TRACKING PUBLIC INFRASTRUCTURE AND TOLL PAYMENT USING BLOCKCHAIN

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1. INTRODUCTION:

1.1 Project Overview

The project aims to leverage blockchain technology to enhance the tracking and management of public infrastructure, specifically toll roads, bridges, and highways. By implementing a blockchain-based solution, the project intends to increase transparency, security, and efficiency in toll payment systems while also ensuring the integrity of infrastructure data.

1.2 Purpose

The purpose of a project that involves tracking public infrastructure and toll payments using blockchain technology can have several benefits:

1. Transparency: Blockchain provides a transparent and immutable ledger, making it easier to track and verify infrastructure development and maintenance activities, ensuring that funds are used as intended.

2. Security: Blockchain's encryption and decentralized nature can enhance the security of toll payment transactions, reducing fraud and unauthorized access.

3. Efficiency: Smart contracts on the blockchain can automate toll collection processes, reducing administrative overhead and potentially lowering costs.

4. Accountability: Stakeholders can have a clear record of who is responsible for infrastructure projects and their progress, promoting accountability.

5. Trust: Blockchain can help build trust among stakeholders, as all transactions and data are tamper-proof and auditable.

6. User Convenience: Toll payment processes can be made more convenient for users through mobile apps and digital wallets integrated with blockchain technology.

Overall, the purpose is to improve transparency, security, efficiency, and trust in the management of public infrastructure and toll payment systems.

2. LITERATURE SURVEY

2.1 Exissting Problem

An exciting problem statement for a project on tracking public infrastructure and toll payments using blockchain could be:

“How can blockchain technology revolutionize the transparency, efficiency, and security of public infrastructure development and toll collection systems, while overcoming scalability challenges, ensuring data privacy, and fostering user adoption to create a more sustainable and accountable future for transportation infrastructure”

2.2 Reference

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2.3 Problem Statement Definition

Traditional infrastructure tracking and toll payment systems suffer from issues such as fraud, lack of transparency, and inefficiency. Users often face delays and discrepancies in toll payments, while authorities struggle to maintain accurate records of infrastructure maintenance and usage.

