SOFTWARE REQUIREMENTS SPECIFICATION

Smart E-VANET For Scheduling and Communication

Version 1.0 approved

Prepared by -

Raj Parmar: 21BCE240
Fenil Ramoliya: 21BCE244
Neha Rana: 21BCE246
Jimisha Patel: 22BCE527

Institute of Technology, Nirma University

September 16, 2023

Contents

1 Introduction **5**
1.1 Purpose 5
1.2 Document Conventions 5
1.3 Intended Audience and Reading Suggestions 5
1.4 Project Scope 6
1.5 Objective 6
1.6 Problem Statement Formulation 6

2 External Interface Requirements **9**
2.1 User Interfaces 9
2.1.1 Graphical User Interface (GUI) Standards 9
2.1.2 Dynamic Main Dashboard 9
2.1.3 Interactive Cartographic Panorama 9
2.1.4 Streamlined Charging Station Scheduler 9
2.1.5 Cognizant Error Articulation and Contextual Help 10
2.1.6 Real-time Notifications and Perceptible Alerts 10
2.2 Hardware Interfaces 10
2.2.1 Telematics Integration 10
2.2.2 Charging Station Interaction 10
2.2.3 Cognition-Enabled Communication Modules 10
2.2.4 GPS and Navigation Integration 10
2.3 Software Interfaces 11
2.3.1 Integration with Traffic Orchestration Systems 11
2.3.2 Database Interaction with Charging Stations 11
2.3.3 Data Security through Blockchain Technology 11
2.3.4 AI-Driven Algorithmic Logic 11
2.4 Communications Interfaces 11
2.4.1 Real-time Data Harmonization via WebSockets 12
2.4.2 HTTP/HTTPS Navigational Connectivity 12
2.4.3 Multi-channel Notification Beacons 12
2.4.4 Secure Data Transit with TLS/SSL Encryption 12

3 System Requirements **13**
3.1 Functional Requirement 13
3.1.1 Login Module 13
3.1.2 Charging Station Scheduling Module 14
3.1.3 EV Communication Module 16

3.1.4 Security Module 17
3.1.5 Block-chain Module 19
3.2 Non-Functional Requirements 20
3.2.1 Performance Evaluation 20
3.2.2 Safety Requirements 21
3.2.3 Security Requirements 21
3.2.4 Software Quality Attributes 22

1 Introduction

This section provides an overview of the contents of the Software Requirements Specification (SRS) document, including the project scope, objectives, and problem statement formulation. It also includes a list of abbreviations and definitions, along with a description of the document's goal.

1.1 Purpose

The purpose of this document is to give a detailed description of the requirements for the "Seamless communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks". It will provide a clear illustration of the system's objectives and full declaration. Additionally, it will discuss the limitations of the system, its interface, and its interactions with any additional software that can be used to find an electric vehicle's current location, provide information on local charging stations, and ensure reliable communication between electric vehicles. This document is primarily intended to be proposed to a customer for its approval and a reference for developing the first version of the system for the development team.

1.2 Document Conventions

In this document, we utilize specific fonts, styles, and sizes for various elements. The main title is specified using Arial font, Bold style, and size 14. Subheadings are presented in Arial font, Bold style, and size 12. Normal text is formatted with Times New Roman font, Normal style, and size 12. Additionally, we are adhering to the IEEE SRS formatting template while preparing this document.

1.3 Intended Audience and Reading Suggestions

This document primarily focuses on enhancing readability and facilitating better project comprehension. It aims to provide developers, managers, and testers with a clear understanding and proper control over the software development life cycle. Following the project scope and problem formulation subsection, the documentation will cover external functional requirements and non-functional requirements.

