Optimizing EV Charging Stations with Blockchain-Based Authentication and Recommendation Policies

A PROJECT REPORT

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF TECHNOLOGY

IN

Information Technology

Submitted by:

ASHWINI KUMAR MEENA (2020IMT-018)

Under the supervision of

Dr. AMRENDRA SINGH YADAV

विश्वजीवनामृतं ज्ञानम्

DEPT. OF COMPUTER SCIENCE AND ENGINEERING

Atal Bihari Vajpayee Indian Institute of Information Technology & Management

Morena Link Road, Gwalior-474015

May 2023 - Aug 2023

CANDIDATE’S DECLARATION

I, Ashwini Kumar Meena (2020IMT-018) student of Integrated Post graduate in Masters of Technology (Information Technology), hereby declare that the Project Dissertation titled — “Optimizing EV Charging Stations with Blockchain-Based Authentication and Recommendation Policies” which is submitted by me to the Department of Information Technology, ABV-IIITM, Gwalior in fulfillment of the requirement for awarding of the Bachelor of Technology degree, is not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma, Fellowship or other similar title or recognition.

Place: Gwalior, M.P.

Date: 25/07/2023

Candidate’s Signature

CERTIFICATE

I hereby certify that the Project titled ”Optimizing EV Charging Stations with Blockchain-Based Authentication and Recommendation Policies” which is submitted by Ashwini Kumar Meena (2020IMT-018) for fulfillment of the requirements for awarding of the degree of Bachelor of Technology (B.tech) is a record of the project work carried out by the student under my guidance & supervision. To the best of my knowledge, this work has not been submitted in any part or fulfillment for any Degree or Diploma to this University or elsewhere.

AYadav 25/07/23

Place : Gwalior,M.P.

Date : 25/07/2023

Dr. Amrendra Singh Yadav

(SUPERVISOR)

Dept. of Computer Science and Engineering

ABV-IIITM Gwalior

ABSTRACT

This research describes a Blockchain-Based Secure Authentication Scheme for Electric Vehicle Charging Stations in Advanced Transportation Technologies. Electric Vehicles (BEVs) in Advanced Transportation Technologies (ATT) can be secured and kept private utilizing a blockchain-based secure authentication mechanism. The proposed protocol solves a number of security issues, including reciprocal authentication and the preservation of BEV and CSU identity privacy.

The project focuses on a blockchain-based CSU selection methodology for BEVs that employs the Authentication and Registration Scheme. We intend to give BEV an additional layer of security and privacy, ensuring trustworthy charging slot reservation, and good Quality of Service (QoS). In addition, we examine the issue of BEV scheduling at a specific CSU for load balancing. The blockchain-based framework takes advantage of the blockchain's inherent strengths and safe identification capabilities. Its implementation allows Battery Electric Vehicles (BEVs) to select Charging Service Units (CSUs) locally without fear of disclosing their private information while still meeting their individual service requirements. Furthermore, the CSUs have carefully analyzed and accounted for BEV scheduling, as well as run extensive simulations. The results revealed the effectiveness of strengthened security and privacy protections while requiring only a little amount of transmission overhead and processing time.

Keywords - Electric vehicles, blockchain, charging station, security and privacy, smart city, smart grid, vehicle-to-grid, mutual authentication, BEV scheduling and recommandations

ACKNOWLEDGEMENT

The successful completion of any task is incomplete and meaningless without giving any due credit to the people who made it possible without which the project would not have been successful and would have existed in theory.

First and foremost, I am grateful to **Prof. Aditya Trivedi**, HOD, Department of Information Technology, ABV-IIITM Gwalior, and all other faculty members of our department for their constant guidance and support, constant motivation and sincere support and gratitude for this project work. I owe a lot of thanks to my supervisor, **Dr. Amrendra Singh Yadav**, Assistant Professor, Department of Computer Science and Engineering, ABV-IIITM for igniting and constantly motivating me and guiding me in the idea of a creatively and amazingly performed Major Project in undertaking this endeavor and challenge and also for being there whenever I needed his guidance or assistance.

I would also like to take this moment to show my thanks and gratitude to one and all, who indirectly or directly have given us their hand in this challenging task. I feel happy and joyful and content in expressing my vote of thanks to all those who have helped me and guided me in presenting this project work for my Major project. Last, but never least, I thank my well-wishers and parents for always being with me, in every sense and constantly supporting me in every possible sense whenever possible.

