LIFI FOR SMART TRANSPORTATION: ENABLING SECURE AND SAFE VEHICULAR COMMUNICATION

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***ABSTRACT*—The most powerful approach that has been used to minimize vehicle injuries is effective vehicle-to-vehicle communication. In this paper, we present a design and prototype of a device for vehicular communication using light fidelity(Li-fi) technology, known as Visible Light Communication(VLC), which is here used for data communication. The proposed device also involves preventing turning point incidents with a MEMS (Micro-Electro-Mechanical System) sensor and Ultrasonic sensors to accurately measure the distance between vehicles. The transmission of information between the vehicles enables us to automate brake systems which will help us avoid sudden close-range accidents. High-speed data transfer, secure, efficient, and environmentally friendly, is provided by Li-Fi technology, and also we made it possible that accidents can also be minimized in the maximum ways possible.**

***Index Terms*—Li-Fi, LCD, data transmission, Visible light communication**.

I.INTRODUCTION

Vehicle-to-vehicle (V2V) communication is an emerging technology that enables vehicles to communicate with each other wirelessly, providing real-time information on road conditions, traffic, and potential hazards. One promising technology for V2V communication is LiFi, a wireless communication technology that uses light waves instead of radio waves to transmit data. Li-Fi technology employs light-emitting diodes (LEDs) as a means of transmitting data. It can provide high-speed data transmission rates, low latency, and high reliability compared to traditional radio frequency (RF) communication technologies. With Li-Fi technology, vehicles can exchange critical information, such as speed, location, and direction, in real-time, allowing them to make quick decisions and avoid accidents.

Moreover, Li-Fi technology is immune to electromagnetic interference, which means that it can be used in areas where RF communication is prohibited or not feasible, such as hospitals, aircraft, and military bases. Li-Fi technology also offers high levels of security since the signal is confined to the area where the light is emitted, making it difficult to intercept. In summary, Li-Fi technology offers a promising solution for V2V communication, providing high-speed data transmission, low latency, high reliability, and enhanced security. As this technology continues to develop and become more widely adopted, it has the potential to improve road safety, reduce congestion, and enhance the overall driving experience.

An affordable Li-Fi network was implemented for vehicle communication, using eight Li-Fi at cell access points (APs) in a single vehicle, along with two additional Wi-Fi APs that served neighbouring vehicles. The Wi-Fi APs could provide data rates ranging from 300 to 867 Mbps, depending on the mode of operation and bandwidth. Each Li-Fi AP could cover a circular coverage area with diameters ranging from 2.8 to 3.5 meters and support up to eight users, resulting in a maximum accumulated data rate of 344 Mbps per vehicle. This proof-of-concept system utilized off-the-shelf unmodified LED luminaires with an electrical bandwidth of around 2 MHz, showcasing the simultaneous capabilities of lighting and wireless communication using the same infrastructure. The primary advantage of this system is its high-speed communication, which is a crucial aspect of vehicle communication.

LiFi utilizes LCDs, transmitters, and receiver circuits to enable communication between two vehicles, with the help of ultrasonic sensors. The potential application of this technology is to prevent road accidents and save human lives. LI-FI offers a low-cost and highly efficient means of transmitting data, including audio, video, and text, which makes it an attractive option for traffic control purposes. Moreover, the widespread usage of LED lights for illumination in our day-to-day activities makes LI-FI a feasible option for data communication. This project showcases eco-friendly communication between vehicles using visible light and white LEDs, which transmit audio signals to the receiver.

II. LITERATURE SURVEY

Vehicle-to-vehicle communication using Li-fi technology [1]: This project is concise in vehicle-to-vehicle communication for avoiding road accidents. We use the ultrasonic sensor, gas sensor, vibration sensor, LCD display, Li-Fi transmitter, and receiver. In case of an abnormal condition in the front vehicle, the vehicle at the back will be on time and will stop on the second [2]: This project focuses on utilizing vehicle-to-vehicle communication to prevent road accidents. The system incorporates various components such as ultrasonic sensors, gas sensors, vibration sensors, LCD displays, Li-Fi transmitters, and receivers. When an abnormal condition is detected in the vehicle ahead, the system will quickly alert the following vehicle and prompt it to stop promptly. [3]: This approach is highly reliable as it does not rely on any network-based architecture or protocols for vehicle-to-vehicle communication. The system enables the distribution of diverse messages containing multiple actions that are generated by the vehicle using its onboard sensors. These messages can include warnings about potential accidents, information on traffic jams, updates on approaching rescue vehicles, as well as details about road conditions and weather conditions. This robust methodology allows for effective communication among vehicles on the road, enhancing safety and situational awareness for drivers. [4]: The system transmits multiple messages, including those related to rash driving, fuel leakage, etc. using Li-Fi technology. Communication between two vehicles is achieved using an LED panel for data transmission, while a photo-detector is used at the receiving end to capture the transmitted data. This approach eliminates the need for any protocols, reducing complexity and streamlining the communication process.

