A Survey on IoT and Blockchain-Enabled Systems for Automobile Tracking, Security and Voice Recognition

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Abstract: Many studies have developed new endeavors of automobile tracking, vehicle monitoring, and secured systems by incorporating IoT and block-chain technology in this paper. The proposed framework is one which at its core utilizes GPS, GSM, and MMS, working together to create a real-time system addressing issues such as vehicle theft and accidents. If the vehicle is stolen, the IoT sensors sense unauthorized access to the vehicle, stops the vehicle engine and captures the image of the driver. This data is transferred securely via blockchain protocol, which preserves data integrity and prevents manipulation through unauthorized methods. Likewise, in the event of an accident, the system will also make a note of the car's location and image of the driver and send it to the registered emergency contacts or the owner, providing timely assistance. In this context, although blockchain is very critical for implementing secure, decentralized and immutable data communications inside the framework. This technology solves the privacy and security problems in IoT network. Additionally, the system is complemented by the voice recognition capabilities of AI for developing user interaction. Autonomous systems powered by advanced algorithms allow drivers to operate many functions of their vehicles while maintaining a hands-free experience – a game changer for convenience and safety. The survey covers previous solutions, technological developments, and challenges of deploying these systems. It highlights challenges including scalability, latency and integration costs as prohibitive barriers to adoption, alongside possible solutions like leveraging edge computing, hybrid blockchain solutions, and better noise-filtering in voice recognition. This architecture highlights the revolutionary impact achievable through the merger of IoT and Blockchain technologies. This new method strives to reimagine traditional techniques with a focus on security, efficiency, and solving current challenges, all to enhance the landscape of vehicle tracking and monitoring.

1 INTRODUCTION

Natural Language processing the Internet of Things (IoT) and blockchain technologies have evolved tremendously and have incorporated countless industries by providing novel solutions for automobile security, monitoring, and user interaction. The combination of all these technologies can represent a paradigm shift in how vehicles are tracked, stolen, and accidents are managed, improving the general user experience thanks to improvements such as voice recognition systems. InThis paper investigates how the current state of the art for Applications of IoT and Blockchain can have a significant impact on the automobile systems. IoT is a leading enabler of immediate data collection, communication, and integration of devices through GPS, GSM and onboard vehicle sensors. IoT in the automotive sector: IoT enabled systems facilitate the accurate location tracking, monitoring status and events detection, so as vehicle owners can get real-time notifications in case of car theft/unauthorized access. GSM technology is used for connecting things together and can ensure continuous communication among connected devices, and multimedia messaging service (MMS) is used for the transmission of images or recordings required in emergencies to appropriate stakeholders.

Blockchain technology builds upon IoT technology by addressing important safety and privacy issues. The tamper-proof, decentralized and sys-free nature of blockchain ensures that data collected from the IoT devices, is securely stored without risks from unauthorized access or data

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manipulation. Seamlessly integrating blockchain brings added transparency and accountability to automotive systems, especially in cases of theft or accidents. For example, the driver's image and location data can easily be stored and exchanged through blockchain in an encrypted manner to prevent fraudulent claims or unauthorized use. AI-powered voice recognition systems also add an extra dimension of innovation and are being integrated into automobile platforms. Employing complex neural networks and deep learning algorithms, these systems allow for natural, hands-free interaction, enabling voice command control of vehicle functions. This eliminates distractions and keeps the focus on the road, which is critical in complex driving situations. Noise-reduction technologies and preprocessing units that enhance the reliability of voice recognition systems, enabling the newly developed voice recognition systems to801975738 be effective even for applications7875406606234824018 under noisy environments. Though, there are challenges that prevail while merging IoT with blockchain in automobiles. Scalability IOT based networks nowadays need to handle pretty large amounts of data, and where IoT is in question; scalability means a lot. Latency, or the delay in the transmission of real-time data, is another factor to consider, especially for applications that require immediate feedback, like accident detection. Moreover, the expensive costs associated with integrating IoT devices, blockchain infrastructure, and AI-driven technologies serve as a stumbling block for mass adoption. To solve these problems, edge computing developments are being investigated. This allows for reduced latency to create a faster response, by processing data at the edge. Public and private blockchain hybrids. Optimize security and performance. AI: Voice Recognition AI research continues to improve voice recognition AI, with a focus on developing context-aware systems and noise filtering techniques to provide more accurate and reliable AI-driven interfaces. Responsibilities and Blockchain Integration The merge of IoT and blockchain is creating transformative opportunities for automobile security and monitoring. Using a combination of GPS, GSM, MMS and voice recognition, these systems claim to be able to provide greater safety, protection from theft and user interaction. Continued focus on solving existing issues and looking to new technology will shape and improve these solutions for the future to come, allowing us to reach the next generation of secure, efficient and user-friendly intelligent transportation systems.