Ashwini Kumar Meena (2020IMT-018)

Contents

Chapter 1

INTRODUCTION

1.1 Overview

Electric Vehicles (BEVs) have emerged as a potential opportunity for the future of Smart Transportation Systems (STS) in smart cities[4]. BEVs have become an important component of STS by providing a promising solution to minimize CO2 emissions. With the rapid increase in the number of BEVs, proper management of EV charging has become critical in guaranteeing the BEV industry's long-term survival. Because public charging stations (CSUs) are now owned by rival energy providers and offer dynamic pricing based on electricity load and charging levels, the focus must move from charging scheduling to picking the best CSU for each charging BEV[1]. A distributed technique was used to handle the difficulty of decentralized CSU selection while protecting the privacy of EV consumers[2].

The present established protocols have allowed electric cars (BEVs) and charging stations to communicate. It is crucial to highlight, however, that these standards have been shown to have serious security and privacy flaws[9]. While authorized mediators are utilized in these protocols to verify and identify BEVs, the centralized structure of the process raises worries about potential data leaks and lacking traceability and accountability. As a result, it is critical to take a decentralized strategy to preserve privacy and security while also reducing trusted intermediates[5]. This strategy will not only improve the scalability of the EV charging process, but it will also protect against any safety or privacy breaches.

1.2 Problem Formulation

The goal is to create a decentralized protocol for Electric Vehicle (BEV) charging that eliminates the need for trusted mediators while also mitigating risks to security and privacy[7]. Furthermore, BEVs must be able to communicate with Charging Stations (CSUs) without disclosing private information to different network entities.

BEVs now safeguard charging slot reservations in the BEV charging protocol by exchanging their private information with both the target CSU and the trusted central leadership organization[9]. This strategy, however, is vulnerable to trust difficulties, and a lack of transparency and responsibility could hinder the charging process, resulting in inefficiency and unfair practices[10].

As a result, we must design a system to enforce honest reservation practices while holding both BEVs and CSUs accountable for their activities during the charging process[18]. Our suggested mechanism attempts to create trust and integrity in the charging network by guaranteeing that charging reservations are honored as agreed upon and transparently recording all transactions.

The research seeks to design a robust and efficient decentralized BEV charging protocol that protects user privacy, maximizes CSU network utilization, and fosters confidence and justice in the charging process by tackling these difficulties.

The key challenges associated with the problem formulation include:

1. Enabling decentralized CSU selection for BEVs.
2. Resolving security and privacy problems with trusted intermediaries.
3. Establishing a method for honest and accountable charging reservations.
4. BEVs Scheduling based on the Priority of the charging urgency.

Chapter 2

PROJECT DESCRIPTION

2.1 Motivation

Adoption of BEVs has advantages such as lower greenhouse gas emissions and dependency on fossil fuels[17]. However, integrating EVs into the transportation system involves issues that must be addressed in order for the transition to be smooth. It is vital to have an efficient and safe charging system[15]. Using trustworthy third parties or aggregators to manage the charging process, handle financial transactions, and organize interactions among EVs and CSs introduces various challenges[14].

1. Privacy and Security Issues:Trusted third parties and central aggregators have access to sensitive information about BEV users, including location data, charging patterns, and payment details. This raises significant privacy and security concerns as potential data breaches or misuse of information can lead to identity theft or unauthorized tracking of BEV owners.

2. Lack of Transparency: In centralized charging models, the lack of transparency in the decision-making process can create a trust deficit between BEV owners and the charging infrastructure providers. BEVs owners may not have insights into the selection criteria for CSUs or the reason behind charging prices, leading to dissatisfaction and potential reluctance in using the charging infrastructure.

3. Dependency on Central Authorities: Relying on central entities for charging operations introduces a single point of failure. If the central system malfunctions or

experiences downtime, it could disrupt the entire charging network, causing inconvenience to BEV users and hindering the growth of electric mobility.

4. Inefficiency in CSU Selection: Existing centralized models may not always result in optimal CSU selection for BEV owners. CSUs may not be efficiently utilized, leading to congestion at some locations while others remain underutilized. This inefficiency could result in longer charging times, increased waiting periods, and higher costs for BEV owners.

To address these pressing challenges and enhance the overall EV charging experience, this research proposes a novel approach by leveraging blockchain-based Distributed Ledger Technology (DLT) [4], [9].

By developing an accurate and robust phishing detection model based on CNN and LSTM networks, this report aims to provide a valuable contribution to the field of cybersecurity, enabling individuals and organizations to enhance their defense against phishing attacks and mitigate the associated risks..

2.2 Objectives

The objectives of this report on ”Optimizing EV Charging Stations with Blockchain-Based Authentication and Recommendation Policies” are as follows:

1. Decentralized Blockchain-Based BEV Charging System: This study proposes a decentralized blockchain-based BEV charging design. This novel design eliminates the need for trusted external intermediaries, allowing for safe and open interaction among BEVs and CSUs. The suggested architecture ensures trustworthy energy trade while protecting user privacy by exploiting the multiple features of blockchain.