[5]: Li-Fi, also known as Light Fidelity, is a cutting-edge technology that leverages light-emitting diodes (LEDs) to transmit data wirelessly, enabling high-speed communication in a manner similar to Wi-Fi. As a derivative of optical wireless communications (OWC), Li-Fi utilizes the visible light spectrum, as well as infrared and near ultraviolet, instead of traditional radio frequency (RF) waves, to deliver network and mobile communication. This technology has been proposed as a solution to the limitations of RF bandwidth, as it can carry significantly more information. Standardization processes led by the industry are crucial for the complete implementation of Li-Fi.[6]: This paper introduces a new concept that utilizes internet-enabled vehicle-to-vehicle (V2V) connectivity as an extension of existing Internet of Things (IoT) solutions for vehicles. The system allows for seamless data transfers between vehicles as they come in close proximity to each other, enabling real-time sharing of road information. This innovative approach has the potential to improve road safety, efficiency, and communication among vehicles, leading to smarter and more connected transportation systems.

Additionally, the use of LabVIEW simulation has been employed to develop communication through IoT, ensuring safer and improved driving conditions for all. [7]: A secure Vehicle-to-Vehicle (V2V) communication system utilizing IoT and Node MCU with Cipher-SMS protocol has been successfully designed. This system enables end-to-end secure communication via SMS between mobile users, employing AES and Caesar Cipher encryption methods to ensure data confidentiality [8]: The proposed use of Li-Fi technology in this paper presents an effective solution for reducing vehicle accidents through vehicle-to-vehicle communication. The system utilizes light-emitting diode (LED) bulbs as a means of connectivity, leveraging the light spectrum as an optical wireless medium for signal propagation. This approach eliminates the need for complex wireless networks and protocols. The paper explores several case studies that mimic vehicle-to-vehicle communication, showcasing the potential of Li-Fi technology in enhancing road safety. [9]: This paper proposes a vibration-based method for automatically detecting potholes, speed breakers, and their coordinates. When the first car encounters a pothole or speed breaker, a message is sent via Li-Fi to alert other vehicles. The data received is then used to activate an automatic braking system on highways. GPS is utilized to pinpoint the location of the potholes on the road, and Node MCU facilitates Wi-Fi communication with Android devices. [10]: LiFi, a recent technology that uses LED-based lights for data communication, has the potential for sustainable traffic control. It can transmit various types of data like audio, video, and text at low cost and high efficiency. This eco-friendly project proposes vehicle-to-vehicle communication using visible light from white LEDs for faster switching, high power efficiency, and safe human vision. [11]: In this study, we utilize Light Fidelity (Li-Fi) as a means of data communication among vehicles, specifically for Vehicle-to-Vehicle (V2V) communication. Li-Fi is a form of Visible Light Communication (VLC) that employs the visible light spectrum as a medium for communication. It offers high-speed communication and is recognized as an eco-friendly method. The integration of Li-Fi into V2V communication is considered a promising approach. [12]: This article explores visible light communication technology that utilizes light-emitting diodes (LEDs) for high-speed data transmission, particularly in vehicle-to-vehicle communication. It discusses key technologies, characteristics, and challenges of visible light communication, which offers innovative applications and possibilities beyond traditional network communication. It also highlights the direction and hurdles of visible light communication. [13]: This paper proposes the use of Li-Fi technology using LED bulbs for data transmission through the light spectrum, eliminating the need for complex wireless networks. Case studies simulating vehicle-to-vehicle communication are presented, with numerical simulations and experimental results showing good agreement. [14]: V2V communication is crucial for reducing traffic accidents in the Intelligent Transportation System (ITS). However, current wireless methods have limitations due to the increasing number of cars on the road. Li-Fi, or Light-Fidelity, which utilizes light-based technology for fast and reliable data exchange between vehicles, is gaining popularity. Li-Fi in-vehicle communication offers a cost-effective solution with high data rates and bandwidth efficiency.