3. IDEATION & PROPOSED SOLUTION

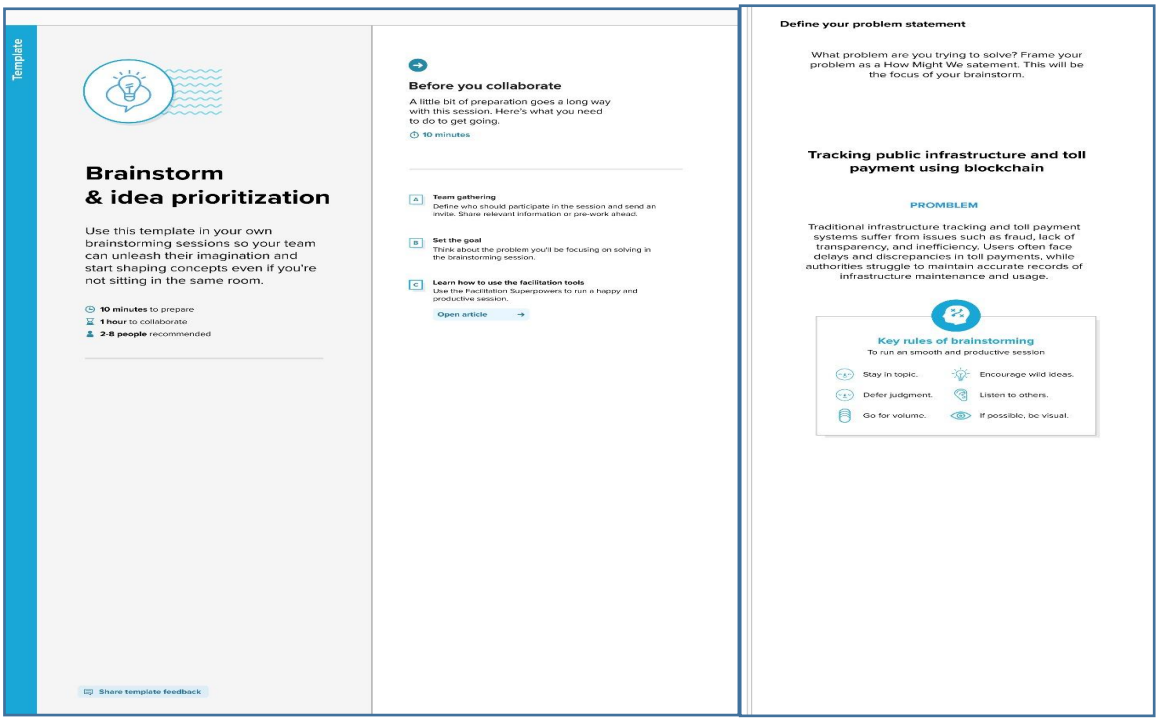
3.1 Empathy Map Canvas

Empathy Map

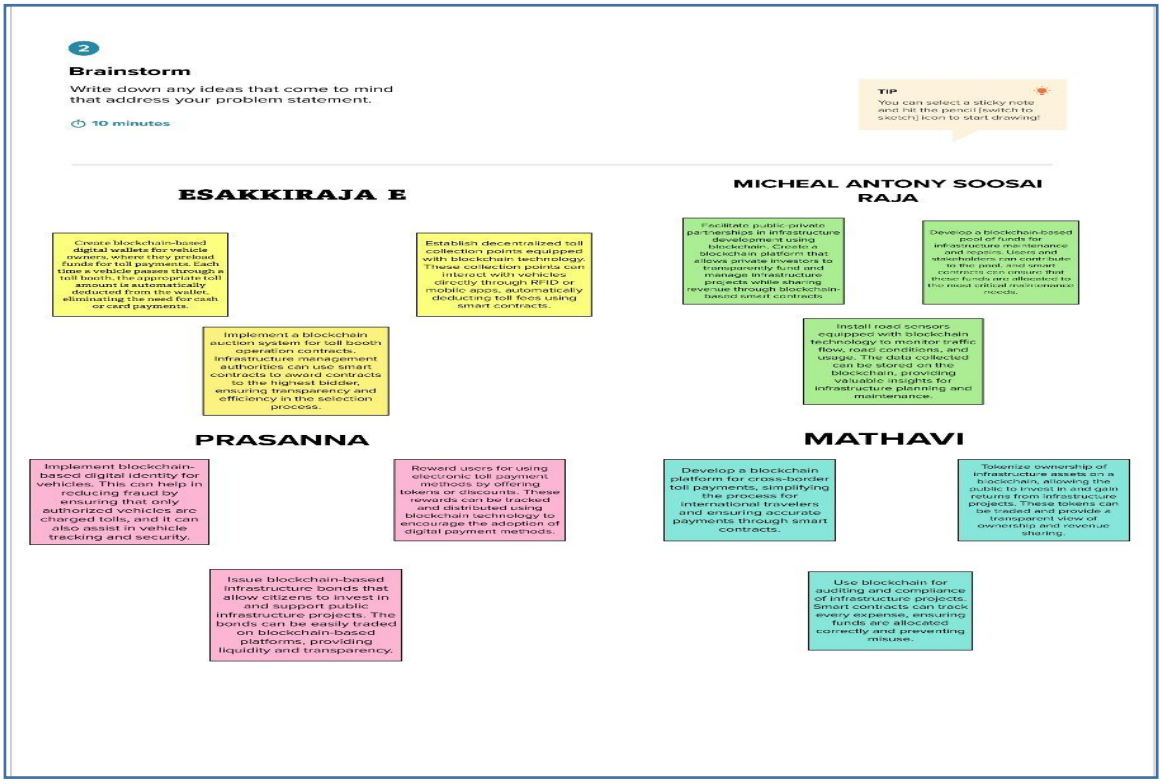

Did all members are came
That was easy
I hope my voting data is accurate
Did i missed something
But I like that work
We need vote list
how can we do this work?
It is safe and secure?
Says
Thinks
Tracking public infrastructure and toll payment using blockchain
Does
Feels
Review thier Voting system
More research
Records will remember
They may feel reassured
Keep calm and do
Make Butget
Accuracy
I Worry about the security
Pain
Lack of access
Difficulty in understanding
Fear of Medical errors
Technical issues
Gain
Efficient workflow
Enhanced Patient care
Security
Trust