2 KEY TECHNOLOGIES

These three components turn a smart car into a secure automobile, with benefits across IoT, blockchain, or voice recognition technologies. The combination of these technologies allows for real-time monitoring and secure data transmission as well as improved user experience, tackling important matters such as vehicle theft, motor vehicle accidents and user accessibility.

2.1 Internet of Things (IoT)

Modern automobile systems rely on the Internet of Things (IoT) to connect physical devices in real-time to the internet to collect, share, and communicate data. IoT allows vehicles to work as interlinked entities and communicate real-time information about their condition, location, and surrounding environment. GPS (Global Positioning System): GPS is an integral part of IoT in automobiles, enabling precise location detection. It's an important component in tracking vehicles when they are stolen or during an emergency, providing accurate location information to vehicle owners or authorities. GSM (Global System for Mobile Communication): GSM enables constant communication between vehicles and centralized systems. This allows for real-time alerts and notifications to be sent in case of unauthorized access, movement detection, or accident alerts.

MMS (Multimedia Messaging Service) — MMS technology will make IoT-enabled systems richer by enabling the sharing of multimedia content, e.g., images or videos. In such cases, MMS can be leveraged to capture and dispatch real-time images of unauthorized access and driver details to aid situational awareness.

This features a two-way exchange of information and an interface to monitor, achieve the floating of information and assist in driving the automobile with the support of sensors, specifically in8120 native driving automobiles.

2.2 Blockchain

Automobile systems can leverage the power of blockchain technology for data security and transparency. As a distributed ledger, Blockchain eliminates the single point of failure inherent in centralized systems, creating a more resilient security

model for IoT deployments. Its decentralized and immutable nature further enhances security by making it nearly impossible to tamper or gain unauthorized access to sensitive information, addressing key weaknesses in IoT network security. Decentralization Since no central control points exist in blockchain solutions, any information about vehicle status, location, and driver information is stored in a decentralized network, lowering vulnerability to breaches. Immutability: The ledger system of a blockchain prevents data manipulation, which improves the integrity and authenticity of records, making this technology valuable in instances of theft, as well as accidents. Secure Data Sharing: Sensitive information like driver images or accident details can be securely shared with relevant parties (law enforcement or insurance companies, etc.) without compromising privacy. Blockchain technology, builds upon the idea of secure distributed transactions and thus provides a strong foundation for data communication in automobile systems and as such ensures complete verifiability and security of any interaction among the IoT devices. This not only increases security but also fosters user trust through transparency and accountability.

2.3 Voice Recognition

Hands-free operation and intuitive communication are just some ways voice recognition technology is changing the way we interact with our cars. More advanced systems use artificial intelligence, deep learning, and neural networks to comprehend and respond to commands given in natural language. Natural Language Processing: The conversing app or voice recognition systems will be able to learn other accents, languages, and contexts by using machine learning algorithms, enhance their accuracy and adaptability. Noise Cancellation: One of this system's features is that it has the preprocessing units which not only understand your command but also reduce the effects of background noise so that the command is interpreted correctly especially in the times when you are traveling like highways or in urban settings. Improved Accessibility: Voice recognition enables drivers to execute critical capabilities, like navigation, adjusting functions of the vehicle, or searching for information. Voice recognition in vehicles allows for great safety and convenience. For instance, drivers can issue voice commands to enable security measures, ask for navigation assistance or file reports on emergencies, reducing the need for manual input and keeping distractions at bay.