III. EXISTING SYSTEM

The prevalence of vehicles in our daily lives has risen significantly, with the average person encountering at least one vehicle while traveling. Unfortunately, many drivers remain unaware of the movements of others on the road, leading to an increased risk of collisions. To address this issue, it is crucial to promote greater awareness and education regarding the use of smart technologies that can help prevent such accidents. By taking steps to reduce this type of unawareness, we can help make our roads safer for all drivers and passengers.

The existing design aims to help the avoidance of road accidents through vehicle-to-vehicle communication. It has been used as an ultrasonic detector, gas detector, vibration detector, LCD display, Li-fi transmitter, and receiver.

However, the following vehicle will admit an alert and come to a stop incontinently, If an abnormal condition is detected in the frontal vehicle.

Ensuring the safety and security of vehicle riders is of paramount importance. To this end, technological advancements have been made to facilitate safer and more secure travel. These upgrades have made it easier for riders to feel protected while on the road, thereby reducing the risk of accidents and other mishaps. By utilizing these advancements, we can promote a culture of safety and security on the roads, making travel a more comfortable and reassuring experience for all. The disadvantages of the existing system are 1) Currently, the system does not include a direction detector to indicate whether the abnormal condition is on the left or right side of the road. 2) The project does not feature an automatic braking system to avoid collisions between two vehicles.

IV.PROPOSEDSYSTEM

The proposed system has been enhanced with an automatic brake system that comprises key components such as a relay, motor, and battery. This advanced system is designed to detect potential collisions and automatically apply the brakes to ensure the safety and security of passengers who are traveling in the vehicle. With this feature, an extra layer of protection is provided to prevent accidents and mitigate the severity of any potential collisions.

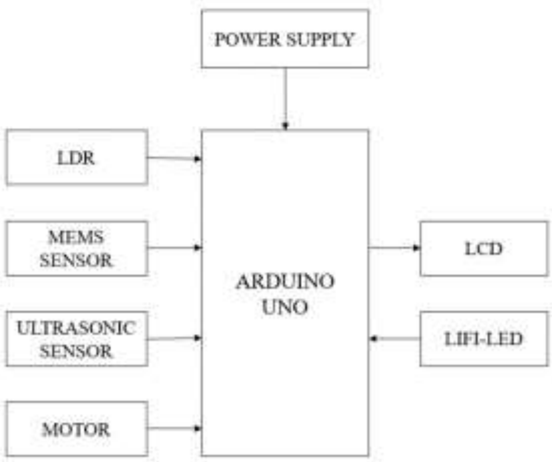


Fig 1: Transmitter

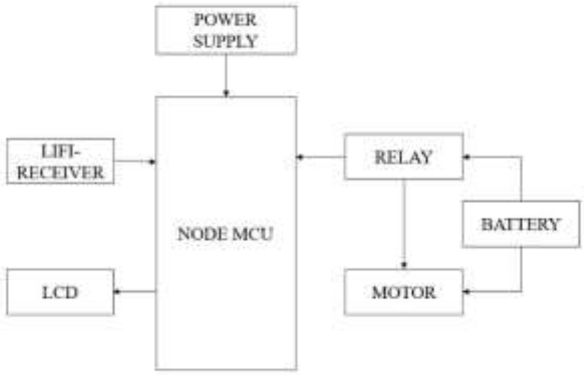


Fig 2: Receiver

A. DETECTION OF MOVEMENT:

Motion sensors can be used in vehicular communication using Li-Fi technology to detect the presence and movement of nearby vehicles. When a motion sensor detects a vehicle, it can trigger a Li-Fi transmitter to send data to that vehicle using visible light communication (VLC) technology. Overall, the use of motion sensors in vehicular communication using Li-Fi technology has the potential to improve the efficiency and safety of transportation systems, particularly in situations where traditional communication methods such as Wi-Fi and cellular networks may be unreliable or unavailable.