1.4 Project Scope

The project scope is to develop an advanced E-VANET (Electric Vehicle Ad-hoc Network) [5] system that enhances communication and scheduling in electric vehicles. It primarily focuses on establishing a reliable communication [4] infrastructure to facilitate real-time data exchange between vehicles, traffic infrastructure, and management centres. Additionally, intelligent scheduling algorithms will be implemented to optimize routes based on factors such as traffic flow, cost, energy consumption, and charging station availability. The integration with existing traffic management systems will enable the efficient dissemination of real-time traffic information and alternative route suggestions. The project also includes energy efficiency solutions, robust data security measures, extensive real-world testing, collaboration for standardization, and initiatives to raise public awareness about eco-friendly and sustainable transportation practices. [8]

1.5 Objective

- Develop a reliable E-VANET system for real-time communication among electric vehicles, traffic infrastructure, and management centres.
- Implement intelligent scheduling and AI Based algorithms to optimize electric vehicle routes considering traffic conditions, energy consumption, and charging station availability.
- Enhance traffic management by providing real-time traffic information, congestion alerts, and alternative route suggestions to drivers.
- Improve energy efficiency by deploying energy-efficient communication protocols and smart scheduling strategies for electric vehicles.
- Ensure data security and privacy measures to protect transmitted information within the E-VANET system using blockchain.

1.6 Problem Statement Formulation

The rising popularity of electric vehicles (EVs) has highlighted the necessity for a reliable and effective Electric Vehicle Ad-hoc Network (E-VANET) system that addresses communication and scheduling challenges [7]. The current lack of a dependable infrastructure for instantaneous data exchange between EVs, traffic infrastructure, and management centres impedes efficient traffic management and route optimization. Moreover, our scheduling methods inadequately account for critical factors like energy consumption, energy cost, and charging station availability [1]. The communication system allows indication of any heavy traffic indication, road-bridge brokage. [3]

Furthermore, the E-VANET system's lack of a secure and private data transmission framework [6] gives rise to concerns about potential cyber threats and privacy breaches.

Additionally, the absence of a user-friendly charging station scheduling solution with a simple one-touch feature poses a challenge; existing solutions either have a complex user interface or offer only basic scheduling capabilities. To comprehensively tackle these issues, the project's objective is to develop an advanced E-VANET system that facilitates seamless communication, intelligent charging station scheduling, enhanced energy efficiency, and robust data security measures. By achieving these objectives, the project aims to make a meaningful contribution to a more sustainable and eco-friendly transportation ecosystem, thereby fostering broader adoption of electric vehicles (EVs) and promoting a smarter urban mobility landscape.[5]

Bibliography

[1] K. Aravindhan et al. "Smart Charging Navigation for VANET Based Electric Vehicles". In: 1 (2021), pp. 1588–1591. DOI: 10.1109/ICACCS51430.2021.9441842.

[2] Xiaosha Chen et al. "Deep-Learning-Based Intelligent Intervehicle Distance Control for 6G-Enabled Cooperative Autonomous Driving". In: *IEEE Internet of Things Journal* 8.20 (2021), pp. 15180–15190. DOI: 10.1109/JIOT.2020.3048050.

[3] Yuxiang Feng et al. "Connectivity Enhancement of E-VANET Based on QL-mRSU Self-Learning Energy-Saving Algorithm". In: *IEEE Access* 11 (2023), pp. 3810–3825. DOI: 10.1109/ACCESS.2023.3235397.

[4] Sebastian Käbisch et al. "Interconnections and Communications of Electric Vehicles and Smart Grids". In: (2010), pp. 161–166. DOI: 10.1109/SMARTGRID.2010.5622035.

[5] Ahmed Jawad Kadhim and Jaber Ibrahim Naser. "Toward Electrical Vehicular Ad Hoc Networks: E-VANET". In: *Journal of Electrical Engineering & Technology* 16.3 (May 2021), pp. 1667–1683. DOI: 10.1007/s42835-021-00687-8.

[6] Chandra Shekhar et al. "A Lightweight IoT-Based Framework for Vehicular Ad Hoc Network (VANET)". In: *2023 15th International Conference on COMmunication Systems NETworkS (COMSNETS)*. 2023, pp. 19–24. DOI: 10.1109/COMSNETS56262.2023.10041282.