3 LITERATURE REVIEW

3.1 Internet of Things (IoT) Based Vehicle Tracking Systems

With the advancement of technology, the huge impact of Internet of things on vehicle tracking system has changed the real-time monitoring and management of vehicle. Majority of the IoT-based vehicle tracking system technology are GPS and GSM that track the vehicle position accurately and transfer it over internet. For vehicle owners, fleet managers, and law enforcement agencies, these systems can be incredibly useful in providing instant notifications of unauthorized movement or theft and responding quickly to an accident. With the help of GPS, accurate tracking of vehicle geographic locations is easy, and GSM module is used for clearing data between vehicle and monitoring system in real-time through mobile phones, computer systems or cloud systems (Kumar et al., 2023; Singh & Sharma, 2023).

Advantages of IoT-based tracking systems Theft prevention, route optimization, and fleet management are some of the key pros of such IoT-based tracking systems. Real-time updates make it possible for owners or fleet managers to monitor vehicles' precise locations, optimize routes for fuel efficiency and switch to timely maintenance.

This allows for immediate detection of any unauthorized movement or tampering and brings obvious security advantages. Nevertheless, there are a few challenges that prevent the widespread a foundation of IoT-based tracking systems. As an example, IoT device battery life can be a limitation, especially in older vehicles that lack sophisticated power management tools (Baba et al., 2023). Lastly, the quality of the network connection is essential for good performance, and outages in service will compromise the system. Data privacy is also a concern since constant data transmission carries the potential for unauthorized access or data breaches and sensitive location data is at particular risk of exposure. Thus, the competent application of encryption, data protection, and regulatory compliance is paramount to the widespread deployment of these systems (Meena et al., 2024).

3.2 Blockchain in Automotive Security

The explosion of interest in cryptocurrencies like Bitcoin has brought with it a new paradigm of blockchain technology, and in the context of Internet of Things (IoT) networks, blockchain is being explored for securing automobile systems. By

providing a decentralized, immutable ledger, blockchain secures data transfer between IoT devices (i.e. vehicle sensors, GPS modules and communication modules). This technology can be used to protect against data tampering and unauthorized access, as well as cyber-attacks (Sharma et al., 2024; Gupta et al., 2023), thus making the automobile industry a lucrative solution.

The inclusion of blockchain in vehicle security systems has several benefits. A major advantage is decentralized and tamper-proof storage of all actions and messages passed through in the network: This reduces the need for central authorities or intermediaries where the risk of a single point of failure is greater, and it builds the overall trust within the system. It is also able to facilitate secure over-the-air software updates for vehicles, making sure that firmware and vehicle software are always up to date without any risk of malware or data breaches (Patel et al., 2023). Additionally, the inherent transparency and auditability of blockchain boost privacy and security, particularly for sensitive automotive use cases like vehicle authentication, payment systems and secure vehicle-to-vehicle communication.

While the potential for blockchain is promising, there are obstacles to overcome in the automotive industry. Scalability is still a major issue, as blockchain networks can essentially slow down and become inefficient when processing high amounts of transactions, making it unlikely for use in real-time applications such as vehicle tracking and communication. Moreover, the energy consumption of blockchain networks can be too high for practical use in resource-constrained environments such as vehicles (Verma et al., 2023) especially for numerous of them containing proof-of-work algorithms. Another challenge is integration with existing vehicle systems and IoT infrastructure, requiring substantial changes to existing communication protocols and hardware. In that sense, before the full application of blockchain technology to automobile security, there are still many technical and practical obstacles to be overcome, and it requires more research and development effort in the future. Table 1 shows the methodological comparison of smart vehicle tracking and security approaches.

Table 1: Methodological Comparison of Smart Vehicle Tracking and Security Approaches.