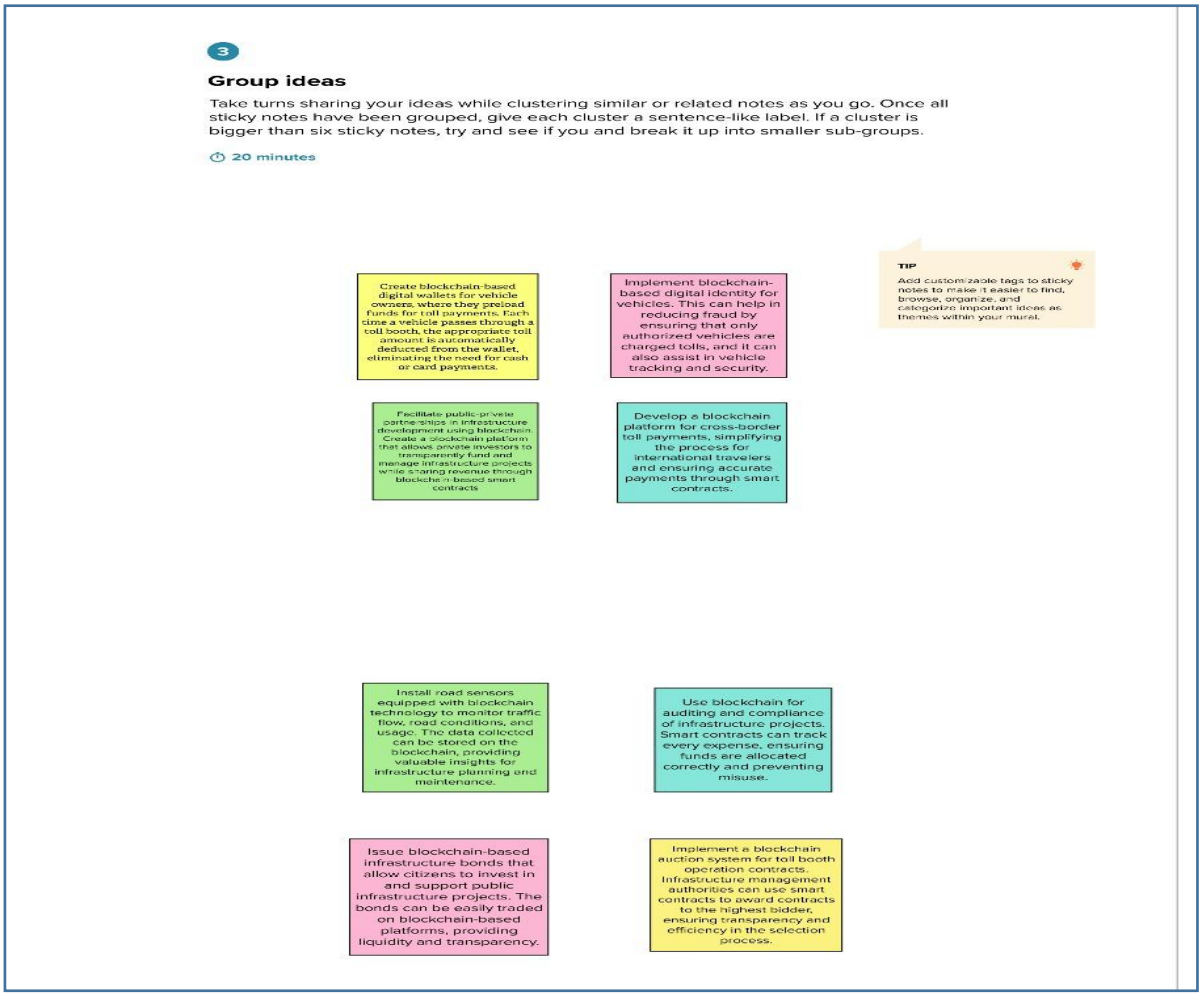
3.2 Ideation & Brainstorming

Step-1: Team Gathering, Collaboration and Select The Problem Statement

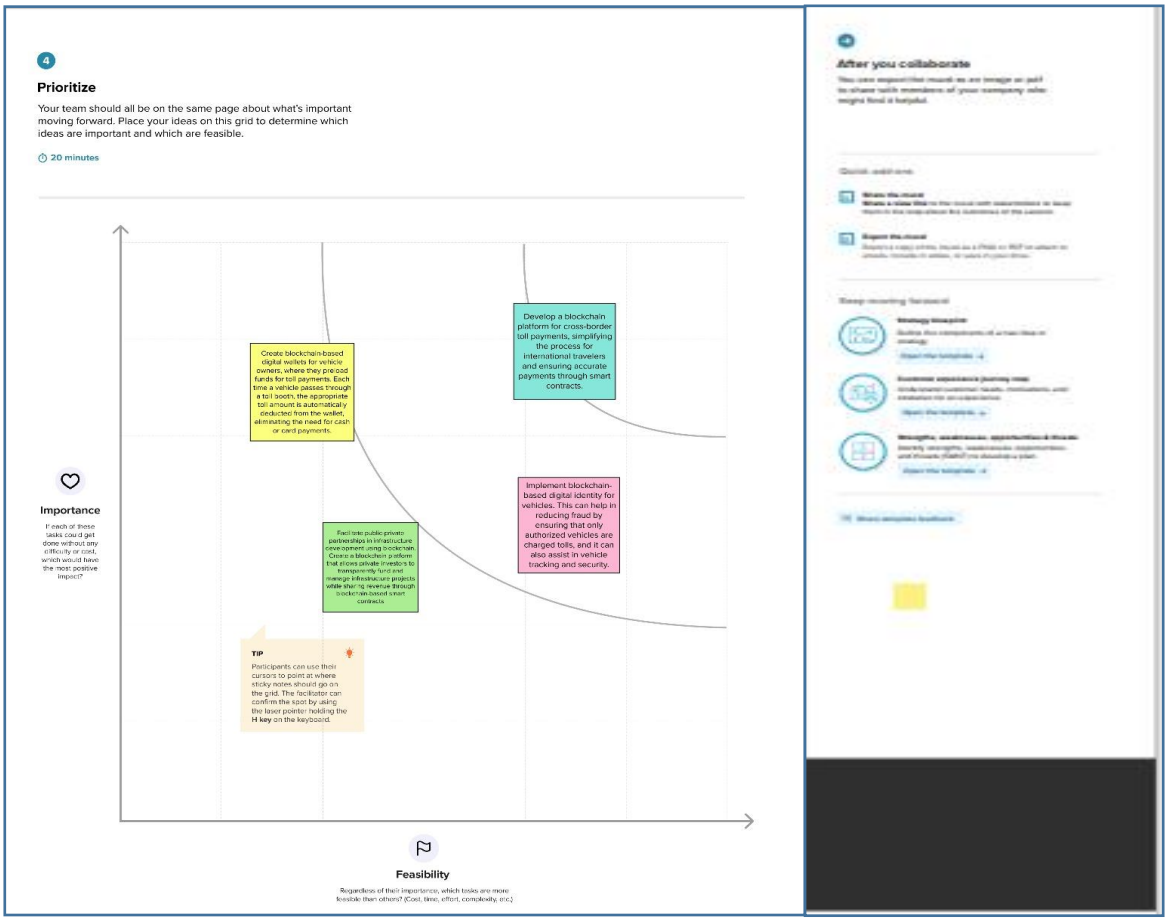


Step-2: Brainstorm, Idea Listing And Grouping





Step-3: Idea Prioritization



4. REQUIREMENT ANALYSIS

4.1 Functional Requirement

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Identity Management	Users should be able to create and manage their digital identities securely on the blockchain to participate in toll payment and access public infrastructure.
FR-2	Transaction Recording	The blockchain should record all toll transactions, including details such as date, time, location, and the amount paid.
