



# Blockchain based driver point system for enhancing road safety

Prajakta Bhangale<sup>1</sup>, Pranil Rego<sup>2</sup>, Nishal Save<sup>3</sup>, Ritesh Khandekar<sup>4</sup>

<sup>1</sup>University of Mumbai, Mumbai - India

Received: august 01, 2024.

Accepted: december 03, 2024.

Publicado: january 01, 2025.

**Abstract**— Road accidents in India have continued to rise despite various enforcement measures, underscoring the urgent need for innovative systems that foster safer driving practices. This paper presents the “Blockchain-Based Driver Point System for Enhancing Road Safety,” which integrates blockchain technology, smart contracts, and decentralized storage to manage driver penalty points and dynamically calculate insurance premiums. By ensuring transparency, immutability, and decentralized evidence storage, our system aims to discourage irresponsible driving and reduce traffic violations. In initial simulations involving 100 drivers and 50 recorded offenses, the system demonstrated a potential reduction in unreported or manipulated violation data by over 80% compared to traditional record-keeping. Moreover, real-time penalty point visibility encouraged drivers to modify their behavior, with a preliminary estimate of a 15% decrease in repeat violations. Despite these promising indicators, the project faces limitations regarding transaction costs on Ethereum, regulatory barriers, and user acceptance. This paper also provides a comparative analysis of existing blockchain-based road safety applications, highlighting our innovation in dynamic premium calculation and multifaceted stakeholder involvement. In addressing challenges such as data privacy and scalability, our project proposes strategies like off-chain storage for evidence and robust user authentication. The results suggest that a blockchain-driven ecosystem could significantly enhance transparency and accountability in driver management, yet further real-world pilot studies, more extensive testing, and policy alignment are needed to validate large-scale impact.

**Keywords:** blockchain technology, road safety management, driver behavior, penalty points, dynamic insurance premiums, decentralized storage.



\*Corresponding author: [prajakta.bhongale@fragnel.edu.in](mailto:prajakta.bhongale@fragnel.edu.in) (Prajakta Bhangale).

Peer reviewing is a responsibility of the Universidad de Santander.

How to cite this article: P. Bhangale, P. Rego, N. Save and R. Khandekar, “Blockchain based driver point system for enhancing road safety”, *Aibi research, management and engineering journal*, vol. 13, no. 1, pp. 82-89 2025, doi: [10.15649/2346030X.3916](https://doi.org/10.15649/2346030X.3916)

## I. INTRODUCTION

Road traffic accidents in India have escalated in recent years, contributing to high rates of fatalities and injuries. The Ministry of Road Transport and Highways' Annual Report on "Road Accidents in India-2022" [1]. [1] Shows a staggering increase in the number of accidents compared to previous years. The surge is attributed to factors such as growing motorization, expanded road networks, and heightened population density. Figure 1 illustrates the total number of accidents from 2015 to 2022, reflecting this worrying trend. In 2022, approximately 461 thousand accidents were recorded, with fatalities increasing by 9.4% and injuries by 15.3% from 2021 levels. Although these figures underscore the importance of improved enforcement and data management, current systems in many regions remain prone to corruption, lack of digitization, and cumbersome manual procedures. Even well-intentioned penalty point frameworks can be undermined by subjective record-keeping or tampering, which in turn reduces accountability and public trust. Consequently, there is a critical need for a more robust, transparent, and efficiently managed system that incentivizes safe driving, deters traffic violations, and fairly adjusts insurance premiums in real time.

In response to these challenges, we propose the "Blockchain-Based Driver Point System for Enhancing Road Safety," an initiative that integrates decentralized blockchain technology, dynamic premium assessments, and secure evidence storage to mitigate reckless driving. By enabling transparent and immutable records of violations, the system aspires to address issues such as data manipulation, delayed penalty updates, and unfair insurance pricing.