[7] *Smart Transport System*. https://github.com/shahriarshafin/smart-transport-system. Accessed: 07 Auguest, 2023.

[8] S. Touré et al. "Assessment methods for the targeted reconfiguration in distribution networks". In: *2015 IEEE Eindhoven PowerTech*. 2015, pp. 1–6. DOI: 10.1109/PTC.2015.7232722.

Provided references encompass a diverse array of topics, from electric vehicular ad-hoc networks (E-VANETs) and smart grid integration to advanced vehicle navigation and intelligent distance control. They collectively contribute to the robustness and sophistication of the *Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks* system, ensuring its alignment with contemporary research and industry standards.

2 External Interface Requirements

2.1 User Interfaces

The user interfaces of the *Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks* system are meticulously crafted to establish an immersive and intuitive interaction between users and the software. The following sections elaborate on the advanced functionalities and technical specifications of the user interfaces:

2.1.1 Graphical User Interface (GUI) Standards

The GUI embodies an amalgamation of sophisticated design principles, encompassing vibrant color schemes, typography hierarchies, and responsive layout paradigms. This meticulous design approach ensures a visually captivating and user-centric experience, adhering to industry-standard UI/UX best practices.

2.1.2 Dynamic Main Dashboard

Post-authentication, users are seamlessly ushered into a dynamic main dashboard, a meticulously designed central hub that dynamically presents real-time telemetry data. This data includes precise spatial coordinates of electric vehicles, comprehensive battery health metrics, and meticulously planned itineraries. The dashboard acts as the focal point for communication and scheduling activities, providing users with a comprehensive operational overview.

2.1.3 Interactive Cartographic Panorama

The interactive cartographic panorama offers a harmonious convergence of utility and elegance, empowering users to visually comprehend real-time electric vehicle positions, proximate charging stations, and live traffic parameters. Users are afforded an immersive experience, allowing seamless map navigation, zooming, and manipulation to explore data-rich visualizations.

2.1.4 Streamlined Charging Station Scheduler

The charging station scheduler epitomizes ergonomic design, seamlessly integrating simplicity and efficiency. Users can effortlessly configure optimal charging intervals, access real-time station availability data, and meticulously fine-tune schedules. A one-touch scheduling feature expedites instantaneous booking, streamlining user interactions for enhanced efficiency.

2.1.5 Cognizant Error Articulation and Contextual Help

Standardized error articulation employs a concise and intelligible language to communicate anomalies, enabling users to swiftly diagnose and resolve issues. A comprehensive contextual help repository offers navigational guidance across diverse features and functionalities, enhancing user autonomy and software mastery.

2.1.6 Real-time Notifications and Perceptible Alerts

Real-time notifications and alerts encompass a symphony of visual cues and auditory signals, ensuring users remain acutely aware of critical updates. Dynamic notifications encompass a spectrum of information, ranging from real-time traffic congestion warnings and itinerary recalibrations to charging milestones and other pertinent updates, fostering continuous user engagement.

2.2 Hardware Interfaces

The software harmoniously interfaces with an array of hardware components, orchestrating seamless communication and scheduling within a meticulously engineered ecosystem:

2.2.1 Telematics Integration

Seamless integration with electric vehicle telematics establishes a conduit for continuous real-time data influx. This data encompasses spatial geolocation coordinates, battery health metrics, and granular energy consumption profiles, facilitating real-time data synchronization between vehicles and the software.

2.2.2 Charging Station Interaction

The software interfaces with charging stations to facilitate a coherent exchange of real-time data. This includes instantaneous updates on station availability, impending scheduling actions, and nuanced energy consumption insights, ensuring users can make informed decisions regarding their charging needs.

2.2.3 Cognition-Enabled Communication Modules

Embedded communication modules within electric vehicles foster a dynamic tapestry of data exchange. This empowers harmonization of data across diverse vehicles, traffic infrastructure nodes, and centralized management entities, ensuring a cohesive communication network for optimal scheduling and route planning.