FR-3	Smart Contracts	Implement smart contracts to automate toll collection and management. These contracts can execute predefined rules and conditions for toll payments and infrastructure access.
FR-4	Access Control	Ensure that the blockchain system has robust access control mechanisms to manage who can access and modify the data on the blockchain.
FR-5	Interoperability	The blockchain system should be able to interact with existing infrastructure and payment systems, such as RFID toll collection, mobile apps, and payment gateways.
FR-6	Privacy and Security	Implement encryption and security features to protect user data and transaction information. Privacy is essential in a public infrastructure system.

4.2 Non-Functional Requirement

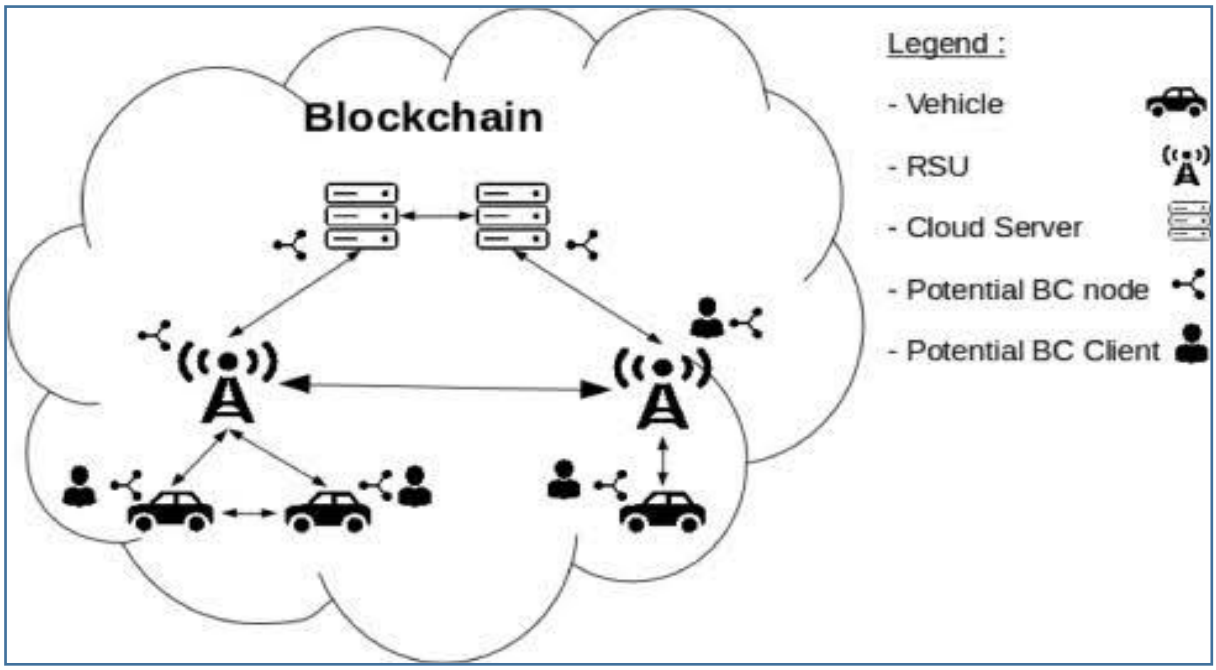
Following are the non-functional requirements of the proposed solution

