

Finding a parking space in busy cities is a major problem. When drivers cannot find parking near their destination, they keep driving around in search of a spot. This increases traffic congestion and air pollution. According to parking expert Donald Shoup, searching for parking can cause about 15% to 74% of traffic in city areas.

This situation wastes a lot of time, fuel, and energy. It also causes stress and reduces productivity. For example, Abhinav, who travels daily from South Delhi to Gurugram, faces serious parking issues. His office has no proper parking space, so employees park on roads, which leads to congestion and risk of vehicle damage.

This is not just a problem in Delhi but in many cities around the world. Due to rapid urbanization and population growth, the number of vehicles has increased, but parking spaces have not increased accordingly. Studies show that on average, drivers spend 18–20 minutes searching for parking, and in some cities, it can take even longer.

Because of limited space, many cars are parked on roads, especially in residential areas. This makes traffic worse. One solution is improving public transport. For example, after the metro was introduced in Connaught Place, Delhi, parking demand reduced by about 10%.

Another effective solution is smart parking systems using sensors.

This helps drivers find parking quickly, reduces traffic, saves fuel, and lowers pollution.

## RELATED WORK

Parking problems in urban areas have been widely studied due to the rapid increase in vehicles and limited parking spaces. Researchers such as Donald Shoup have shown that a large percentage of city traffic is caused by drivers searching for parking. Traditional parking systems rely on manual monitoring and fixed signboards, which do not provide real-time information. As a result, these systems are inefficient and contribute to congestion and delays. To overcome these issues, many researchers have proposed smart parking systems using sensor-based technologies. Early systems commonly used infrared sensors to detect vehicle presence in parking slots. However, IR sensors are affected by environmental factors like light intensity and temperature, reducing their reliability. To improve accuracy, ultrasonic sensors have been introduced, which work effectively under

different lighting conditions. These sensors can precisely detect whether a parking space is occupied or vacant. In addition, some systems use wireless communication and IoT technology to send real-time parking data to a central server. This information can be accessed by users through mobile applications or web platforms. Such systems help drivers find parking quickly and reduce unnecessary vehicle movement. Recent advancements also include camera-based systems using computer vision for better monitoring and security. Although these systems offer high accuracy, they are more expensive and complex. Therefore, sensor-based smart parking systems are considered a cost-effective and practical solution for modern cities.

## **LITERATURE SURVEY**

Many research works have been done to improve car parking systems using different technologies. In the “Automatic Car Parking System with Visual Indicator along with IoT,” ultrasonic sensors are used to detect whether a parking slot is empty or occupied. This information is sent through a Wi-Fi module (ESP8266) to an online IoT platform, allowing users to check parking availability from anywhere. The system also shows slot status using indicators and online dashboards, and the results prove that it works accurately for different car models. Another approach, “Real-

Time Car Parking System using Image Processing,” uses cameras instead of sensors to detect vehicles. It captures images at parking areas and processes them to count vehicles and identify empty spaces, making it suitable for managing large parking lots efficiently. In the “Automatic Car Parking Indicator System,” sensors at the entry point detect vehicles and allow access only if slots are available, while display boards guide drivers by showing available and occupied spaces and even directing them to specific slots.

Advanced technologies like fog computing are used in “Fog Enabled Efficient Car Parking Architecture” to reduce delay and network usage by processing data closer to the system instead of relying only on the cloud. This improves system speed but raises privacy concerns when cameras are used. In autonomous parking systems, techniques like Bi-RRT\* and Model Predictive Control help vehicles park automatically even in narrow or complex spaces by planning paths and controlling movement precisely. Wireless sensor networks are also important, and studies on path loss models help improve communication between sensors by predicting signal behaviour in parking environments. Some systems use probabilistic filters and camera-based monitoring (AVM) to detect parking slot markings more accurately, even in difficult conditions like shadows or obstacles.