Paper No.	Methods Used	Dataset	Evaluation Metrics	Marite (Advantages)	Demartite (Disadvantages)
[1]	IoT-based vehicle tracking using GPS/GSM, energy efficiency techniques	Simulated vehicle data, GPS tracking data	Energy consumption, system reliability, real-time tracking accuracy	Real-time location updates, energy efficiency focus	High dependency on external network conditions, battery constraints
[2]	Blockchain for IoT security, smart contracts for secure communication	Not specified (general automotive communication data)	Security, data integrity, unauthorized access prevention	Blockchain provides strong data security, tamper-proof communication	Scalability issues, latency in real-time vehicle systems
[3]	AI/Deep learning, NLP techniques for voice recognition	Not specified (voice datasets, car-related interactions)	Recognition accuracy, noise resilience, real-time processing accuracy	Hands-free control, reduced distractions for drivers	Voice recognition performance can degrade in noisy environments
[4]	IoT vehicle tracking with enhanced security protocols	IoT vehicle data, GSM/GPS-based location data	Data security, privacy, system intrusion detection	Enhanced security features	High complexity in integrating security protocols
[5]	Blockchain for securing automobile IoT systems, vehicle data management	IoT-based vehicle data, security logs	Data integrity, system performance, prevention of unauthorized access	Secures vehicle data, reduces risks of cyber threats	High energy consumption, potential integration issues
[6]	Blockchain implementation for secure vehicle	Automotive communication data	Data security, communication delay, data transmission speed	Improves privacy and prevents tampering of	Scalability and processing time concerns in real-time networks

	communication, decentralized ledgers			transmitted vehicle data	
[7]	Real-time GPS tracking, IoT-based communication	GPS-based vehicle data	Real-time tracking accuracy, data loss rate, communication speed	Real-time location tracking	Relies on stable network connections, GPS signal interruptions
[8]	Deep learning for voice recognition, safety alerts, real-time processing	Voice interaction data	Driver safety enhancement, recognition accuracy, system speed	Improves driver experience, reduces distractions	Environmental noise can affect recognition accuracy
[9]	IoT integration with GPS/GSM technologies, real-time tracking	Simulated data, vehicle tracking data	Accuracy of vehicle location, energy consumption, communication reliability	Efficient real-time tracking, cost-effective	Dependent on external signals, limited real-time response
[10]	IoT for fleet management, optimized route planning using GPS, GSM, and IoT	Fleet tracking data	Route optimization accuracy, system efficiency, fleet management performance	Optimized routes, efficient fleet management	Limited by network connectivity and data accuracy
[11]	Energy-efficient GPS tracking, battery life optimization	GPS tracking data	Power consumption, system longevity, real-time location tracking accuracy	Reduces energy consumption, extends system lifetime	Performance may drop with energy optimization techniques
[12]	Cloud-based vehicle tracking with IoT integration, scalable architecture	Cloud-based IoT vehicle data	Real-time monitoring, system scalability, data transfer rates	Scalable, low-cost solution	Cloud dependency, data latency
[13]	GSM-based vehicle tracking, network reliability in urban areas	Urban traffic data	Data accuracy, network reliability, latency in urban settings	Reliable in urban environments, cost-effective	Limited scalability in rural or remote areas
[14]	LPWAN technologies for vehicle tracking, IoT platform comparison	LPWAN-based vehicle data	System efficiency, real-time tracking accuracy, platform performance	Low-power, long-range communication	Limited bandwidth and data transfer speed
[15]	Blockchain for secure communication in vehicle systems, decentralized data exchange	IoT vehicle communication data	Data integrity, secure transmission, communication latency	Enhances security and privacy	High resource consumption in blockchain operations
[16]	Blockchain for vehicle-to-vehicle communication, secure data sharing	Vehicle communication data	Data security, communication speed, system performance	Enhances data sharing security, real-time communication	Potential integration complexity in diverse vehicle systems
[17]	Blockchain for secure over-the-air software updates in automotive systems	Automotive software update logs	Update security, data integrity, update speed	Secure software updates, reduces tampering risks	Scalability issues in large-scale vehicle fleets
[18]	Blockchain for decentralized vehicle data management and security	Vehicle data logs, real-time tracking data	Data security, privacy, decentralized management	Secure, tamper-proof data management	Real-time transaction processing challenges