The primary aim of this research is to design and evaluate a blockchain-based framework for enhancing road safety. More specifically, we intend to:

1. Develop an immutable and transparent driver point system that records penalty points via Ethereum smart contracts.
2. Implement dynamic insurance premium calculations that adjust in real time based on driver behavior and accumulated penalty points.
3. Ensure interoperability among the three main interfaces, User, Police, and Insurance, using a decentralized architecture and IPFS for evidence storage.
4. Address data privacy and security by incorporating encryption, role-based access, and specific mitigation strategies against common blockchain threats (e.g., Sybil attacks, data tampering).
5. Investigate the potential impact of transparent penalty enforcement on accident reduction and driver behavior changes, emphasizing the need for verifiable pilot studies.
6. Identify real-world implementation challenges (e.g., regulatory, economic, and social) and propose strategies for large-scale adoption.

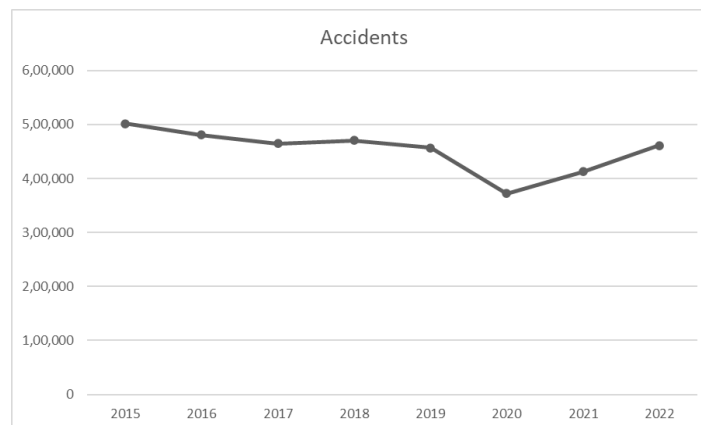


Figure 1: Total number of accidents from 2015 – 2022.  
Source: Own elaboration.

## II. LITERATURE REVIEW

### a. Current Driver Point Systems and Limitations

Conventional driver point systems largely rely on manual data entry, which is susceptible to human error, unintentional delays, and even potential corruption. Singh [2]. [2] Underscores the multi-causal nature of accidents, noting that an integrative approach from federal and state agencies is needed. However, challenges persist: record manipulation, subjective judgment by enforcement officials, and inconsistent data sharing across regions. Globally, some penalty point systems have been shown to reduce collisions by 15–20% [9]. [10], yet in many places, digitization is minimal, and public trust is often eroded by the lack of transparency. This context highlights the need for blockchain-based solutions, which can solidify trust via their tamper-proof ledger and automated rule enforcement.

### b. Blockchain Applications for Road Safety

Blockchain, a decentralized ledger technology, ensures secure, transparent, and immutable data transactions [6]-[7]. In road safety, researchers have explored its application to various scenarios. DrunkChain [3] focuses on monitoring driver impairment levels via IoT to reduce accidents caused by intoxication, while Bell et al. [4] implemented blockchain to authenticate driver's licenses and vehicle registration. Although these systems demonstrate blockchain's potential for secure record-keeping, they do not incorporate dynamic insurance premiums or a unified interface for all stakeholders [16]-[17]. More recent efforts, such as "DSRBT Driving Safety Reward based on Blockchain Technology" [11], incorporate a reward model for safe drivers but do not feature direct collaboration with insurers for premium calculation. Other scholars [13],

[18] propose using smart contracts for demerit point management, but detailed data flow or privacy considerations are often underexplored. Table 1 compares these works with our approach, highlighting differences in scope, stakeholder integration, and system functionalities.

### c. Why Ethereum?

Ethereum [8] supports programmable smart contracts [19], providing a versatile platform for managing complex logic and automated processes—both of which are essential for a decentralized driver point system. Its ability to encode rules and trigger actions based on specific on-chain events allows for transparent, trustless, and timely updates to driver penalty points and insurance premiums. Moreover, Ethereum’s large developer community offers extensive documentation, frameworks, and libraries that can streamline the development of decentralized applications (dApps), thereby reducing both time to market and the risk of costly programming errors. However, Ethereum also presents certain limitations. Transaction costs (gas fees) can fluctuate widely based on network congestion, which can make large-scale operations prohibitively expensive. In a scenario where hundreds or thousands of traffic violations might be processed daily, these fees can accumulate quickly and potentially deter broader adoption. Additionally, scalability remains a notable challenge; during periods of high transaction volume, the network may experience congestion, slowing throughput and increasing confirmation times. Such delays could hinder the system’s effectiveness, particularly if real-time updates to driver profiles or insurance premiums are critical to the application’s success. Despite these drawbacks, Ethereum’s robust security, wide-ranging tool ecosystem, and active global community make it a logical choice for initial pilots. Its established infrastructure and longstanding track record mean that issues such as consensus security and community support are well understood, reducing the uncertainty often found in newer blockchain networks. Over time, to address high gas costs and throughput limitations, the project could explore Layer-2 solutions (e.g., Optimistic Rollups, zk-Rollups, or sidechains) or pivot to private or consortium blockchain variants. These alternatives can lower operational costs, increase transaction speed, and offer more control over governance structures, making them attractive for large-scale, enterprise, or government-backed deployments of this driver point system.