Other research focuses on predicting parking availability using data such as traffic, weather, and past trends. For example, neural network models can estimate the number of free slots in advance, helping drivers save time. Deep learning-based mobile applications further improve this by providing real-time parking information and predictions through smartphones. Earlier systems also explored SMS-based parking updates, camera-based vehicle identification, wireless communication systems, and FPGA-based designs using fuzzy logic to reduce processing time. Overall, these studies show that smart parking systems using sensors, cameras, IoT, and artificial intelligence can significantly reduce traffic congestion, save time and fuel, and make parking more efficient and user-friendly.

## **EXISTING METHOD**

In many developed countries, smart parking systems have been implemented using a combination of infrared (IR) sensors and ultrasonic sensors to detect the presence of vehicles in parking slots. However, IR sensors are highly sensitive to environmental conditions, particularly variations in light intensity, which can affect their accuracy and reliability. To overcome this limitation, the proposed approach focuses on using ultrasonic sensors as an alternative, since they operate based on sound waves and are not influenced by

lighting conditions. This makes them more stable and efficient for parking detection in diverse environments. Additionally, instead of using conventional Ethernet shields or LAN cable connections, the system integrates the ESP8266 Wi-Fi module for wireless communication. This not only reduces installation cost by eliminating extensive wiring but also enhances system flexibility and scalability.

The working of the system is illustrated through a flowchart, where the process begins with system initialization. Ultrasonic sensors are placed in each parking slot to measure the distance between the sensor and any object (vehicle). The measured distance is compared with a predefined threshold value to determine whether the slot is occupied or vacant. If the distance exceeds the threshold, the slot is considered occupied and a red LED is activated; otherwise, the slot is identified as vacant and a green LED is turned on. This process is repeated for all parking slots to ensure continuous monitoring. The collected data is then transmitted to the ESP8266 Wi-Fi module, enabling real-time communication with an IoT platform. Users can remotely access this information through a mobile or web application to check parking availability. The use of LEDs provides immediate visual feedback for nearby users, while IoT integration ensures remote monitoring and efficient

management. This cycle repeats continuously, ensuring accurate and up-to-date parking information.

Despite these advancements, traditional parking systems still suffer from several limitations. They often require continuous human intervention for monitoring and control, lack real-time updates on parking availability, and contribute to traffic congestion due to inefficient space utilization. Furthermore, such systems incur higher operational costs due to manpower requirements, are prone to human errors, and increase the risk of vehicle collisions. Managing and scaling these systems for larger parking areas also becomes challenging, highlighting the need for more automated and intelligent parking solutions.

## **PROPOSED METHOD**

The IR parking slot sensors (IR1, IR2, IR3, IR4, etc.) are installed in individual parking spaces and their main function is to detect the presence or absence of vehicles in each slot. When a vehicle occupies a slot, the corresponding IR sensor sends a signal to the control logic indicating that the slot is occupied; otherwise, it indicates availability. This enables accurate real-time monitoring of parking space usage. The IR entry sensor is placed at the entrance of the parking area and its function is to detect incoming vehicles. When a vehicle is detected, it informs the control logic to increment the

vehicle count and allows gate operation if parking space is available. Similarly, the IR exit sensor is installed at the exit and its function is to detect vehicles leaving the parking area, enabling the system to decrement the vehicle count and update slot availability.

The fire sensor continuously monitors the parking area for fire or abnormal temperature rise. Its function is to provide early detection of fire hazards and immediately alert the control logic to trigger emergency responses. The smoke sensor detects the presence of smoke or harmful gases and helps in identifying dangerous conditions such as fire or poor air quality, especially in enclosed parking spaces. The soil moisture sensor monitors water presence or moisture levels on the ground, and its function is to detect water leakage or flooding conditions, particularly in basement parking areas.

The control logic acts as the central processing unit of the entire system. Its function is to receive inputs from all sensors, process the data according to predefined logic, and generate appropriate control signals for output devices. Based on sensor inputs, it manages parking slot allocation, vehicle counting, safety alerts, and automation functions. The motors are used for automatic gate operation at the entry and exit points, and their function is to open or close the gates based on parking availability and vehicle

detection. The LEDs serve as visual indicators and their function is to display parking status such as slot availability, full condition, and emergency alerts. The LCD display provides real-time information to users by displaying available and occupied parking slots as well as warning messages during abnormal conditions. Finally, the buzzer functions as an audible alert system that activates during emergencies such as fire, smoke detection, or critical system alerts to immediately draw attention and ensure safety.