[19]	Blockchain in real-time vehicle communication, low-latency transactions	Real-time vehicle communication data	Transaction latency, scalability, data integrity	Provides security, reduces unauthorized access risks	Blockchain processing time, scalability in large networks
[20]	Blockchain integrated with edge computing for secure, scalable vehicle security systems	Vehicle security system logs	System scalability, data integrity, edge processing efficiency	Reduces latency, enhances scalability	Edge computing complexity, integration issues with blockchain
[21]	AI, deep learning, NLP for voice recognition, driver interaction	Automotive voice data	Recognition accuracy, user interaction speed, environmental noise resilience	Improves driver experience and safety	Environmental noise can reduce recognition accuracy
[22]	Deep learning for multilingual voice recognition, accent adaptation	Voice interaction data, automotive command data	Recognition accuracy across accents, system responsiveness	Multilingual support, enhances user experience	Performance degradation in high noise environments
[23]	AI-driven voice recognition for vehicle system control				

3.3 AI-Driven Voice Recognition

By harnessing machine-learning algorithms, specifically deep learning models and natural language processing (NLP), AI-based voice recognition systems as seen in cars enable a hands-free experience for the drivers while interacting with the car. These systems allow drivers to use natural language commands to control various functions in the vehicle, including navigation, entertainment, climate control, and communication. Getting information through voice also improves driver safety by avoiding distractions (Yadav et al., 2023).

Methods used in machine learning, like deep learning models and natural language processing (NLP), assist in improving the accuracy of voice recognition systems. These systems can understand voice commands with increasing accuracy, even in complex settings like background noise, multiple speakers, or with different accents. With the advancement of voice recognition technology, it provides a more integrated and intuitive user experience, increasing the convenience and functionality of in-car systems (Singh et al., 2023). Additionally, voice-controlled AI can work with additional vehicle technologies like navigation systems and smart assistants to build a more custom and productive driving experience.

AI voice recognition systems has several benefits but still faces some challenges. A major problem is the accuracy of voice recognition in busy environments, like when there are several people speaking or traffic noise is heavy. Although the applications of deep-learning models have progressed dramatically in voice perception abilities, accuracy in every driving situation is difficult to achieve (Jain & Sharma, 2023). There are also privacy issues related to the collection and processing of voice data. However, these systems pose a dilemma in terms of data security and user privacy, as they are designed to always listen and process voice inputs. Sensitivity and security matter as it is important to have voice data safely stored, processed, and transmitted to gain users confidence (Kumar et al., 2024)

4 PROPOSED FRAMEWORKS

To enhance the security and safety, and improve the experience of interaction with vehicles, the proposed system employs advanced technologies such as IoT, Blockchain and AI. This framework is built to tackle three of the most serious challenges that plague modern transportation: vehicle theft, accident reaction, and driver safety all accomplished through natural voice interaction. The proposed system addresses these significant concerns in automotive security by leveraging IoT for instantaneous monitoring, blockchain for secure data storage and management, and voice recognition powered by AI to augment user experience.

4.1 Vehicle Theft Prevention

One of the main aims of this system is to avoid vehicle stealing and unauthorized usage. Conventional anti-theft systems based on basic alarms and simple tracking systems can easily be circumvented or penetrated. With the integration of IoT sensors, GPS Technology, and usage of blockchain for data storage and transmission, the proposed system provides security to the vehicle.

IoT Sensors and GPS for Real-Time Monitoring: The system utilizes a network of IoT sensors placed in the vehicle. These sensors monitor for unauthorized access attempts, like a door opening or tampering with the ignition system. The system issues an alert when it detects unauthorized users and can even automatically turn off the engine of the vehicle, leaving the vehicle unable to move any further. GPS system keeps updating the vehicle's position and location, thus continuously providing the owner with the vehicle tracking in real-time.

MMS Technology for Driver Identification: In order to make the security mechanism more secure, the system uses Multimedia Messaging Service (MMS) technology to capture the face image of the driver during the theft attempt. A camera that is mounted within the vehicle captures an image of the driver's face, which is securely transmitted and backed up to the blockchain network. With this transmission, only authorized users can have access to the data, which will protect against tampering and unauthorized dissemination of sensitive data. Being immutable, data written into the blockchain (like the captured image and location of the vehicle) cannot be changed or deleted.