2.2.4 GPS and Navigation Integration

Synchronization with GPS and navigation systems enhances cartographic accuracy, delivering precise spatial coordinates, geographical visualizations, and navigational directives. This integration bolsters the software's ability to provide real-time and contextually accurate information to users.

2.3 Software Interfaces

The *Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks* system seamlessly interacts with a multifaceted array of software components, orchestrating a symphony of functional prowess:

2.3.1 Integration with Traffic Orchestration Systems

Seamless integration with pre-existing traffic orchestration systems establishes a comprehensive ecosystem for real-time traffic intelligence. This integration empowers the system to receive up-to-the-minute traffic data, congestion warnings, and alternative route suggestions, augmenting overall traffic management efficacy.

2.3.2 Database Interaction with Charging Stations

The software maintains an interactive dialectic with an encompassing charging station database. This interaction enhances user awareness by providing real-time charging station data, including availability status and dynamic energy tariff updates, enabling users to make informed charging decisions.

2.3.3 Data Security through Blockchain Technology

Incorporating blockchain technology ensures data sovereignty and cryptographic integrity. By encapsulating data transmissions within an impenetrable layer of security and confidentiality, the software establishes a resilient shield against unauthorized access, securing the sanctity of transmitted information.

2.3.4 AI-Driven Algorithmic Logic

Harnessing the power of artificial intelligence and advanced algorithms, the software orchestrates intelligently tailored routing blueprints. This includes a holistic synthesis of factors such as traffic flow, energy optimization, and charging station readiness, resulting in optimized and adaptive route planning. [2]

2.4 Communications Interfaces

The *Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks* system leverages a sophisticated web of communication interfaces, fostering dynamic and seamless data interchange:

2.4.1 Real-time Data Harmonization via WebSockets

The system's communication protocol, powered by WebSockets, orchestrates a harmonious real-time data exchange among electric vehicles, traffic nodes, and central command hubs. This real-time data synchronization creates a dynamic data ecosystem, enhancing communication efficiency.

2.4.2 HTTP/HTTPS Navigational Connectivity

User navigation within the virtual interface is facilitated by the venerable HTTP/HTTPS protocols, ensuring secure and pervasive connectivity. This connectivity enables users to seamlessly traverse the system's virtual landscape, accessing information and functionality with ease.

2.4.3 Multi-channel Notification Beacons

Notification delivery is executed through a versatile fusion of email, SMS, and in-app notifications. This multi-channel approach ensures that users receive timely and relevant updates, spanning traffic alerts, charging milestones, and scheduling synchronizations, enhancing user engagement.

2.4.4 Secure Data Transit with TLS/SSL Encryption

The software's communication infrastructure champions data security through robust encryption protocols like TLS/SSL. By enveloping data transmissions within these layers of encryption, the system guarantees data confidentiality, integrity, and secure transit, safeguarding sensitive information.

Incorporating these comprehensive external interface requirements, the *Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks* system delivers a cutting-edge user experience while seamlessly interacting with diverse hardware and software components. This intricate network of interfaces ensures a holistic and optimized solution for efficient electric vehicle communication and intelligent scheduling.

3 System Requirements

3.1 Functional Requirement

3.1.1 Login Module

Introduction

The Login Module plays a vital role within the system as it facilitates user authentication and controls access. This component ensures secure entry to the application by verifying user credentials and effectively managing user sessions.

Input

For the log-in page, we need the below-listed sub-modules.

1. **User id**: Users can log in by themselves with their unique e-vehicle registration id.
2. **Password**: The password must be matched by their previous sign-in password. Then and the user can log in themselves on the site.
3. **Forget password**: If the user forgot the password then the user can receive the link of the reset password via email.

For the Sign-in page, we need the below-listed sub-modules.

1. **User id**: The user has to enter the unique e-vehicle registration id while they are registering themselves on the site.
2. **Password**: The user creates the password with the correct validation.
3. **Name of the user**: User enters their valid name with the first name and the last name.
4. **Email-id**: The user has to enter a valid email-id, by the user can communicate with the app.
5. **Confirm password**: For security purpose user has to confirm the password.