2. The research provides an exceptional possibility for BEVs to secretly reserve charging slots at CSUs without giving their private information to any trusted intermediaries or CSUs. This reservation system with enhanced privacy ensures that BEV users can engage with CSUs remotely while maintaining data security. The pro-

tocol also ensures that the reserved charging slots are available, reducing conflicts between multiple BEVs.

3. Smart Contract Design: Including smart contracts in the protocol is a critical step toward enabling anonymous communication between BEVs and CSUs in an untrustworthy environment. These smart contracts have been designed to apply fines for BEV or CSU misbehavior, as well as to build a proper method for grading CSUs based on user experiences.

4. Effective Decentralized CSU Selection System: Our study presents a decentralized CSU choosing mechanism with the goal of empowering individual BEVs to make educated judgments when selecting CSUs based on their specific service requirements.

5. The Performance Evaluation project aims to provide a full and thorough security analysis of the proposed protocol, with the goal of evaluating its resilience against various security assaults. Furthermore, the study uses comprehensive simulations to compare the performance of the blockchain-based framework to other traditional schemes and industry-standard protocol. These tests have shown the efficacy and superiority of the offered remedies, which speaks well for the protocol's future success.

Chapter 3

PROJECT SUMMARY

3.1 Work Completed

1. Understanding Blockchain Fundamentals (Week 1-2):

   - Learned about the essential concepts of Blockchain technology, such as decentralization and its role in BEV charging.
   - Investigate cryptographic hashing, consensus methods, and immutability as key elements of blockchain systems.
   - Learn how to construct smart contracts in Solidity and become acquainted with contract development tools such as Remix.

2. Literature Review and Identification (Week 3-4):

   - Analyze related research papers to conduct an in-depth literature assessment on the application of blockchain in electric vehicle scheduling and charging.
   - Investigate the many strategies and tactics used in electric vehicle charging inside blockchain systems. Identify possible project ideas, assess their practicality and uniqueness, and discuss their viability.

3. Model Formulation Proposal (Week 5-6):

   - Create algorithms for effective BEV charging scheduling based on demand and supply concerns. To measure the effectiveness of the developed algorithms, compare them to existing methodologies.

- Calculate the cost of energy transfer during BEV charging using demand and supply ideas.

4. Model Architecture Development (Week 7-9):

   - Within the blockchain-based system, create a thorough mechanism for charging and discharging electric vehicles. Using the blockchain network, create a framework and connect electric automobiles and charging stations.
   - To ensure efficient communication between charging stations, implement a layer two solution.

5. Model Performance Assessment(Week 10 & 11):

   - Create a dataset that may be used to evaluate the performance of the stated algorithms.
   - Perform a comprehensive assessment of the Charging and cost control algorithms. Analyze the results to acquire insights into the performance of the algorithms, discover strengths, and identify areas for development.

3.2 Work Scheduled

1. Authentication Scheme Development and Research (Week 12):

   - Conduct a thorough review of existing authentication algorithm research articles. Examine the principles of operation of Mutual Authentication methods and identify the entities that must be incorporated into the system, such as User Device Credentials (UDC).
   - Assess the effectiveness of various security methods and authentication techniques.

2. Development of a Trust-Based Security Protocol (Week 13):

   - Create an algorithm for computing hashes and the authentication challenge for the suggested security protocol. Include the communication procedures required for block validation and inclusion in the blockchain-based EV charging system.

- To confirm the trust-based security protocol's effectiveness in safeguarding EV charging transactions, test and validate it.