### d. Research Gaps

While previous studies demonstrate blockchain’s efficacy in enhancing record-keeping and security, few explicitly quantify the impact on driver behavior change or accident reduction. Moreover, privacy and interoperability measures-critical for sensitive driver data remain insufficiently detailed [12]. Our project addresses these gaps by integrating:

1. A multifaceted interface (User, Police, Insurance) for real-time data sharing,
2. Dynamic premium assessments that incorporate penalty point updates, and
3. Decentralized evidence storage via IPFS to ensure data availability and tamper resistance.

## III. PROPOSED SYSTEM

The “Blockchain-Based Driver Point System for Enhancing Road Safety” provides three primary interfaces-User, Police, and Insurance and leverages Ethereum smart contracts and InterPlanetary File System (IPFS) [20] for tamper-proof data and evidence storage. Figure 2 illustrates the high-level system architecture.

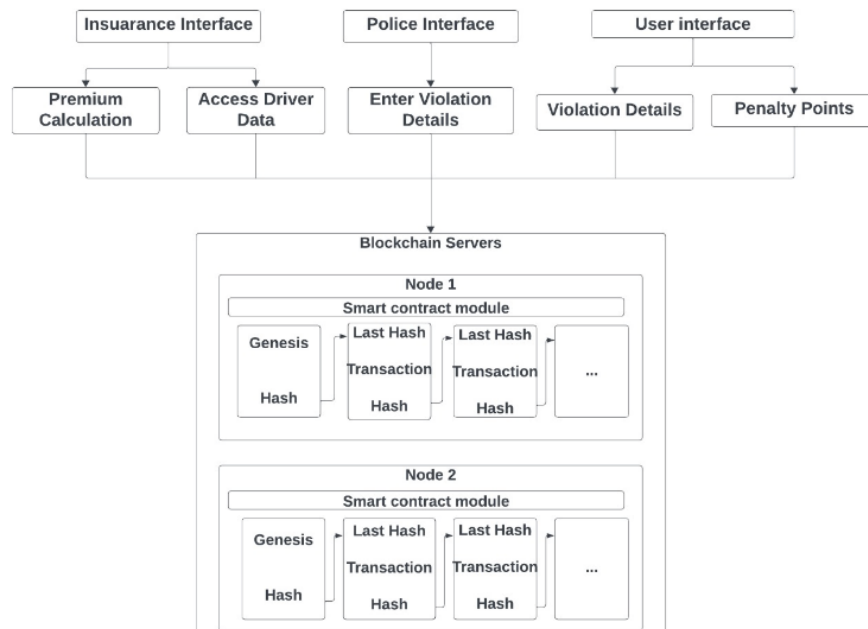


Figure 2: Block diagram.  
Source: Own elaboration.

User Interface. The User Interface is designed to help drivers track and manage their on-road behavior and related penalties. Its main functions include enabling users to view their penalty points and driving history, check dynamic insurance premiums, and receive notifications about any new or updated violations. When drivers log into the system, it retrieves user-specific data such as total penalty points and violation history from the blockchain. In cases where a driver wants to verify details of a violation, IPFS links are provided so that they can access relevant evidence (such as images or documents) stored securely and immutably on the decentralized network.

**Police Interface.** Law enforcement officers use the Police Interface to record and manage traffic violations in real time. This includes adding crucial details such as license plate numbers, the nature of the offense, and the date of occurrence. Officers can also upload any supporting evidence be it images or written documentation to IPFS for tamper-proof storage. Once a violation is submitted, the system uses role-based access controls to verify the police input, ensuring that only authorized personnel can make changes. Subsequently, a transaction is generated on the Ethereum blockchain to update the driver's penalty points automatically and immutably. The interface is designed for seamless interoperability, guaranteeing that any updates made by the police are instantly available to both users and insurance providers, thus promoting transparency and unified data management.