Processing

1. **Database Schema:**
    - Define the database schema to store user information, including usernames, hashed passwords, and any additional user-related data.
    - Plan how to securely store and manage passwords using appropriate hashing algorithms and techniques.
2. **Monitoring and Maintenance:**
    - Monitor the login module for any anomalies, such as suspicious login attempts or performance issues.
    - Provide ongoing maintenance and updates as needed, especially for security patches and improvements.
3. **Back-end Implementation:**
    - Develop the backend logic to handle user authentication.
    - Implement authentication services that validate user credentials against the stored data in the database.
    - Set up mechanisms for generating and managing session tokens.
4. **Password Security:**
    - Implement password security measures such as salting and hashing for storing passwords securely.
    - Enforce password complexity rules and validation.

Output

After entering all the detail on the log-in page user can see one another web page which redirects the user to the main page of the application which is the user profile.

3.1.2 Charging Station Scheduling Module

Introduction

The Charging Station Scheduling Module is an integral component of the overall system, designed to efficiently manage and schedule charging sessions for electric vehicles at charging stations. This module aims to optimize the utilization of available charging resources, minimize waiting times for users, and ensure fair access to charging services.

Input

1. **User Requests:**: The module receives input from users through the user interface. Users specify their vehicle's charging requirements, such as preferred charging time, charging duration, and urgency.

2. **Charging Station Information:** : The module takes input from the system database containing details about available charging stations, their locations, charging rates, and current availability.

3. **Energy Grid Status:**: Input is obtained from the energy grid system, providing information about the current grid load, available energy capacity, and any grid constraints.

Processing

1. **Scheduling Algorithm:**
   - The module employs an advanced scheduling algorithm to efficiently allocate charging slots to incoming user requests.
   - The algorithm takes into account factors such as user preferences, charging station availability, energy grid constraints, and historical usage patterns.

2. **Load Balancing:**
   - The module optimizes charging station utilization by considering load balancing across different stations.
   - It ensures that stations are utilized evenly to prevent congestion or underutilization.

3. **Urgency Handling:**
   - The scheduling algorithm also addresses urgent charging requests by prioritizing vehicles with critically low battery levels, ensuring they are given priority slots when available.

Output

1. **Charging Schedule:**
   - The module generates a detailed charging schedule based on the input data and processing results.
   - This schedule outlines the allocated charging slots for each user, specifying the start time, duration, charging station, and other relevant details.

2. **User Notifications:**
   - The module provides notifications to users, informing them about their allocated charging slots, any changes in the schedule, or potential delays due to unforeseen circumstances.

3. **Real-time Updates:**
   - The module continually updates the charging schedule in real-time to accommodate any changes in user requests, station availability, or grid conditions.

- Users and system administrators can access up-to-date information through the user interface.

3.1.3 EV Communication Module

Introduction

The Electric Vehicle Communication Module is a fundamental component within the system, dedicated to facilitating seamless communication between electric vehicles (EVs) and the charging infrastructure. This module enables EVs to transmit essential data and instructions to the charging stations, ensuring efficient and secure charging processes.

Input

1. **Vehicle Identification:** The module receives input from the EVs, including unique vehicle identification information such as vehicle identification number (VIN) or RFID tags, which is used to associate the vehicle with its charging requirements.

2. **Charging Parameters:** EVs provide input about their charging needs, such as the desired charging rate, estimated charging duration, and any special charging preferences (e.g., fast charging or battery preservation mode).

3. **Authentication Data:** For secure and authorized charging, the module accepts authentication data from the EVs, including credentials or digital certificates, to validate their eligibility to use the charging infrastructure.

Processing

1. **Authentication and Authorization:**
   - The module processes the provided authentication data to ensure that the EV is authorized to access the charging services.
   - It verifies the authenticity of the EV and its user before granting access.

2. **Charging Protocol Negotiation:**
   - The module communicates with the EV to negotiate the appropriate charging protocol, considering factors like vehicle compatibility, charging station capabilities, and grid conditions.