3. Report Writing and Documentation:

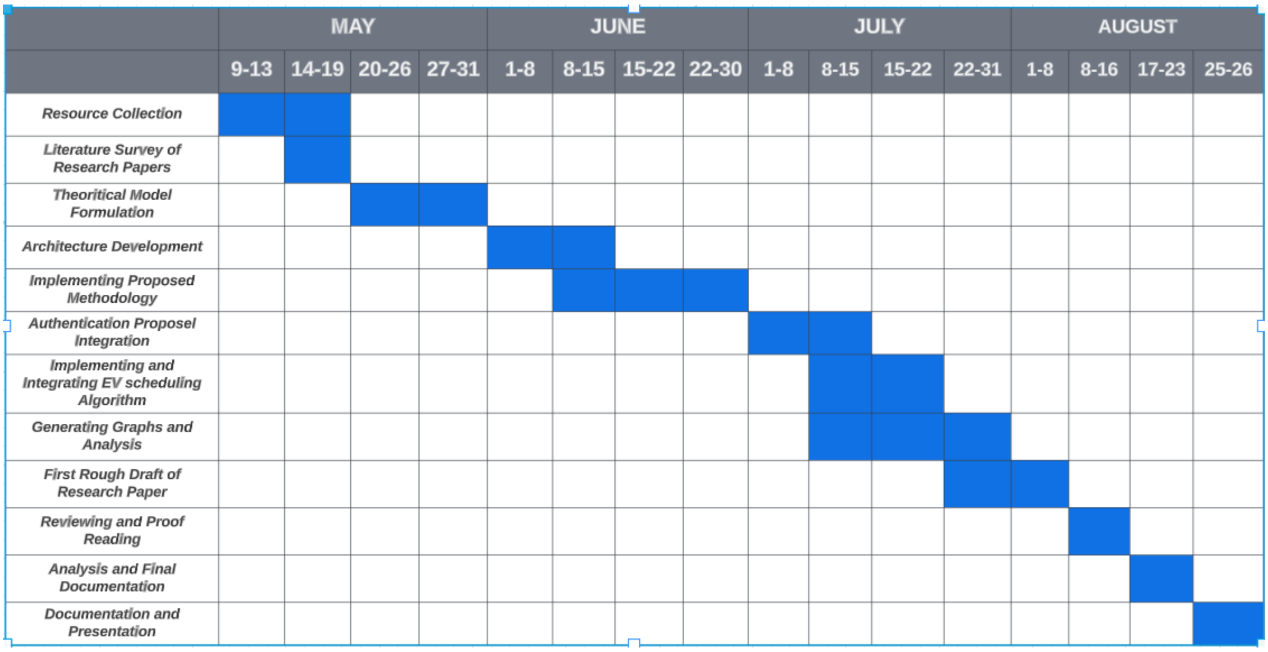
   - Document the full study approach, experimental setup, and authentication scheme findings.
   - Prepare a detailed report outlining the work done, including model architectural specifics, security protocol performance evaluation, and insights acquired.
   - Make sound recommendations for future study and potential blockchain applications in electric vehicle scheduling and charging. Week 15: Presentation Planning

4. Presentation and Dissemination:

   - Organize the study findings, techniques, and experiment results. Create a visually appealing and informative presentation to effectively communicate the project's progress and outcomes.
   - Use relevant visualizations, graphs, and data to demonstrate the proposed authentication scheme's performance and effectiveness.

It's important to note that the timeline provided is a generalized estimation, and the actual duration of each phase may vary depending on the complexity of the research, availability of resources, and the level of experimentation required.

3.3 Timeline (Gantt Chart)



Chapter 4

OVERALL SUMMARY

The proposed research addresses the privacy and security concerns in BEV charging infrastructures by employing blockchain technology to improve the efficiency, security, and privacy of BEV charging systems.

We designed a blockchain-based framework for BEV reservation services that is secure and reliable. The protocol supports safe charging services while protecting user privacy by utilizing smart contracts. The suggested protocol also contains a theoretical framework for efficient CSU selection, which optimizes the decision-making process to improve the overall BEV user experience. Evaluations show model has lower blockchain transaction and storage overhead than previous systems, resulting in enhanced scalability.

A blockchain-based authentication approach is presented to achieve secure and identity-protected communication between BEVs, Charging Stations (CSUs), and Utility Companies (UDC). The system employs a lightweight, cryptographically one-way hash function to ensure mutual authentication and the anonymity of all persons involved. Security evaluations show that the proposed strategy successfully eliminates security assaults and outperforms prior ideas in terms of communication cost and computing time.

This strategy prioritizes BEV charging based on charging urgency, taking charging demand and parking length into account. Using the BEV scheduling policy as a foundation, a CSU-Selection system is presented to reduce BEV travel duration while ensuring optimal charging within the parking duration. The results reveal that the suggested CSU-Selection system greatly decreases BEV travel duration through intermediate charging, increases the number of fully charged BEVs, and increases the number of fully charged BEVs.

Finally, the study offers a comprehensive set of ideas for improving the efficiency, security, and privacy of BEV charging infrastructure. The suggested protocols and standards, which make use of blockchain technology, provide BEV users and stakeholders with dependable and secure communication, improved CS selection, and optimum charging experiences. These contributions represent important advances in the field of blockchain-based BEV charging systems, with interesting real-world applications.

Bibliography

[1] ”J. J. Blum and A. Eskandarian, ”A reliable link-layer protocol for robust and scalable intervehicle communications,” in IEEE Transactions on Intelligent Transportation Systems, vol. 8, no. 1, pp. 4-13, Mar. 2007.