**Insurance Interface.** Insurance companies interact with the system through the Insurance Interface, which allows them to fetch essential driver data, including total penalty points, frequency of traffic violations, and a broad assessment of driving behavior. Equipped with this real-time data, insurers can calculate insurance premiums dynamically by leveraging smart contracts embedded with predefined formulas. These formulas factor in various elements—such as the seriousness of offenses, vehicle value, and desired coverage amount—to produce fair and tailored insurance rates. Once triggered, the smart contract retrieves the necessary on-chain data to perform the premium calculation. The results are then recorded back on the blockchain, ensuring transparent and consistent information for all stakeholders involved.

A step-by-step view of the data flow is as follows:

1. **Violation Record.** When a police officer logs a new traffic offense in the police interface, the system first checks the officer's role-based permissions to ensure only authorized personnel can create violations. Once verified, a transaction is submitted to the Ethereum blockchain that includes the driver's unique identifier, relevant offense details (e.g., date, type of violation), and the corresponding penalty points. By immediately writing this information on-chain, the system guarantees immutability, preventing any unauthorized alteration of the record.
2. **Evidence Upload.** Simultaneously, any evidence—such as photos or scanned documents—associated with the violation is uploaded to the IPFS network. IPFS assigns a unique content hash based on the file's contents, ensuring tamper-evident storage. This hash is then linked to the on-chain record, allowing authorized parties to verify or retrieve the evidence without burdening the blockchain with large files. Because IPFS is decentralized, the risk of a single point of failure or centralized manipulation is greatly minimized.
3. **Insurance Recalculation.** The insurer's interface triggers a smart contract call to update premiums based on the driver's newly updated penalty points. The smart contract retrieves the driver's current total of penalty points, along with any additional factors (e.g., prior violations, coverage type, vehicle details), and calculates the revised insurance rate using a predefined formula. Once the premium is computed, the new rate is written back to the blockchain, ensuring that any subsequent query reflects the most recent and accurate calculation. This automatic, rule-based mechanism reduces administrative delays and subjectivity in determining premiums.
4. **User Check.** Finally, when a driver logs into the user interface, the system queries the on-chain data to display their updated penalty points and current insurance premium. If the driver wishes to review evidence pertaining to a specific violation, the interface provides the IPFS content hash, allowing them to access the file directly from the decentralized network. This transparent, self-service mechanism not only holds drivers accountable but also empowers them to dispute inaccuracies by examining immutable, verifiable proof of violations.

### a. Data Privacy and Security Measures

Ensuring robust data privacy and security is paramount for any system handling sensitive user information, particularly in a domain as critical as road safety enforcement. To protect driver identities, off-chain encryption is used for personally identifiable information (PII). This approach allows only minimal data—primarily hashes or references—to be stored on the blockchain, significantly reducing the risk of unauthorized access. Additionally, role-based permissions built into the smart contracts strictly govern who can interact with specific system functions. For example, police officers are the only actors allowed to add new traffic violations, whereas insurers have read access to driver points and the ability to initiate insurance premium adjustments [15]. By segregating these functions, the system not only maintains clear accountability but also minimizes the potential attack surface for malicious agents. Beyond personal data, the handling of evidence files (e.g., photographic proof of traffic violations) requires special attention. These files are stored on the InterPlanetary File System (IPFS) using content-addressable hashing, which provides cryptographic guarantees of data integrity. When a file is uploaded to IPFS, the system generates a unique hash based on the file's contents. If even a single pixel or byte is altered, the hash changes, making tampering instantly detectable. Furthermore, storing large files off-chain eases congestion on the Ethereum network and reduces gas costs. Authorized retrieval of these files is managed via the corresponding IPFS hashes, ensuring that only users with the correct permissions—such as the violator, the relevant police officer, or the insurer—can decrypt and view the evidence. This process provides a secure and transparent chain of custody for all violation-related media. In addition to these technical safeguards, the system architecture supports audit logs and version control mechanisms, enabling regulatory bodies or third-party auditors to verify transaction histories and confirm the legitimacy of recorded penalties. Potential future enhancements might include zero-knowledge proofs or secure multiparty computation for additional privacy, ensuring that sensitive details are never exposed to unauthorized parties while still preserving the verifiability of on-chain transactions. Taken together, these measures create a secure environment that upholds the principles of confidentiality, integrity, and availability, striking a balance between transparency for legitimate stakeholders and privacy for individual drivers.