3. **Charging Instruction Transmission:**
   - Based on the EV's charging parameters and the available charging infrastructure, the module generates and sends charging instructions to the charging station.
   - These instructions may include the requested charging rate, charging start time, and any dynamic adjustments during the charging process.

Output

1. **Charging Status Updates:**
   - The module receives real-time updates from the charging stations regarding the charging process.
   - These updates include information about the current charging rate, charging duration, and any interruptions or pauses in the charging process.
2. **Charging Completion Notification:**
   - When the charging process is completed, the module informs the EV owner/user through notifications.
   - It provides details about the charging session, including energy consumed, charging duration, and any associated costs.
3. **Error and Exception Handling:**
   - In case of errors, interruptions, or abnormalities during the charging process, the module generates error messages and communicates them to both the EV user and the system administrators for prompt resolution.

3.1.4 Security Module

Introduction

This portion presents a thorough outline of the Security Module, offering a detailed explanation of the steps and requirements in place to guarantee the reliability of data, the privacy of information, and the strength of the system in the context of the "Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks" framework. It encompasses the security goals, needs, and tactics used to counteract potential cybersecurity risks and breaches of privacy.

Input

The Security Module receives the following inputs:

1. **User and Vehicle Data:** Information about users and vehicles, including identification details and access privileges.
2. **Communication Data:** Data exchanged between electric vehicles, traffic infrastructure, and management centers.
3. **System Configuration:** Settings related to encryption methods, access controls, authentication mechanisms, and more.

Processing

The Security Module processes inputs through the following steps:

1. **Authentication and Authorization:**
   - User and vehicle authentication using secure credentials, such as usernames, passwords, and bio-metric data.
   - Authorization checks to grant access to specific functionalities based on user roles and permissions.
2. **Data Encryption and Integrity:**
   - Encryption of sensitive data using strong encryption algorithms before transmission.
   - Implementation of digital signatures to verify the integrity and authenticity of messages.
3. **Privacy Protection:**
   - Anonymization of personal user data and location information to protect user privacy.
   - User-controlled data sharing options to ensure data privacy preferences are respected.
4. **Intrusion Detection and Prevention:**
   - Real-time monitoring of system logs and network traffic for signs of unauthorized access or suspicious activities.
   - Immediate response to detected anomalies using intrusion detection and prevention systems (IDS/IPS).

Output

The Security Module produces the following outputs:

1. **Authorized Access:**
   - Grants authenticated users and vehicles access to specific functionalities and data within the system.
2. **Encrypted Communication:**
   - Securely encrypted data transmissions between electric vehicles, traffic infrastructure, and management centers.
3. **Data Integrity and Authenticity:**
   - Ensures that data remains unaltered during transmission and provides methods to verify its authenticity.

4. **Privacy Protection:**
   - Preserves user privacy by anonymizing data and providing control over the sharing of personal information.

5. **Threat Mitigation:**
   - Identification and mitigation of potential cyber threats through intrusion detection and prevention mechanisms.

3.1.5 Block-chain Module

Introduction

The Block-chain Module has a crucial role in guaranteeing secure and transparent data transactions within the system of *Seamless Communication and Smart Scheduling in Electric Vehicular Ad-hoc Networks.* This segment delineates the intentions, goals, and primary attributes of the Block-chain Module.

Input

The Block-chain Module receives the following inputs:

1. **Authenticated Data:** Data generated and exchanged between electric vehicles, traffic infrastructure, and management centers after successful authentication.
2. **System Configuration:** Configuration settings related to block-chain network parameters, consensus mechanisms, and cryptographic algorithms.

Processing

The Block-chain Module processes inputs through the following steps:

1. **Data Encryption and Integration:**
   - Encrypt sensitive data using cryptographic algorithms before adding it to the block-chain.
   - Integrate encrypted data into the block-chain's data structure.

2. **Consensus Mechanism Implementation:**
   - Implement a consensus mechanism (e.g., Proof of Work, Proof of Stake) to ensure agreement on valid data transactions.
   - Validate and confirm transactions through consensus among network participants.