## ARCHITECTURE

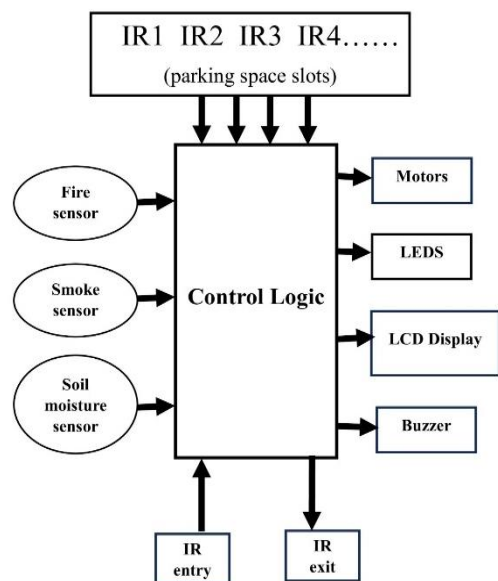


Figure 1: proposed method architecture

## METHODOLOGY DESCRIPTION

The system works by using different sensors to monitor parking spaces and environmental conditions. First, IR sensors are placed in each parking slot to detect whether a vehicle is

present or not. Additional sensors like fire, smoke, and soil moisture sensors continuously check for safety and environmental changes. All these sensor inputs are sent to a central control unit (control logic), which processes the data.

Based on this information, the control unit updates the system outputs. It controls motors (for gates or barriers), turns LEDs on or off to show slot availability, displays the number of free and occupied spaces on the LCD screen, and activates a buzzer in case of emergencies like fire or smoke detection. Entry and exit IR sensors are used to track vehicles entering and leaving, ensuring accurate counting of available parking slots. This makes the system automatic, safe, and efficient.

## SOFTWARE REQUIREMENTS

### Software Tools:

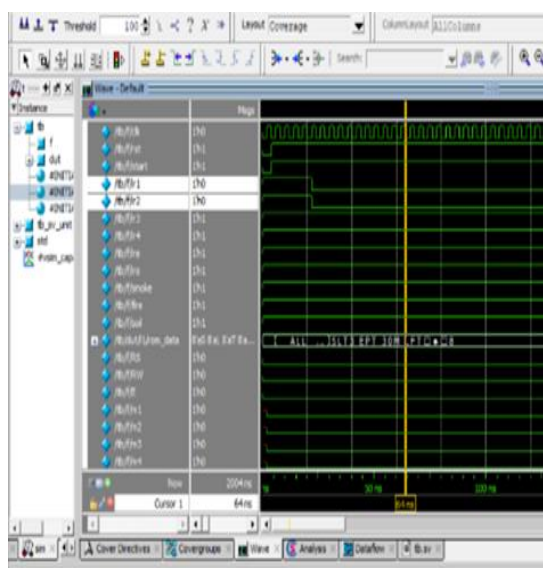
Questa Sim is a powerful simulation and functional verification tool used for designing and testing digital circuits using languages like Verilog and VHDL. Developed by Siemens EDA, it helps detect errors early through simulation before hardware implementation. It also provides debugging, waveform analysis, and coverage features to ensure accurate and reliable system performance.

### Languages:

Verilog – Hardware design and implementation  
System Verilog – Verification, testbench, and simulation.