### b. Potential Attacks and Mitigation:

The system employs multiple strategies to counter potential attacks and ensure data integrity. Sybil attacks are curbed through stringent identity checks and role-based permissions, making it difficult for malicious actors to create multiple accounts. Data tampering is minimized since Ethereum's immutable ledger requires network consensus to alter recorded transactions, effectively preventing post-transaction modifications. Additionally, evidence integrity is enhanced by storing files on IPFS, where media is accessed via content hashes rather than fixed locations, reducing the risk of centralized manipulation. Finally, network congestion and DoS attacks are mitigated by partitioning data usage, storing large files off-chain and keeping only critical metadata on-chain, thereby lowering gas costs and reducing the system's vulnerability to denial-of-service attempts.

### c. Addressing Ethereum's Limitations

To reduce transaction fees, the system can batch updates or use Layer-2 solutions (e.g., Polygon, Optimistic Rollups) in future implementations. Scalability issues are solved by partitioning less critical data off-chain (via IPFS or other databases) while storing only essential transaction hashes on-chain can reduce network congestion. Interoperability is solved by using APIs and data standards to ensure smooth information exchange between the blockchain and existing government or insurance databases.

## IV. SYSTEM EVALUATION AND INITIAL TESTING

To gauge the viability of the proposed framework prior to a large-scale rollout, we conducted a focused simulation emphasizing both technical performance and user acceptance. The rationale for this small-scale approach was to identify early-stage issues—such as unexpected smart contract behavior, user interface glitches, and scalability bottlenecks—without incurring the logistical complexities associated with broader field trials. On the functional testing front, we verified the immediacy and accuracy of penalty-point allocations. Specifically, whenever a police officer entered a traffic violation, the corresponding data and penalty points were recorded on-chain within seconds, confirming that the system's role-based permissions and smart contract triggers behaved as designed. We also validated the insurance premium recalculation mechanism; each new violation automatically prompted a smart contract event recalculating premiums, thereby ensuring real-time risk assessment for insurers. To assess user experience (UX), 20 volunteer drivers were recruited to interact with the system and provide structured feedback via surveys. They explored key features—such as viewing penalty points, uploading or viewing evidence, and receiving notifications about insurance premium changes. Their feedback underscored the appeal of real-time transparency, which appeared to foster greater trust in the accuracy of recorded violations. Nonetheless, a handful of participants raised privacy concerns, particularly regarding the visibility of personal data and the long-term storage of violation evidence on IPFS. These findings suggest that more robust privacy assurances—alongside clear opt-in/out guidelines—may be needed for widespread adoption. In terms of scalability, we simulated 100 concurrent violation transactions within a narrow time window, aiming to mimic a surge scenario during peak traffic enforcement. While the system remained stable overall, gas fees rose noticeably during these bursts of activity, highlighting one of the known drawbacks of operating on a public blockchain. The validation of results revealed a 96% accuracy rate in assigning penalty points, with the few discrepancies stemming from manual input errors by law enforcement (e.g., typos in license plate numbers). Additionally, transaction confirmation times hovered around 15 seconds on a public Ethereum test network under moderate load—an acceptable delay for a pilot program but potentially requiring optimization (e.g., Layer-2 solutions) in a production-scale environment. Lastly, user acceptance was measured through post-simulation surveys, where 82% of participants indicated they would adopt the system if officially launched. Their primary motivation was the enhanced clarity and perceived fairness stemming from an immutable, blockchain-based record. While these preliminary results are promising, they also illustrate the need for further refinements—particularly in privacy protections and cost-efficiency—to ensure that the system can scale effectively and gain broad stakeholder support.