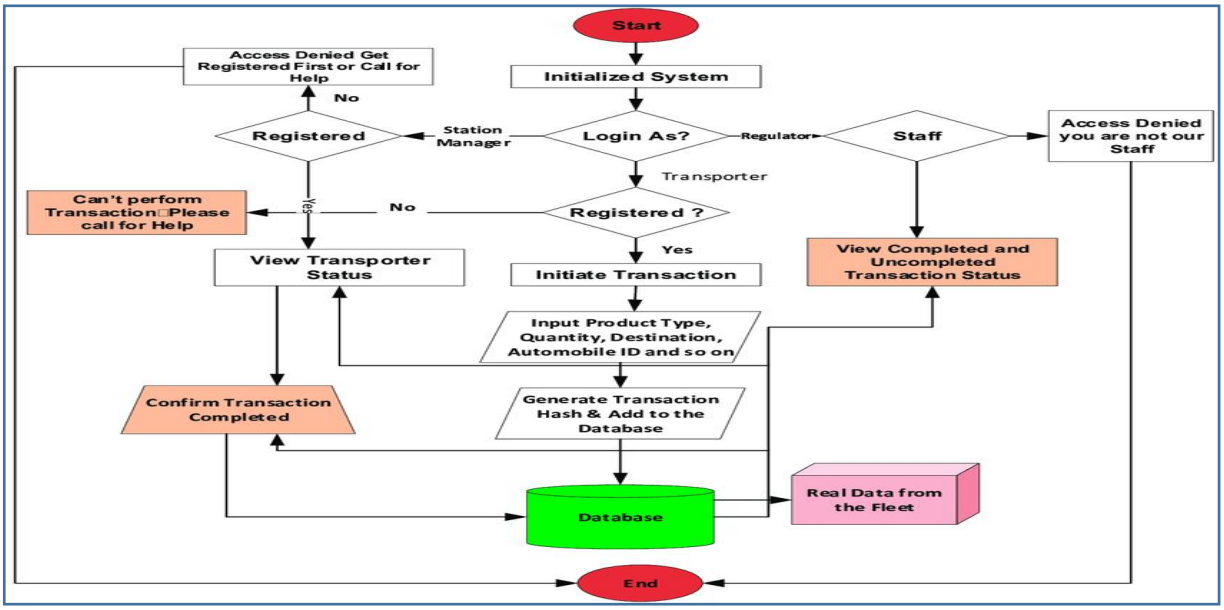
FR No.	Non-Functional Requirement	Description
NFR-1	Performance	Response Time: Define acceptable response times for transactions, ensuring that toll payments are processed swiftly. Scalability: The system should be able to handle increased user traffic without compromising performance.
NFR-2	Reliability	Availability: Specify the system's uptime requirements to ensure that it is accessible to users at all times. Fault Tolerance: Define how the system will handle hardware or software failures without data loss or service interruptions
NFR-3	Security	Data Encryption: Ensure data in transit and at rest is encrypted to protect user information and transaction data. Access Control: Specify strict access control mechanisms to prevent unauthorized access to sensitive data.
NFR-4	Usability	User Experience: Design a user-friendly interface that is easy to navigate and understand, promoting user adoption. Accessibility: Ensure that the system is accessible to users with disabilities.
NFR-5	Maintainability	Upgradability: Define how the system will handle updates and new features without major disruptions. Code Maintainability: Ensure that

		the codebase is well-documented and follows best practices for easier maintenance.
NFR-6	Scalability	Horizontal and Vertical Scalability: Define how the system can scale horizontally (adding more servers) and vertically (increasing the capacity of existing servers) as needed.

