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Intelligent Blockchain-Based IoT Framework for Sustainable and Secure Transportation

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Abstract- ***The growth of smart cities has made transportation more connected than ever. Vehicles, traffic signals, and road sensors constantly exchange information to improve mobility. But this increased connectivity also brings challenges such as security risks, data tampering, privacy issues, and high energy usage. This paper proposes a simple, practical, and intelligent blockchain-based IoT framework that makes transportation systems more secure, transparent, and environmentally friendly. The framework combines IoT devices, edge-level data processing, and blockchain security to ensure that transportation data is reliable, tamper-proof, and used responsibly. It also supports sustainable mobility through energy-efficient routing and smart traffic management***

I. INTRODUCTION

Transportation systems today depend heavily on IoT devices — GPS units in vehicles, pollution sensors on roads, smart traffic lights, and more. These connected systems help reduce congestion, improve safety, and support city-level planning.

However, because most smart transportation systems are still built on centralized servers, they face problems such as:

- Data security risks
- Slow response times
- Privacy leakage
- High network load
- No built-in transparency

Blockchain technology naturally solves many of these issues because it provides decentralized trust, transparency, and immutability. When combined with IoT and edge computing, blockchain can create transportation systems that are not only secure and reliable but also more sustainable and energy-efficient.

This human-centered research paper presents an Intelligent Blockchain-Based IoT Framework for Sustainable and Secure Transportation (IBIoT-SST). The aim is to show how a simple and practical system design can improve mobility and reduce environmental impact.

II. PROPOSED FRAMEWORK (IBIoT-SST)

Overall Architecture
The system is built on four logical layers that work together:

(a) IoT Sensing Layer

This layer includes all physical devices:

- Vehicles with onboard sensors
- GPS units
- Pollution and weather sensors
- Smart traffic lights
- Roadside cameras

These devices generate continuous real-time data about traffic flow, vehicle movement, and environmental conditions.

(b) Edge/Fog Intelligence Layer

Instead of sending all data to the cloud, some processing happens near the data source, at edge devices like roadside units (RSUs).
This layer performs:

- Quick traffic prediction
- Accident or anomaly detection
- Data filtering and compression

This reduces latency and network congestion and saves energy.

(c) Blockchain Security Layer

A permissioned blockchain ensures:

- Secure and verified identities for vehicles
- Immutable logs of events (accidents, signals, congestion)

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- Automatic enforcement of rules through smart contracts

Consensus algorithms like PBFT are used because they are fast, energy-efficient, and suitable for IoT nodes.

(d) Application Layer

The final layer provides useful services such as:

- Eco-friendly route suggestions
- Real-time congestion updates
- Secure vehicle-to-vehicle and vehicle-to-infrastructure communication
- Traffic management dashboards for authorities

III. KEY FEATURES OF THE PROPOSED FRAMEWORK

3.1 Smart Contracts

Smart contracts help automate:

- Vehicle authentication
- Access control for sensitive data
- Toll collection
- Reward programs for eco-driving
- Automatic traffic rule violation logging

This reduces the need for human intervention and ensures fairness.

3.2 Edge-Based Intelligence

Lightweight AI models running on RSUs allow:

- Instant response to road incidents
- Better traffic timing decisions
- Local decision-making without waiting for cloud results

3.3 Sustainability Focus

A major strength of the framework is its focus on sustainability, achieved through:

- Green routing suggestions
- Energy-efficient data usage
- Reduced network traffic
- Emission monitoring

The system encourages drivers to follow eco-friendly routes and habits.

IV. BENEFITS OF THE FRAMEWORK

The proposed system offers several practical advantages:

- High Security: Blockchain ensures trustworthy data.
- Faster Decision-Making: Edge computing reduces delays.
- Eco-Friendly Mobility: Sustainable routing reduces fuel usage.

V. CHALLENGES

Although promising, a few challenges remain:

- High initial cost of deploying RSUs and blockchain nodes
- Need for government and industry cooperation
- IoT devices still have limited processing power
- Blockchain scalability must be carefully managed

VI. CONCLUSION

This paper presents a practical and human-centric view of an Intelligent Blockchain-Based IoT Framework for Sustainable and Secure Transportation. By integrating blockchain security, IoT sensing, and edge-level intelligence, the proposed system ensures safer mobility, reduces environmental impact, and supports the goals of smart cities.

The framework is not only technically strong but also realistic enough to be implemented in modern urban environments.