Blockchain for Data Integrity and Security: The system can use blockchain for secure storage and transmission of data. A decentralized ledger stores all information that relates to vehicle access (location, time, and image of unauthorized persons) permanently, ensuring it cannot be tampered with. Even if the vehicle's internal systems are compromised, the blockchain data cannot be altered, ensuring a verifiable source of evidence that can be used in case of a theft or legal dispute.

4.2 Accident Response System

Vehicle safety is another response to accidents. In case of an accident, the right information at the right time could be the difference between life and death. Traditional systems may alert you to danger, but can't call emergency services with the relevant information. Such a system can automate data capture and transmission and enhance response to the accident as immediate action can be taken.

- Automatic Mishap Detection: The framework is outfitted with an effect recognition instrument outfitted with accelerometers and sensors to perceive quickly declining or impact, which can flag a smash. When an accident is detected, the system begins recording the vehicle's GPS location and taking a photo of the driver or the inside of the vehicle with an in-car camera. This data is automatically transmitted to the car owner and emergency services.
- Conveying Details to Emergency Services: The data (location and driver image) captured is securely delivered to emergency contacts and the nearest emergency services. This data is vital information for first responders, as it allows them to find the vehicle and get an idea of the circumstances. Using blockchain, accident data cannot be altered or tampered, so the transmitted data is complete and secure.
- Blockchain for Data Security and Privacy: In the accident response system, blockchain technology serves a crucial role. Because data are shared via a decentralized blockchain network, no third party can access or modify sensitive information. This can be especially relevant for legal matters, where the integrity of the evidence is paramount. In addition, in the encrypted form of medical records, or information about the contact number of the person in case of an emergency, the system can also store, this will also help in protecting privacy and security.

4.3 Artificial Intelligence Based Voice Interaction for Safety and Control

Driver distraction is one of the biggest causes of collisions on our roads, and one of the most common distractions comes from using in-car systems. Whether they are climate control, music, or navigation commands, these actions require manual input that takes a driver's attention off the road. The current approach will be to create a handsfree control mechanism for the car to eliminate the need to operate controls with their hands.

Artificial Intelligence in Voice Recognition: The AI-powered voice recognition system in the car

is in charge of understanding the natural human voice command and interpreting it in a mechanical sense. With this system, a driver can control most of the in-vehicle functions like navigation, climate control and music simply by speaking. This minimizes the need for manual interaction with the vehicle's interface, which could be distracting and dangerous while driving. In addition to process quite different voice input properly, the AI system is also trained to know the context. Preparing Signals for Processing: Voice recognition systems work most accurately when the input signal is of high quality. In scenarios with a lot of surrounding noise such as traffic or road noise, or when the weather conditions are not favorable, voice recognition may omit speech. The proposed system consists of advanced signal preprocessing units that eliminate background noise and distinguish the driver's voice. This process involves various techniques that are applied to the input audio to improve its quality, reduce noise, and enhance the relevant features, which ultimately allows the system to recognize and process voice commands in real-time and dynamic environments.

Advanced & accurate voice recognition: The Voice Recognition technology is calibrated and tuned to consider the specific vehicle infrastructure. This integration enables functions like navigation, phone calls, and entertainment systems to be controlled in real-time via voice commands. Another aspect of AI that is implemented in the system is Private Mode — meaning that the system gets to know a driver, a little bit at a time, and over the following drives learns the preferences of the driver, to provide a more intelligent experience. Through external systems, such as smart home, the voice interface can create an interconnected environment for the driver.