5. PROJECT DESIGN

5.1 Data Flow Diagram & User & Solution Aechitecture





6.PROJECT PLANNING & SCHEDULING

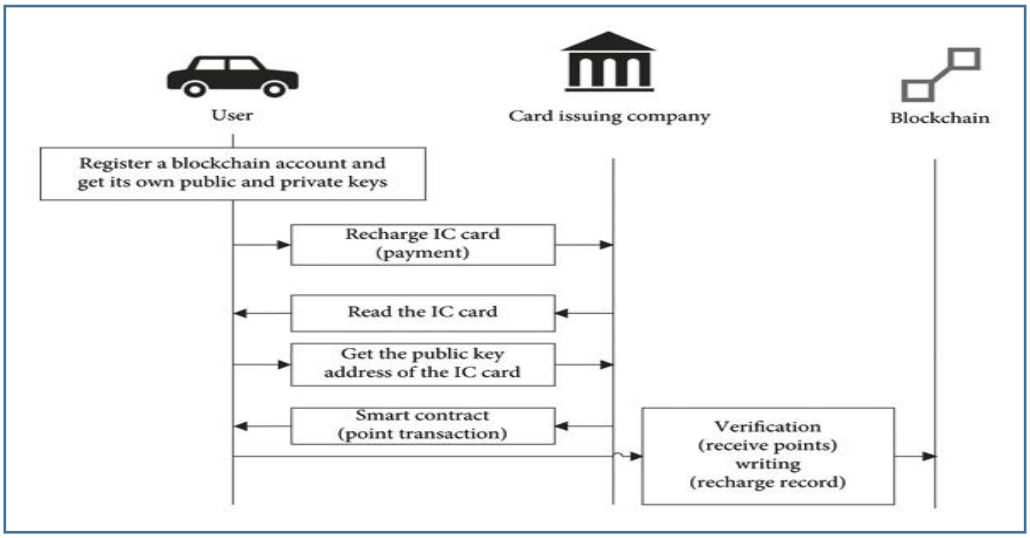
6.1 Technical Architecture

Blockchain Network:

Utilize a permissioned blockchain network for enhanced security and privacy.
Consider blockchain platforms like Hyperledger Fabric or Corda.

Smart Contracts:

Develop smart contracts to manage toll collection, asset tracking, and payment settlements.
Smart contracts automate toll calculations, payment verification, and infrastructure data updates.



6.2 Sprint Planning & Estimation

Sprint planning and estimation are crucial components of an Agile development methodology, and they can be applied to the project of

tracking public infrastructure and toll payment using blockchain. Sprint planning involves selecting a set of features or user stories to work on during a specific time frame (sprint), while estimation helps in determining the effort required for each task. Here's how you can plan sprints and estimate tasks for this project:

1. Define User Stories:

- Break down the project into user stories or features. For example:
  - User registration and wallet integration
  - Toll payment smart contract
  - Infrastructure management
  - User interface development
  - Notifications system
  - Testing and deployment

2. Prioritize User Stories:

   - Prioritize the user stories based on their importance and dependencies. What needs to be completed before other tasks can start?

3. Determine Sprint Duration:

   - Decide on the sprint duration, typically ranging from 2 to 4 weeks. Consider the complexity of your tasks and the team's capacity.

4. Estimate Tasks:

   - Use various estimation techniques like story points, time-based estimation, or relative estimation (e.g., using the Fibonacci sequence) to estimate the effort required for each user story. The development team should be involved in this process.

Remember that estimations are not always 100% accurate, and adjustments may be needed as you progress through the sprints. Agile methodologies allow for flexibility and adaptation, which is crucial when dealing with emerging technologies like blockchain.

5.2 Sprint Delivery Schedule

A sprint delivery schedule for developing a blockchain-based system for tracking public infrastructure and toll payment can be structured in multiple iterations. Each sprint typically spans two to four weeks, depending on your development team's capacity and project complexity. Here's a sample sprint delivery schedule:

Sprint 1 (Duration: 2 weeks) - Project Setup and Requirements Gathering

- Define project objectives and scope.
- Assemble the development team.
- Establish the blockchain network (e.g., Hyperledger Fabric).
- Gather initial requirements from stakeholders.
- Create a high-level project plan.
- Set up version control and project management tools.

Project Timeline: 12 sprints over the course of a year.

Sprint Duration: 2 weeks per sprint.

Sprint 1-2: Project Initiation (2 weeks)

7.CODING &SOLUTIONING (Explain the features added in the project along with code)

7.1 Feature 1

Code for User Registration (Smart Contract):

```solidity
// Solidity code for a User Registration smart contract
Pragma solidity ^0.8.0;

Contract UserRegistration {
   Struct User {
      Address walletAddress;
      String username;
      Bool isRegistered;
   }
```

```
    Mapping(address => User) public users;

    Event UserRegistered(address indexed userAddress, string username);

    Function registerUser(string memory _username) public {
        Require(!users[msg.sender].isRegistered, “User is already registered”);
        Require(bytes(_username).length > 0, “Username cannot be empty”);

        User storage newUser = users[msg.sender];
        newUser.walletAddress = msg.sender;
        newUser.username = _username;
        newUser.isRegistered = true;

        emit UserRegistered(msg.sender, _username);
    }
}
```