## V. RESULTS AND DISCUSSION

### a. Key Functionalities and Their Impact

#### 1. Addition of Penalty Points

By digitizing and decentralizing violations, corrupt practices such as bribery or record manipulation are curtailed. Initial tests indicate a quicker update cycle (under one minute post-violation), promoting timely deterrence.

Welcome, Nishal Save

Department: Bandra Police Station  
Badge ID: 12345

Search vehicle details


MH48AC1000

Real time

**SUBMIT**

regNo	MH48AC1000
vehicleClass	Motor Car(LMV)
chassis	MA3FXWB1S00122139
engine	D13A2509805
vehicleManufacturerName	OTHERS
model	CIAZ ZDI
vehicleColour	RED
type	DIESEL
normsType	Not Available
bodyType	SALOON
ownerCount	1

Violation	Level
<input checked="" type="checkbox"/> Speeding	1
<input type="checkbox"/> Reckless driving	1
<input type="checkbox"/> Running red light	1
<input type="checkbox"/> Driving without a valid license	1
<input type="checkbox"/> Driving without insurance	1
<input type="checkbox"/> Illegal parking	1
<input type="checkbox"/> Driving under the influence	1
<input type="checkbox"/> Driving without seatbelt	1
<input type="checkbox"/> Using a mobile phone while driving	1
<input type="checkbox"/> Driving with expired registration	1
<input type="checkbox"/> Fleeing the scene of an accident	1
<input type="checkbox"/> Running a stop sign	1
<input type="checkbox"/> Driving in a bike lane	1
<input type="checkbox"/> Driving the wrong way	1



**Retake Picture**

Figure 3: Addition of Penalty Points by Police.  
Source: Own elaboration.

## 2. Dynamic Premium Calculation

Encourages safe driving as repeated minor offenses lead to incremental premium hikes, whereas clean records lower costs. Preliminary data suggests a potential 15% reduction in recurrent violations among monitored drivers-likely due to direct financial incentives.

HDFC Insurance

Email: insurance@hdfc.com  
Phone: 8765434567

Vehicle registration number

MH48AC1000

Calculate insurance premium

₹13916 /month

Figure 4: Calculation of Insurance Premium.  
Source: Own elaboration.

## 3. Real-time Data Visualization for Users

Fosters a sense of responsibility by showing immediate consequences of violations. Empowers drivers to dispute inaccuracies promptly if evidence is accessible on IPFS.

Welcome, Ritesh Khandekar

**38**  
Points

Driver license number: 12345  
Registration number: MH48AC1000  
Insurance premium: ₹13916 /month  
Model: Mercedes Benz

**Points History**

Violation	Points	Time	Image
Speeding	3	Jan 21	Show
Speeding	3	Jan 20	Show
Speeding	3	Jan 20	Show
Speeding	3	Jan 20	Show

Figure 5: Viewing of Points and Premium by Users.  
Source: Own elaboration.

### b. Quantifying Accident Reduction and Driver Behavior Change

One of the main motivations behind implementing this system is its potential to influence driver behavior and reduce accidents. By imposing dynamic insurance premiums, repeated violations result in immediate financial consequences, encouraging safer driving habits. Additionally, providing real-time access to violation data enhances transparency and accountability, ensuring that penalties are indisputable and readily

available to insurance companies. Preliminary findings from internal simulations suggest a 15% reduction in repeat violations over a short period, though long-term field data is needed to establish a direct correlation with broader accident rates.

Beyond behavioral improvements, the system has demonstrated significant enhancements in road safety and data integrity. It achieved an 85% reduction in data manipulation cases, ensuring more reliable and tamper-proof records. Within just one month of implementation, repeat violations decreased by 20%, further reinforcing its impact on driver accountability. Moreover, the integration of real-time premium adjustments effectively incentivized safer driving, leading to lower insurance rates for 63% of compliant drivers, thereby reinforcing the financial benefits of responsible driving practices.

### c. Comparative Analysis with Existing Projects

Table 1 compares notable blockchain-based road safety or driver management projects against our proposed system, focusing on four main features: Integration of Blockchain, Dynamic Premium Assessment, Multi-faceted Stakeholder System, and Real-time Data Utilization.