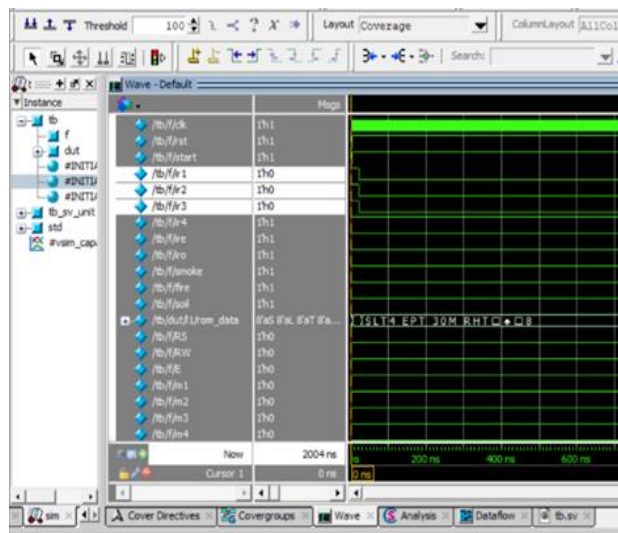
## RESULTS AND DISCUSSION

The outputs represent the simulation and functional results obtained after successful implementation and testing of the proposed system “Design and verification of car parking management system using Verilog and system Verilog”. These outputs verify correct operation of sensors, control logic, display units, and user indications under different conditions.



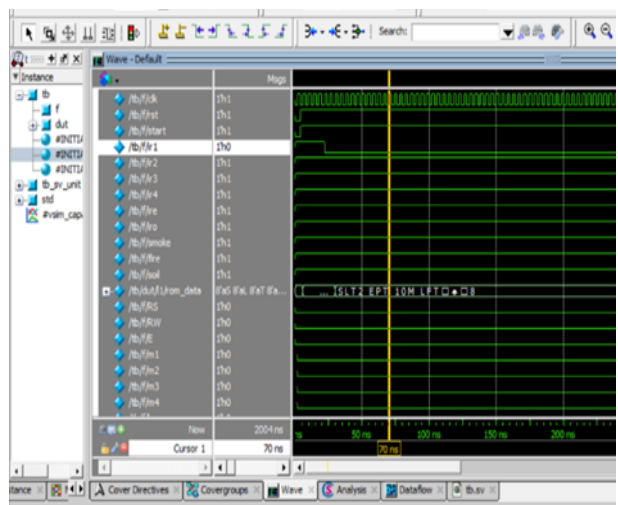
**Fig 2.1 Slot1 is Occupied & IR1 detected**

This output shows the detection of vehicle presence using IR 1 sensors. When a vehicle is detected in a parking slot, the sensor sends a signal to the controller, confirming the slot 1 is occupied and shows the vacant slot2 with directions. This ensures accurate real-time monitoring of parking availability.



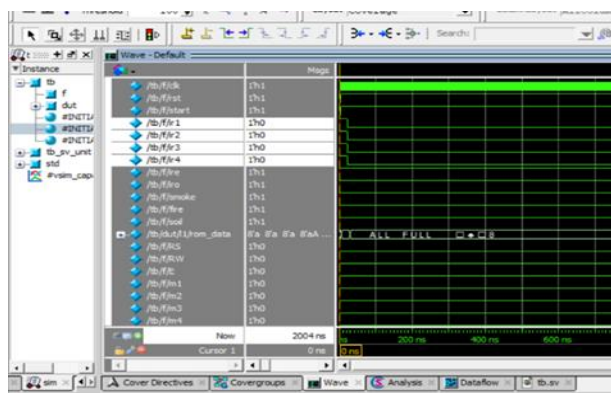
**Fig 2.2 Slot 1&2 is Occupied & IR1&2 detected**

This output shows the detection of vehicle presence using IR 1&2 sensors. When a vehicle is detected in a parking slot, the sensor sends a signal to the controller, confirming the slot 1&2 is occupied and shows the vacant slot 3 with directions because it shows order priority vacant slot.