7.2 Feature 2

Code for Smart Contracts for Toll Payment (Solidity):

```solidity
// Solidity code for a Toll Payment smart contract
Pragma solidity ^0.8.0;

Contract TollPayment {
    Address public owner;
    Mapping(address => uint) public balances;

    Constructor() {
        Owner = msg.sender;
    }

    Function payToll() public payable {
        Require(msg.value > 0, “Payment must be greater than 0”);
        Balances[msg.sender] += msg.value;
```

```
    }

    Function checkBalance() public view returns (uint) {
        Return balances[msg.sender];
    }

    Function withdrawBalance() public {
        Require(msg.sender != owner, “Owner cannot withdraw funds”);
        Uint balance = balances[msg.sender];
        Balances[msg.sender] = 0;
        (bool success, ) = msg.sender.call{value: balance}(“”);
        Require(success, “Transfer failed”);
    }
}
```

8.PERFORMANCE TESTING

8.1 Performance Metrices

Measuring the performance of a system for tracking public infrastructure and toll payment using blockchain is crucial to ensure efficiency, scalability, and user satisfaction. Here are some performance metrics you can consider:

Transaction Throughput: Measure the number of toll transactions processed per second. A higher throughput indicates the system’s ability to handle a larger volume of transactions efficiently.

Latency: Track the time it takes for a transaction to be recorded on the blockchain and for users to receive confirmation. Low latency is critical for real-time transactions.

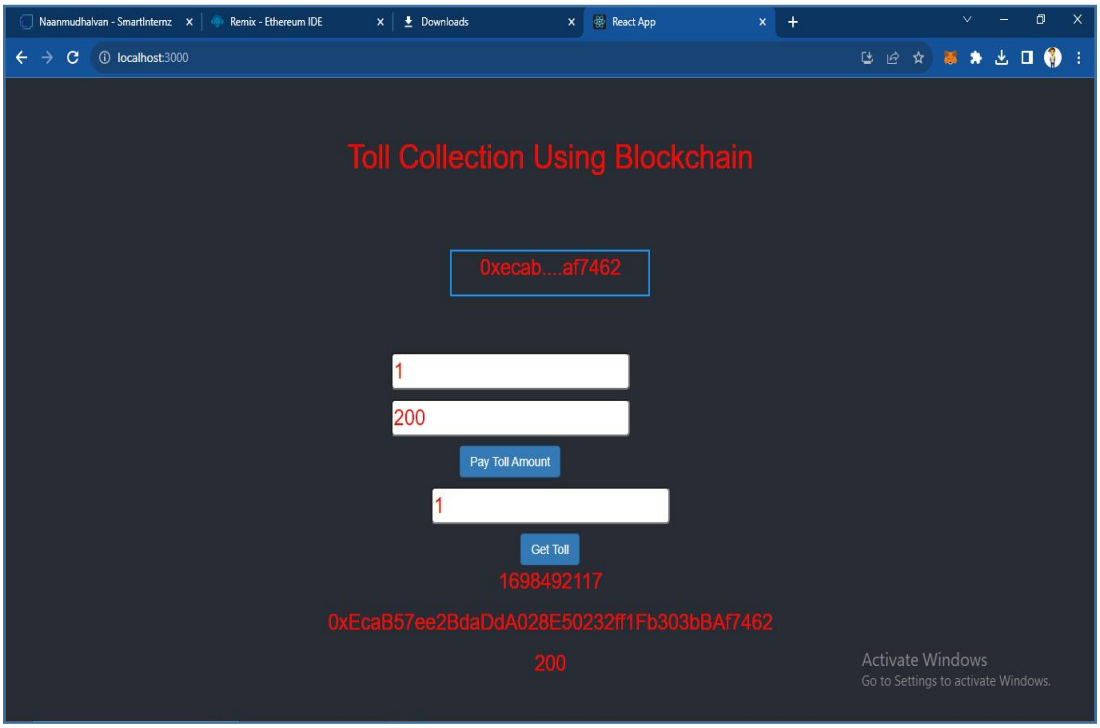
Confirmation Time: Monitor the time it takes for a toll payment transaction to be confirmed by the blockchain network. Faster confirmation times enhance user experience.

Scalability: Measure how well the system can scale to accommodate an increasing number of users and transactions without a significant decrease in performance.

Blockchain Gas Fees: Analyze the cost of gas fees (transaction fees) required for processing smart contracts on the blockchain. Lower fees are favorable for users.