B. DETECTION OF LIGHT:

LDR sensors can be used in vehicular communication using Li-Fi to detect the presence of light. In this context, LDR sensors could potentially be used to adjust the LED lighting levels based on ambient light conditions in order to improve the performance of the Li-Fi system.

C.DETECTION OF DIRECTION:

MEMS sensors can provide valuable information about the environment and the movement of vehicles. For example, environmental monitoring sensors such as temperature, humidity, and pressure sensors can be used to monitor the conditions inside and outside the vehicle. This information can be transmitted to other vehicles using Li-Fi, allowing drivers to make informed decisions and improve situational awareness.

D. DETECTION OF PROXIMITY:

Ultrasonic sensors can be used in vehicular communication using Li-Fi in various ways such as Proximity detection, Parking assistance, and Obstacle detection. Ultrasonic sensors are capable of detecting objects at a distance by emitting high-frequency sound waves and measuring the time it takes for the waves to bounce back. The use of ultrasonic sensors in vehicular communication using Li-Fi technology has the potential to improve the safety and efficiency of transportation systems. These sensors can provide valuable information about the presence and movement of vehicles and other objects, which can be shared with other vehicles using Li-Fi to improve situational awareness and prevent accidents.

E. TRANSMITTING THE DATA:

To transfer data using Li-Fi, the first step is to connect a transmitter to an Arduino board. The Arduino board sends data to the transmitter, which converts it into binary format and prepares it for transfer. The LED bulb is then used to transmit the binary data - if the binary number is 0, the LED will not blink, but if the binary number is 1, the LED will blink. The LED bulb will flash so rapidly that it is not visible to the human eye. This method is just one example of how data can be transferred using Li-Fi.

F. RECEIVING THE DATA:

The receiver part of vehicular communication using Li-Fi includes ABS (Automatic Braking System) and a photo-detector to receive the transmitted data via LED bulbs. The photo-detector is connected to a receiver circuit, which is responsible for converting the received binary data into a format that can be understood by the receiving device, such as a computer or a mobile device. The receiver circuit may also include an amplifier to boost the signal strength and a decoder to decode the binary data. Once the data is decoded, it can be used for a variety of applications such as traffic management, collision avoidance, and navigation. Overall, the receiver part plays a crucial role in ensuring reliable and efficient communication between vehicles using Li-Fi technology.

V.IMPLEMENTATION

The proposed system includes various components, such as an LDR sensor, an ultrasonic sensor, a MEMES sensor, a relay, Arduino, Node MCU, LCD, a LiFi transmitter, a LiFi receiver, and male and female jack connectors. The following are the specifications of the components utilized in the system's implementation:

A. LDR SENSOR:

A Light Dependent Resistor (LDR) is a specific type of resistor that exhibits a resistance that varies depending on the amount of light that it is exposed to. LDR sensors typically feature two pins - VCC for positive voltage supply and OUT for output signal. Some models may also include a GND pin. As light levels increase, the resistance of an LDR sensor decreases, ranging from a few hundred ohms in well-lit conditions to several mega ohms in darkness. This characteristic enables LDR sensors to be used in a variety of applications, including light-activated circuits and ambient light sensing.

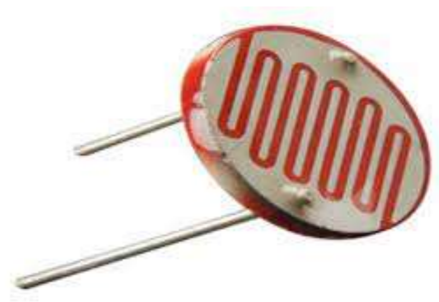


Fig 3: LDR Sensor

B. ULTRASONIC SENSOR:

Ultrasonic sensors are electronic gadgets that use ultrasonic sound waves to determine the distance of an object. These sensors emit ultrasonic waves from a transmitter, which bounce off the target object and return to the sensor. The sensor's receiver picks up the reflected sound waves and converts them into an electrical signal, which is used to calculate the distance of the object. Unlike audible sound waves, ultrasonic waves travel faster and cannot be heard by humans. Ultrasonic sensors typically consist of two essential components: the transmitter and the receiver. The transmitter uses piezoelectric crystals to emit ultrasonic waves, while the receiver detects the waves after they have travelled to and from the target object.