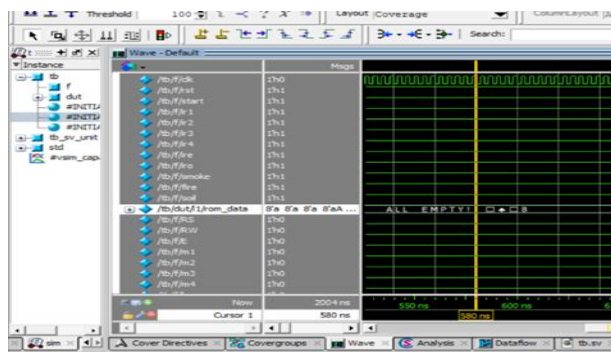
**Fig 2.3 Slot 1,2&3 is Occupied & IR1,2&3 detected**

This output shows the detection of vehicle presence using IR 1,2&3 sensors. When a vehicle is detected in a parking slot, the sensor sends a signal to the controller, confirming the slot 1,2&3 is occupied and shows the vacant slot 4 with directions because it shows order priority vacant slot.



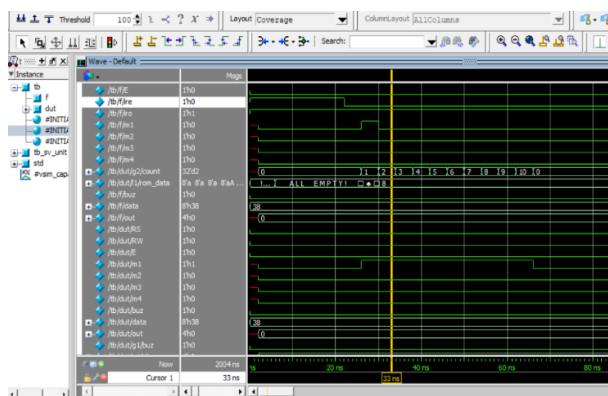
**Fig 2.4 Slot 1,2,3&4 is Occupied & IR1,2,3&4 detected**

This output shows the detection of vehicle presence using IR 1,2,3&4 sensors. When a vehicle is detected in a parking slot, the sensor sends a signal to the controller, confirming the slot 1,2,3&4 is occupied and shows the “ALL FULL” means all slots are occupied.



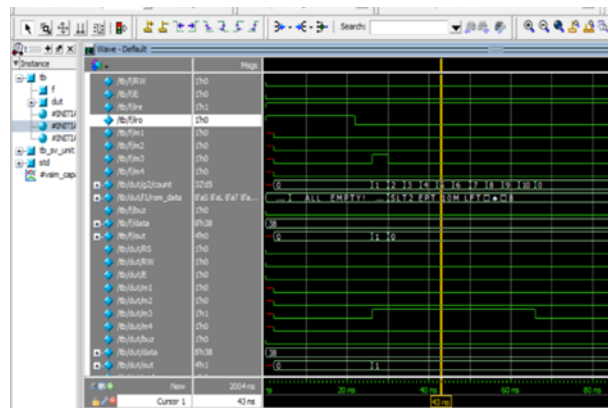
**Fig 2.5 ALL EMPTY slots**

This output shows the All slots are Empty and not detection of vehicle presence using IR 1,2,3&4 sensors. It shows the “ALL EMPTY” slots are vacant.



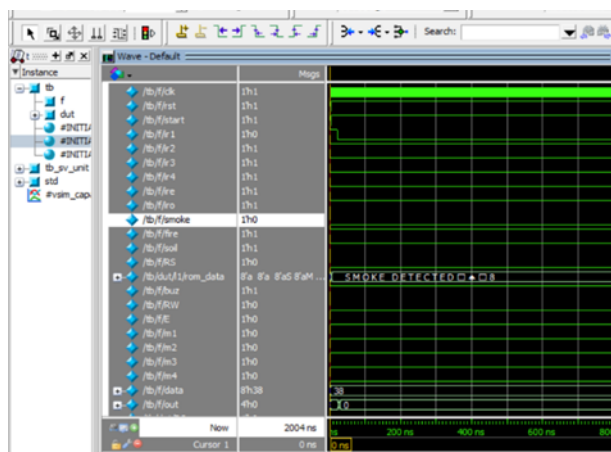
**Fig 2.6 Gate Entry**

This simulation output shows the vehicle entry operation. When the entry IRe sensor is triggered, the parking counter increments 10 sec and the display updates, confirming successful detection of a vehicle entering the parking area.