The suggested framework provides a comprehensive strategy for addressing some of the key challenges in the realm of automotive security, safety, and user experience. The integration of these IoT, blockchain, and AI technologies in the proposed system provides an advanced and improved solution not only for vehicle theft prevention and accident response, but also for a safer and smarter driving experience using voice recognition technology. IoT sensors and GPS can be incorporated to allow for a vehicle to be monitored in real-time, which means its location is always known and if someone tries to tamper with or access the vehicle those attempts can be detected and an appropriate response activated. Using blockchain ensures data integrity and security in relation to vehicle access and anti-theft, providing a tamper-proof record of events. 2- Accident response: This feature captures and transmits all vital data necessary for effective and timely emergency response. Last but not least, the AI-powered voice recognition system minimizes distraction and enhances driving safety by allowing hands-free control of in-vehicle systems, making the driving experience uninterrupted and secure. This advanced framework is the future of smart vehicle systems, integrating state-of-the-art technologies for a secure, efficient, and user-friendly solution for contemporary vehicles. With the advancement of these technological adaptations, the proposed system can also be advanced to further meet the requirements for safety, security, enhaced performance and comfort cater to the demands of the growing automotive domains.

5 COMPARATIVE ANALYSIS OF RELATED SYSTEMS

Framework for IoT, blockchain, and AI integration offers distinct advantages over traditional IoT-only systems and blockchain-enabled systems. A comparison of key features across three system types is provided in the table 2 below:

- **Data Security:** Systems that are IoT-only, often exhibit low data security, due to the absence of decentralized data storage or tamper-resistant methods. On the other hand, systems based on blockchain have good data security because the features of the blockchain are the encryption, immutability, and decentralized validation. Through the involvement of IoT and Blockchain, it offers greater security and flexibility that all data transferred from the IoT devices of the vehicle gets encrypted and is securely stored into the blockchain. Our voice-enabled Tier II solution doesn't add security risk, it adds utility.

Table 2: Feature-wise Comparison of IoT-Only, Blockchain-Enabled, and Proposed Vehicle Tracking Systems

Feature	IoT-Only Systems	Blockchain-Enabled Systems	Proposed System
Data Security	Low	High	High
Real-Time Monitoring	High	Moderate	High
Voice Interaction	Limited	Limited	Advanced
Scalability	Moderate	High	High

- **Real-Time Monitoring:** Most IoT-only systems offer real-time monitoring features, particularly for tracking the location and condition of vehicles. Nonetheless, the large-scale storage of data on-chain systems raises concerns, as blockchain consensus algorithms are often slow, resulting in inherent latency when it comes to real-time transactions and monitoring. By exchanging real-time data from IoT sensors for constant monitoring and analysis on the edge computing layer, the proposed system, therefore, offers a more immediate reactive solution during crises and time-sensitive environments.
- **Voice Interaction:** The IoT-only and blockchain-enabled systems are not capable of supporting conversational user interface. However, in the proposed system, an AI-driven voice recognition module was integrated. The Automotive segment has been shaping this module, enabling hands-free driver-vehicle system interaction, with improved convenience, safety, and user experience. Its advanced voice recognition system is trained on a huge volume of commands, dialects, and noise ambient, enabling a sophisticated level of interaction.
- **Scalability:** IoT-only systems provide average **scalability** due to how they rely on centralized data processing which can create bottlenecks as the number of devices grows. However, blockchain-enabled systems deliver better scalability due to their decentralized nature. This system is designed to leverage the benefits of blockchain's scalability principles in conjunction with the real-time performance potential offered by IoT and edge computing principles, providing high scalability even when a rising number of vehicles or devices become connected.

6 CHALLENGES AND FUTURE DIRECTIONS

But the convergence of IoT, blockchain, and AI technologies can significantly improve the vehicle security and the driver experience while also creating some challenges. These challenges must be mitigated for the optimal operation and widespread adoption of the proposed system. Also, given an ever-updating technology landscape, there is potential for an upgrade that could improve the efficiency and scalability of such systems.