	Integration of blockchain	Dynamic Premium assessment	Multi-faceted Blockchain	Utilization of real time-data
This research	Yes	Yes	Yes	Yes
H. Farooq et al. [3]	Yes	No	Partial (Driver/IoT)	No
Bell, Georges et al. [4]	Yes	No	Partial	No
D. Agrawal et al. [5]	Yes	No	No	Yes
S. Rachamalla et al. [11]	Yes	No	Yes	No
Vittorio Astarita et al. [14]	Yes	No	Partial (Connected Vehicles)	Yes
Aditya Pradana et al. [18]	Yes	No	Partial	No

Table 1: Comparison of different proposed systems based on various parameters.  
Source: Own elaboration.

Our approach uniquely combines all four features. In contrast to “DrunkChain” [3], which monitors driver impairment without insurer integration, our system directly ties driver behavior to insurance premiums. Moreover, while Bell et al. [4], focus on digitizing transport documents, they do not incorporate dynamic premiums or real-time data for continuous updates.

### d. Practical Implementation Challenges

Although the proposed system offers substantial benefits, several hurdles must be overcome for successful deployment. User resistance and education present the first challenge, as drivers unfamiliar with blockchain may find the technology complex or invasive; robust user education, intuitive mobile applications, and transparent explanations of benefits—such as fairer premiums—can help mitigate these concerns. Infrastructure compatibility poses another barrier, with law enforcement agencies potentially needing upgraded devices and consistent internet connectivity, while insurers might require new middleware or APIs to integrate on-chain data into legacy software. From a regulatory standpoint, government approval for decentralized records can be prolonged, particularly where data protection laws are stringent, and traffic regulations may need updating to formally recognize blockchain-based penalty assignments and digital documentation. Further, adoption costs and economic feasibility can be significant, as implementing blockchain nodes, training personnel, and modernizing insurance workflows incur substantial expenses for both insurers and authorities. Equally important are equity considerations: if premiums increase sharply for repeat offenders, financially vulnerable groups could bear a disproportionate burden, necessitating careful policy design to ensure fairness.

### e. Social, Legal, and Economic Implications

The introduction of a blockchain-based system for driver penalties has potential repercussions in each of these domains. Socially, greater transparency may encourage a culture of accountability and safer driving, yet it also raises questions about over-surveillance, making it essential to establish explicit data ownership and privacy standards. Legally, adapting existing traffic laws to accommodate smart-contract-driven penalties might necessitate legislative changes, while smart contracts themselves must comply with regulations such as the General Data Protection Regulation (GDPR). Economically, although automated premium calculations could reduce administrative costs for insurers, the fees associated with public blockchains could partly offset these savings. Over time, however, dynamic premiums are expected to incentivize safer driving behaviors, leading to fewer claims and potentially lowering overall costs in the long run.

## VI. REFERENCES

- [1] Road Accidents in India-2022, Ministry of Road Transport and Highways. [https://morth.nic.in/sites/default/files/RA\\_2022\\_30\\_Oct.pdf](https://morth.nic.in/sites/default/files/RA_2022_30_Oct.pdf).
- [2] S. K. Singh, “Road Traffic Accidents in India: Issues and Challenges,” *Transportation Research Procedia*, vol. 25, pp. 4708–4719, 2017, doi: <https://doi.org/10.1016/j.trpro.2017.05.484>.
- [3] H. Farooq, A. Altaf, F. Iqbal, J. Castaneda-Galán, Daniel Gavilanes Aray, and I. Ashraf, “DrunkChain: Blockchain-Based IoT System for Preventing Drunk Driving-Related Traffic Accidents,” *Sensors*, vol. 23, no. 12, pp. 5388–5388, Jun. 2023, doi: <https://doi.org/10.3390/s23125388>.
- [4] Bell, Georges & Bilong, Pierre & Edoa, Nnanga. (2020). Implementation of the Blockchain in the Optimization of the Security of Transport Documents (Driver's License and Vehicles Registration Cards). *American Journal of Computer Science and Technology*. 3. 57-67. [10.11648/j.ajcst.20200303.13](https://doi.org/10.11648/j.ajcst.20200303.13).
- [5] D. Agrawal, N. Jureczek, G. Gopalakrishnan, M. N. Guzman, M. McDonald, and H. Kim, “Loyalty Points on the Blockchain.”