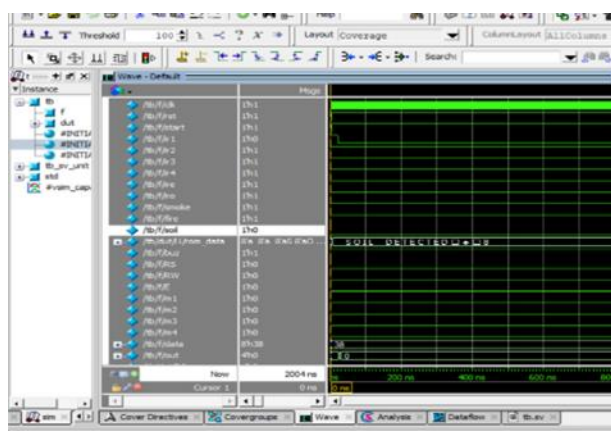
**Fig 2.7 Gate Exit**

This simulation output represents the vehicle exit operation. When the exit IRO sensor is activated, the parking counter decrements 10 sec and the display updates, indicating a freed parking slot.



**Fig 2.8 Fire Detected**

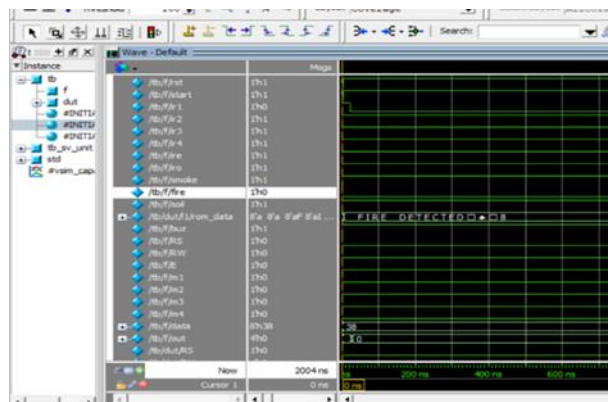
The simulation output confirms proper fire detection functionality of the system. When the fire sensor input is activated, the controller processes the signal and displays the message “**FIRE DETECTED**” on the output display. At the same time, the alert mechanism such as the buzzer is triggered to indicate an emergency condition. This verifies that the system can reliably detect and respond to fire hazards.



**Fig 2.9 Smoke Detected**

The smoke detection waveform verifies that the system correctly identifies the presence of smoke. When the smoke sensor signal becomes active, the system processes the input and

displays “**SMOKE DETECTED**”. The alert output is also activated, ensuring early warning and safety. This confirms accurate smoke monitoring and response by the system.



**Fig 2.10 water Detected**

The soil detection output demonstrates correct operation of the water or moisture sensing module. When the soil moisture sensor detects the water required condition, the system processes the signal and displays “**SOIL DETECTED**”. This confirms that the system can successfully monitor environmental parameters and provide appropriate output indication.



**Fig 2.11 Coverage Report Output**



situations, further strengthening overall system reliability.

Overall, the designed system minimizes human intervention, improves parking efficiency, and enhances safety and automation in modern parking infrastructures. The successful verification of the design confirms its functional correctness and suitability for real-time smart parking applications.

## **FUTURE ENHANCEMENT**

Future enhancements of this system can focus on improving accuracy, automation, and scalability by integrating advanced technologies. The existing sensor-based detection can be upgraded with IoT connectivity to enable real-time remote monitoring through mobile or web applications. Incorporating machine learning algorithms can enhance decision-making by predicting parking availability patterns and detecting fire or smoke hazards more intelligently. The system can also be expanded by adding camera-based monitoring using computer vision for more reliable vehicle detection and security. Additionally, cloud integration can allow data storage and analytics for long-term insights, while renewable energy sources like solar power can make the system more energy-efficient. Future versions may also include automated alert systems, such as SMS or app notifications, to inform users and authorities

instantly in case of emergencies, thereby making the system smarter, safer, and more user-friendly.

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