9.RESULTS

9.1 Output Screenshots



10.ADVANTAGES & DISADVANTAGES

ADVANTAGES:

Tracking public infrastructure and toll payment using blockchain technology offers several advantages:

1. Transparency: Blockchain provides a transparent and immutable ledger, allowing stakeholders to track every transaction and development activity in real-time, reducing opportunities for corruption and fraud.

2. Security: The decentralized and cryptographic nature of blockchain enhances the security of transactions, making it difficult for unauthorized parties to manipulate or alter data.

3. Efficiency: Smart contracts on the blockchain can automate toll collection and payment processes, reducing administrative costs and the need for intermediaries, which can lead to quicker and more cost-effective transactions.

4. Accountability: Blockchain creates a clear and tamper-proof record of who is responsible for infrastructure projects and maintenance, improving accountability among various stakeholders.

5. Trust: With blockchain's immutable ledger, all parties involved can trust that the information is accurate and has not been tampered with, fostering confidence in the system.

DISADVANTAGES:

While there are several advantages to using blockchain for tracking public infrastructure and toll payments, there are also some disadvantages and challenges to consider:

1. Scalability: Blockchain networks may struggle to handle a high volume of transactions, especially in real-time systems like toll collection, potentially leading to delays and congestion.

2. Integration Complexity: Integrating blockchain into existing infrastructure and payment systems can be complex and may require significant changes and cooperation from various stakeholders.

3. Privacy Concerns: Blockchain's transparency can be a disadvantage when it comes to protecting the privacy of individuals and sensitive data, as all transactions are permanently recorded.

4. Regulatory Hurdles: Navigating regulatory requirements, especially in the context of financial transactions and transportation infrastructure, can be challenging and may require compliance with various laws and standards.

5. User Adoption: Convincing users to adopt blockchain-based toll payment methods and infrastructure tracking tools can be challenging and may require education and incentives.

11.CONCLUSION

In conclusion, utilizing blockchain technology for tracking public infrastructure and toll payment systems presents a promising approach with several potential benefits and challenges. The advantages include enhanced transparency, security, efficiency, and accountability, which can lead to cost savings and improved user experiences. However, it's essential to consider the disadvantages, such as scalability concerns, privacy issues, regulatory complexities, and the need for user adoption.

Successful implementation will require a well-thought-out strategy, collaboration among stakeholders, and a robust technical infrastructure. Addressing these challenges and maximizing the advantages can lead to a more reliable, transparent, and efficient public infrastructure and toll payment system, ultimately benefiting both the government and the public. The potential of blockchain in this context is significant, but careful planning and ongoing development are necessary to realize its full potential.

12.FUTURE SCOPE

The future scope of tracking public infrastructure and toll payment using blockchain is promising and may lead to several advancements and developments:

1. Widespread Adoption: As blockchain technology matures and gains acceptance, it's likely to become a standard for tracking public infrastructure and toll payments in many regions globally.

2. Interoperability: Future systems may focus on standardizing blockchain protocols to enable interoperability between different regions and countries, making it easier for travelers to pay tolls seamlessly.

3. Smart Cities: The integration of blockchain technology in smart city initiatives could revolutionize urban transportation, making toll payment, and infrastructure tracking more efficient and sustainable.

4. Tokenization: Governments may issue blockchain-based tokens or digital currencies for toll payments, simplifying transactions and reducing the need for traditional currency.

5. Environmental Impact: The blockchain industry is moving towards more eco-friendly consensus mechanisms, reducing energy consumption concerns associated with older protocols.

13.APPENDIX

Source code

```
// SPDX-License-Identifier: MIT
pragma solidity ^0.8.0;

contract tollCollection{
   struct TollData {
      uint timestamp;
      address collectedBy;
      uint amount;
   }

   mapping(address => mapping(uint => TollData)) public tolls;
```

```
    function payTollAmount(uint highwayId, uint _amount) public {

      // TollData memory newToll = TollData(block.timestamp, msg.sender,
amount);
        tolls[msg.sender][highwayId].timestamp = block.timestamp ;
        tolls[msg.sender][highwayId].collectedBy = msg.sender;
        tolls[msg.sender][highwayId].amount += _amount;
    }

    function getToll(uint highwayId) public view returns (TollData memory)
{
        return tolls[msg.sender][highwayId];
    }

    // function updateToll(uint highwayId, uint amount) public {
    //     require(
    //         tolls[msg.sender][highwayId].timestamp > 0,
    //         "Toll data not found."
    //     );
    //     tolls[msg.sender][highwayId].amount = amount;
    // }
}
```

GITHUB & PROJECT DEMO LINK:

Github Link:
https://github.com/ESAKKIRAJA2003/NM2023TMID08503

Project Demo Link:
https://youtu.be/IhaQ_-2g8Bg?si=AxUArplLLPCkxrx4