[2] J. Pajic, J. Rivera, K. Zhang, and H.-A. Jacobsen, ”EVA: Fair and auditable electric vehicle charging service using blockchain,” in Proceedings of the 12th ACM International Conference on Distributed Event-Based Systems, Jun. 2018, pp. 262-265.

[3] W.-L. Liu, Y.-J. Gong, W.-N. Chen, Z. Liu, H. Wang, and J. Zhang, ”Coordinated charging scheduling of electric vehicles: A mixed-variable differential evolution approach,” in IEEE Transactions on Intelligent Transportation Systems, vol. 21, no. 12, pp. 5094-5109, Dec. 2020.

[4] J. Rivera, C. Goebel, and H.-A. Jacobsen, ”Distributed convex optimization for electric vehicle aggregators,” in IEEE Transactions on Smart Grid, vol. 8, no. 4, pp. 1852-1863, Jul. 2017.

[5] F. Knirsch, A. Unterweger, and D. Engel, ”Privacy-preserving blockchain-based electric vehicle charging with dynamic tariff decisions,” in Computer Science - Research and Development, vol. 33, nos. 1-2, pp. 71-79, Feb. 2018.

[6] Y. Cao, T. Jiang, O. Kaiwartya, H. Sun, H. Zhou, and R. Wang, ”Toward preempted EV charging recommendation through V2V-based reservation system,” in IEEE Transactions on Systems, Man, and Cybernetics: Systems, early access, Jun. 11, 2019, doi: 10.1109/TSMC.2019.2917149.

[7] ”Innovation Outlook: Smart Charging for Electric Vehicles,” IRENA, Abu Dhabi, United Arab Emirates, 2019.

[8] Y. Yu, T. Song, C. Su, X. Tang, and Z. Han, ”Hierarchical game for electric vehicle public charging market,” in Proceedings of the IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm), Oct. 2019, pp. 1-6.

[9] J. Antoun, M. E. Kabir, B. Moussa, R. Atallah, and C. Assi, ”A detailed security assessment of the EV charging ecosystem,” in IEEE Networks, vol. 34, no. 3, pp. 200-207, May 2020.

[10] M. H. Eiza, Q. Shi, A. K. Marnerides, T. Owens, and Q. Ni, ”Efficient, secure, and privacy-preserving PMIPv6 protocol for V2G networks,” in IEEE Transactions on Vehicular Technology, vol. 68, no. 1, pp. 19-33, Jan. 2019.

[11] K. Bao, H. Valev, M. Wagner, and H. Schmeck, ”A threat analysis of the vehicle-to-grid charging protocol ISO 15118,” in Computer Science - Research and Development, vol. 33, nos. 1-2, pp. 3-12, Feb. 2018.

[12] C. Alcaraz, J. Lopez, and S. Wolthusen, ”OCPP protocol: Security threats and challenges,” in IEEE Transactions on Smart Grid, vol. 8, no. 5, pp. 2452-2459, Sep. 2017.

[13] V. Odelu, A. K. Das, M. Wazid, and M. Conti, ”Provably secure authenticated key agreement scheme for smart grid,” in IEEE Transactions on Smart Grid, vol. 9, no. 3, pp. 1900-1910, May 2018.

[14] C. Alcaraz, J. Lopez, and S. Wolthusen, ”OCPP protocol: Security threats and challenges,” in IEEE Transactions on Smart Grid, vol. 8, no. 5, pp. 2452-2459, Sep. 2017.

[15] F. Wu, L. Xu, X. Li, S. Kumari, M. Karuppiah, and M. S. Obaidat, ”A lightweight and provably secure key agreement system for a smart grid with elliptic curve cryptography,” in IEEE Systems Journal, vol. 13, no. 3, pp. 2830-2838, Sep. 2019.

[16] P. Gope and B. Sikdar, ”Privacy-aware authenticated key agreement scheme for secure smart grid communication,” in IEEE Transactions on Smart Grid, vol. 10, no. 4, pp. 3953-3962, Jul. 2019.

[17] L. Cai, J. Pan, L. Zhao, and X. Shen, ”Networked electric vehicles for green intelligent transportation,” in IEEE Communications Standards Magazine, vol. 1, no. 2, pp. 77-83, 2017.

[18]] Y. Cao, O. Kaiwartya, Y. Zhuang, N. Ahmad, Y. Sun, and J. Lloret, ”A decentralized deadline-driven electric vehicle charging recommendation,” in IEEE Systems Journal, vol. 13, no. 3, pp. 3410-3421, 2019.