3. **Smart Contract Deployment:**
   - Deploy smart contracts to automate predefined processes within the block-chain network.

- Execute contract-based functions for authentication, data validation, and predefined rules enforcement.

Output

The Block-chain Module produces the following outputs:

1. **Immutable Ledger:**
   - Generates an immutable ledger containing encrypted and verified data transactions.
   - Ensures that data once added to the block-chain cannot be altered or deleted.
2. **Data Provenance and Auditing:**
   - Enables traceability of data origins and changes, facilitating data auditing and regulatory compliance.
3. **Authenticated Data Transactions:**
   - Authenticated and verified data exchanges between electric vehicles, traffic infrastructure, and management centers.
4. **Transparent and Trustworthy Records:**
   - Provides tamper-proof records of communication, transactions, and system events, enhancing accountability and non-repudiation.
5. **Block-chain Network Status:**
   - Produces information about the block-chain network's health, status, and consensus agreements.

3.2 Non-Functional Requirements

3.2.1 Performance Evaluation

Performance Evaluation involves systematic testing and analysis to assess the effectiveness, efficiency, and scalability of a system, ensuring it meets predefined benchmarks and operational requirements.

1. Latency Analysis: Evaluate communication latency, ensuring messages between EV maintain a response time under 100 milliseconds, even in varying network conditions.
2. Scheduling Efficiency: Measure scheduling algorithm effectiveness, targeting a minimum accuracy of 90% for optimal charging slot allocation and electric vehicle routing.

3. Scalability Testing: Conduct scalability assessments to confirm the system's capacity to support at least 1000 vehicles without compromising latency or scheduling precision.

3.2.2 Safety Requirements

Safety Requirements encompass specific criteria and measures integrated into a system's design and functionality to ensure user well-being, aiming to prevent accidents, injuries, and damage during operation.

1. Safety Assurance: The system will implement fail-safe mechanisms to mitigate risks during seamless communication and scheduling processes, ensuring safe operation of electric vehicles within the ad-hoc network.

2. Privacy Protection: The system will incorporate robust encryption and data anonymization techniques to safeguard the personal information of electric vehicle users, maintaining their privacy and preventing unauthorized access.

3. Redundant Localization: The system will incorporate redundant location determination methods to ensure accurate positioning of electric vehicles, reducing the risk of miscommunication and enhancing overall safety.

4. Charging Station Information Integrity: The system will ensure the accuracy of information regarding local charging stations, preventing misinformation that could compromise user safety.

3.2.3 Security Requirements

Security Requirements encompass specific measures and protocols integrated into a system's design and functionality to ensure protection against unauthorized access, data breaches, and malicious attacks, preserving the confidentiality, integrity, and availability of sensitive information and system resources.

1. Access Control: The system will ensure that users have appropriate permissions and restrictions based on their roles to prevent unauthorized access to sensitive functions and data.

2. Authentication Mechanism: The system will require users to provide valid credentials, such as usernames and passwords, to access the system, ensuring that only authorized individuals can interact with it.

3. Secure Communication: The system shall enforce the use of secure communication protocols, such as HTTPS, to ensure that data exchanged between users and the system remains confidential and tamper-proof. item User Session Management: The system shall implement session timeout mechanisms to automatically log out inactive users, reducing the risk of unauthorized access in case of user inactivity.

3.2.4 Software Quality Attributes

Software Quality Attributes are inherent characteristics that will determine the overall excellence of a software system, encompassing attributes such as reliability, usability and maintainability.

1. Reliability: The software shall exhibit robustness and fault tolerance, minimizing system failures and ensuring consistent operation to prevent disruptions in communication and scheduling processes.

2. Usability: The user interface shall be intuitive and user-friendly, catering to a diverse user base of developers, managers, and testers, enhancing their understanding and control over the software development life cycle.

3. Maintainability:The software shall be designed with modular and well-documented code, allowing for ease of future enhancements, updates, and bug fixes to support the ongoing development and maintenance of the system.