Fig 4: Ultrasonic Sensor

C. MEMS SENSOR:

MEMS (Micro-Electro-Mechanical Systems) sensor is capable of detecting the orientation or tilt of a car's axis, and when it senses any deviation from the normal axis, it sends a message. This feature can be particularly useful in detecting instances of reckless driving. By monitoring the car's axis, the MEMS sensor can detect sudden movements or changes in direction, which may indicate dangerous driving behaviour. This information can then be used to alert the driver, or even trigger automated safety features to help prevent accidents.

Fig 5: MEMS Sensor

D.CORRELATIONPHOTOELECTRIC SENSOR MODULE:

The Correlation Photoelectric Sensor Module is an excellent sensor module that is made with high-quality materials. It uses correlation photoelectric infrared technology and is designed to detect and count objects accurately. Despite its low price, it offers high-quality performance and comes in a compact size that makes it ideal for various applications. The module features an imported groove coupler sensor with a slot width of 5mm. It produces an output status indicator lamp that lights up when the output is high and turns off when the output is low. The comparator output signal is clean, and the waveform is of good quality, providing high driving ability.

Fig 6: Correlation photoelectric sensor module

E. RELAY MODULE:

A relay module is an electronic device that consists of a relay and a control circuit. The relay is an electromagnetic switch that is used to control the flow of electrical current in a circuit. The control circuit provides the necessary voltage and current to the relay coil to activate or deactivate the switch. Relay modules are commonly used in a wide range of applications, such as industrial control systems, home automation, and automotive electronics. The main advantage of using a relay module is its ability to switch high currents and voltages with a low-power control signal. This allows for the isolation of the control circuit from the high-power circuit, improving safety and reliability. Relay modules are also easy to use and can be interfaced with a microcontroller or other digital device.

Fig 7: Relay Module

F. DC MOTOR:

A DC (Direct Current) motor is an electrical machine that converts electrical energy into mechanical energy using the principles of electromagnetism. DC motors are widely used in various applications, including industrial automation, robotics, electric vehicles, and household appliances. The speed of a DC motor is controlled by varying the voltage applied to the armature windings. As the voltage is increased, the speed of the motor also increases

Fig 8: DC Motor

G. LCD DISPLAY:

LCD stands for "Liquid Crystal Display". It is a flat-panel display technology that is commonly used in electronic devices such as calculators, watches, televisions, and computer monitors. An LCD consists of several layers of polarised glass, which are aligned to allow light to pass through or be blocked by liquid crystals in response to an electric current.

LCDs are able to produce high-quality images with sharp contrast and tri-colours while consuming less power than other display technologies such as CRTs (Cathode Ray Tubes).

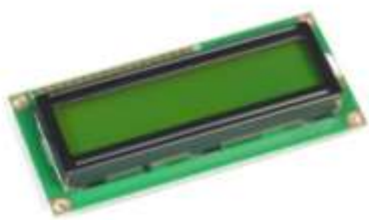


Fig 9: 16x2 LCD

H. ARDUINO UNO:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It consists of a physical programmable circuit board and a software development environment, allowing users to create a wide range of interactive electronic projects. The Arduino board is designed to be easily programmable through a simple programming language and IDE (Integrated Development Environment), which is similar to C/C++.

The board typically features a microcontroller, input/output pins, and other components, allowing it to interface with various sensors, actuators, and other electronic devices. Arduino boards are widely used in a variety of applications, including home automation, robotics, environmental monitoring, and interactive art installations.

Fig 10: Arduino UNO

I. NODE MCU:

Node MCU is an open-source firmware and development board based on the ESP8266 Wi-Fi chip. It features a Lua-based scripting language, allowing for easy programming and integration with various sensors and devices. The Node MCU board is equipped with onboard Wi-Fi, which enables it to connect to the internet and other Wi-Fi-enabled devices. It also has GPIO pins, which can be used to interface with other electronic components, such as sensors, actuators, and displays. It provides a cost-effective and easy-to-use platform for building Wi-Fi-enabled devices and systems.

Fig 11: Node MCU

J. POWER SUPPLY:

A power supply is an electronic device that converts one form of electrical energy into another form suitable for powering electronic devices or electrical equipment. The most common type of power supply is the AC-to-DC power supply, which takes the alternating current (AC) from a wall outlet and converts it into direct current (DC) that can be used to power electronic circuits.