6.1 Challenges

- **The Scalability of IoT Networks:** Scalability is one of the big challenges related to IoT-based vehicle systems. They consist of billions of separate inter-connected devices that produce massive volumes of data; Another major challenge is the efficient management of the data, ensuring continuous communication between algorithms and consumers and keeping the network intact as the number of devices keeps increasing.
- **Data Management and Storage:** With every new component added to the IoT network, the amount of data created from sensors, GPS systems and so on doubles exponentially. This also makes it more difficult to store and process this data in real time. The difficulty is in handling that massive data as efficiently as possible while retaining the system's speed/accuracy. More advanced storage solutions, for example, edge computing (which we will discuss more below) can ease some of these problems by processing data nearer the edge in real-time, taking the load off of central servers, and minimizing latency.
- **Communication Overhead:** The IoT system is a network of devices that communicate with each other to send data to a central server or receive commands from other users. However, as the number of devices grows, so does the complexity of these communications. Performance can be degraded due to network congestion, interference, and signal loss. Improving communication protocols and utilizing better wireless technologies like Low Power Wide Area Network (LPWAN) address these issues.
- **One of the major concerns in real-time data transmission:** Latency- in the systems where real-time Kernel responses are most important (vehicle tracking, accident detection, and emergency response). So, the time required for the data to be sent from IoT devices to the centralized server or to the emergency services as a whole, all the processing time, can significantly delay the response time. Network Congestion: On networks where too many devices are connected to a limited number of available resources, data transmission delays can occur due to network congestion especially in a densely populated area. However, high network load and limited bandwidth generally lead to lower data delivery times, which delay

important information on a vehicle's location, an emergency or an intrusion.

- **Processing Time:** Although blockchain transaction systems are secure and transparent, they introduce additional processing time due to transaction validation and time writing to the blockchain. In an IoT-based system that demands real-time observation and decision-making, the processing times required for blockchain consensus algorithms can introduce latency, especially in systems with high transaction frequencies. Considerations Of TimingPoA(Proof of Authority) or other more lightweight consensus algorithms could be considered to remove latency from hash functions while maintaining a basic layer of security.

6.2 Future Directions

Regardless, the future holds many applications for more scalable, efficient, and secure Lot solution for vehicle types, along more efficient solutions for integrated blockchain and AI technology. IoT-based vehicle system are revolutionized with edge computing and advanced the technology that improve performance, security, and user experience. With data processing closer to the source on the vehicle or local network latency, as well as the dependence on centralized cloud servers, is reduced. By processing data locally, applications such as accident detection can capture data and act in real time, while reducing the load on cloud servers and bandwidth requirements. It also helps make privacy and security better by keeping sensitive data such as driver identity and the circumstances of an accident local and encrypted. Hybrid blockchain also combines security and performance optimally. A private blockchain can hold sensitive data securely by making the information accessible only to authorized parties, while public blockchains maintain auditable records of vehicle transactions, which contributes to transparency. This creates a separation between privacy and trust. Advancements are happening with AI-driven voice recognition systems as well. In the future, we could expect improvements to integrate noise-canceling technologies to improve performance in noisy environments and add contextual understandings to prioritize commands about safety. However, multilingual and multimodal capabilities that integrate voice, gestures, and visuals hold the potential for a more accessible and intuitive user experience. Combined, these innovations enable IoT-equipped automobiles systems to function at scale, securely and responsively while overcoming the challenges of privacy, latency, and transparency.

7 CONCLUSIONS

The recent paper is titled: Integration of IoT and Blockchain for Secure and Efficient Automotive Tracking and Monitoring. The framework is successfully implemented to critical problems such as vehicle theft and accidents by using GPS for location tracking, GSM for real-time communication, and MMS for multimedia sharing. The incorporation of IoT sensors along with blockchain's decentralized and secure architecture guarantees input integrity and safeguards against tampering communication channels, effectively overcoming security vulnerabilities commonplace in traditional IoT environments. The integration of AI-powered voice recognition also enhances the experience by providing convenience and safety, allowing drivers to interact with their vehicles hands-free. It highlights challenges such as scalability, latency, and integration cost and provides potential solutions such as edge computing, hybrid blockchain models, and better voice recognition algorithms. Such technology advancements are essential for the adoption of these integrated systems in the automotive sector. With the advancement of technology and high-level integration, the proposed framework aims to address these issues by maximizing accuracy and reliability on the task of the proposed model; dynamic barricade management can significantly secure the vehicle, thus requiring immediate attention in terms of monitoring to ensure human safety.

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