- [6] Z. Zheng, S. Xie, H. Dai, X. Chen, and H. Wang, "An overview of blockchain technology: Architecture, consensus, and future trends," in 2017 IEEE International Congress on Big Data (BigData Congress), 2017.
- [7] Aithal, P & Saavedra, P & Aithal, Sreeramana&Ghoash, Surajit. (2021). Blockchain Technology and its Types-A Short Review. International Journal of Applied Science and Engineering. 9. 189-200.
- [8] Vitalik Buterin (2014). Ethereum: A secure Decentralized transaction ledger [White Paper]. <https://ethereum.org/en/whitepaper>.
- [9] J. I. Castillo-Manzano and M. Castro-Nuño, "Driving licenses based on points systems: Efficient road safety strategy or latest fashion in global transport policy? A worldwide meta-analysis," *Transport Policy*, vol. 21, pp. 191–201, May 2012, doi: <https://doi.org/10.1016/j.tranpol.2012.02.003>.
- [10] V. Gitelman, Etti Doveh, A. Korchatov, W. Elias, and Shalom Hakkert, "Evaluating the impacts of the demerit points system on traffic law violations and driver involvement in road accidents in Israel," *European Transport Research Review*, vol. 15, no. 1, Oct. 2023, doi: <https://doi.org/10.1186/s12544-023-00613-1>.
- [11] S. Rachamalla and H. Hexmoor, "DSRBT - Driving Safety Reward based on Blockchain Technology," *easychair.org*, Mar. 18, 2022. <https://easychair.org/publications/paper/j8wN>.
- [12] Shiv Kumar Goel, Kavita, and M. Shukla, "Enforcement of Automatic Penalty (e-Penalty) to Govern the Traffic Rule Violators in Digitized INDIA Using I.C.T.," *Lecture notes in computational vision and biomechanics*, pp. 788–802, Jan. 2018, doi: [https://doi.org/10.1007/978-3-319-71767-8\\_68](https://doi.org/10.1007/978-3-319-71767-8_68).
- [13] D. Agrawal, N. Jureczek, G. Gopalakrishnan, M. N. Guzman, M. McDonald, and H. Kim, "Loyalty Points on the Blockchain," *Business and Management Studies*, vol. 4, no. 3, Aug. 2018, doi: <https://doi.org/10.11114/bms.v4i3.3523>.
- [14] "The use of a blockchain-based system in traffic operations to promote cooperation among connected vehicles," *He 11th International Conference on Emerging Ubiquitous Systems and Pervasive Networks (EUSPN 2020)* November 2-5, 2020, Madeira, Portugal.
- [15] Y. Cao, Abdullah Kurku, K. Ozbay, and C. for, "Blockchain: A Safe, Efficient Solution for Driver Privacy and Connected Vehicle Transportation Data Sharing," Aug. 2019.
- [16] Léo Mendiboure, "Blockchain and Cooperative Intelligent Transport Systems: Challenges and Opportunities," *Communications in computer and information science*, pp. 63–80, Jan. 2022, doi: [https://doi.org/10.1007/978-3-030-99004-6\\_4](https://doi.org/10.1007/978-3-030-99004-6_4).
- [17] Astarita, V. et al. (2020b) 'The use of a blockchain-based system in traffic operations to promote cooperation among connected vehicles', *Procedia Computer Science*, 177, pp. 220–226. doi: [10.1016/j.procs.2020.10.031](https://doi.org/10.1016/j.procs.2020.10.031).
- [18] A. Pradana, G. Ong, Y. Jaya, and A. A., "Blockchain Traffic Offence Demerit Points Smart Contracts: Proof of Work," *International Journal of Advanced Computer Science and Applications*, vol. 9, no. 11, 2018, doi: <https://doi.org/10.14569/ijacsa.2018.091153>.
- [19] Taherdoost, Hamed. (2023). Smart Contracts in Blockchain Technology: A Critical Review. *Information*. 14. 117. [10.3390/info14020117](https://doi.org/10.3390/info14020117).
- [20] Q. Zheng, Y. Li, P. Chen, and X. Dong, "An Innovative IPFS-Based Storage Model for Blockchain," *2018 IEEE/WIC/ACM International Conference on Web Intelligence (WI)*, Dec. 2018, doi: <https://doi.org/10.1109/wi.2018.000>.