Fig 12: DC Battery

K. DC BATTERY:

A 9V DC battery is a type of battery commonly used in small portable electronic devices such as smoke detectors, remote controls, and audio equipment. The cells are typically made of zinc-carbon, alkaline, or lithium materials, which provide a long-lasting and reliable source of power. Due to its compact size and high voltage, the 9V battery is popular in applications where a smaller size battery with a higher voltage is required.

Fig 13: DC Battery

L. MALE-FEMALE JACK:

Male and female jacks are connectors used to join electrical cables and devices. A male jack typically has a protruding pin that connects with a socket on a female jack, which has a corresponding hole or receptacle. The male jack is usually inserted into the female jack to establish a connection between devices, such as audio equipment or power supplies. These jacks are commonly found in electronic devices, audio and video equipment, computers, and other electronic systems.

Fig 14: MALE FEMALE JACK

M. LI-FI TRANSMITTER:

To transfer data using Li-Fi, the first step is to connect a transmitter to an Arduino board. The Arduino board sends data to the transmitter, which converts it into binary format and prepares it for transfer. The LED bulb is then used to transmit the binary data - if the binary number is 0, the LED will not blink, but if the binary number is 1, the LED will blink. The LED bulb will flash so rapidly that it is not visible to the human eye. This method is just one example of how data can be transferred using Li-Fi.

Fig 15: Li-fi transmitter

N. LI-FIRECEIVER:

The receiver part of vehicular communication using Li-Fi includes ABS (Automatic Braking System) and a photo-detector to receive the transmitted data via LED bulbs. The photo-detector is connected to a receiver circuit, which is responsible for converting the received binary data into a format that can be understood by the receiving device, such as a computer or a mobile device. The receiver circuit may also include an amplifier to boost the signal strength and a decoder to decode the binary data. Once the data is decoded, it can be used for a variety of applications such as traffic management, collision avoidance, and navigation. Overall, the receiver part plays a crucial role in ensuring reliable and efficient communication between vehicles using Li-Fi technology.

Fig 16: Li-fi receiver

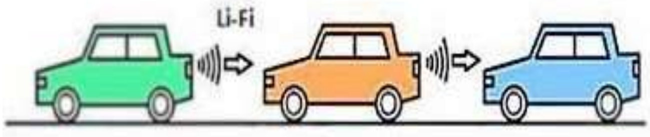
VI.RESULT:

The system has been developed with the primary objective of enhancing safety for drivers and passengers alike. Its core functionality is cantered on utilizing data gathered from various sensors to maintain a level of control over the vehicle at all times.

Cases	Condition	Output
Case 1:	When a vehicle that is moving forward suddenly changes direction to the right or left.	The transmitter sends the data to the receiver and the ultrasonic sensor senses the direction and displays it as 'right' or 'left' in the LCD.
Case 2:	When the vehicles are moving tend to get collided with each other.	The data sends to the receiver and the brake will be applied automatically.

Let's imagine there are three cars traveling at very close ranges in a series. The first vehicle makes a sudden break. The second vehicle might be able to avoid collision but the third vehicle has very less reaction time and has a high probability that it will collide with the vehicle in front.

Now, let's imagine there are three cars traveling at very close ranges in a series with this technology implemented. When the first vehicle makes a sudden break, the ultrasonic sensor in the second vehicle detects the collision range distance and sends a message to the vehicle in the back i.e. the third vehicle which is programmed to stop the motion of the vehicle i.e. by automating the brake systems, the collision is avoided.



Through its advanced technological capabilities, this system is able to facilitate safe driving practices, ultimately promoting a culture of responsible motoring and contributing to a safer, more secure transportation environment. By prioritizing safety in this way, we can work towards minimizing the number of accidents on our roads and ensure a safer journey for all those involved.

VI. CONCLUSION:

In conclusion, the system has been improved with an automatic brake system that utilizes advanced technology to ensure the safety and security of passengers traveling in the vehicle. With the inclusion of key components such as a relay, motor, and battery, the system can detect potential collisions and automatically apply the brakes to prevent accidents and mitigate the severity of any potential collisions. This advanced safety feature adds extra protection and gives passengers peace of mind while traveling on the road.

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