



الجمهورية الجزائرية الديمقراطية الشعبية
The People's Democratic Republic of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research
جامعة محمد بوضياف بالمسيلة
University Mohamed Boudiaf of M'sila



كلية الرياضيات والإعلام الآلي

قسم الإعلام الآلي

Faculty of Mathematics and Informatics

Department of Computer Science

Domain: Mathematics and Computer Science

Thesis Presented to Fulfill the Partial Requirement
for Master's Degree in Computer Science

Specialty: Networks and Information and
Communication Technologies

Prepared By: Mahdi Mebrak, Chaima Zakkar

Supervised By:

Makhlouf Benazi

ENTITLED

All police: a platform
to issue Fines

Jury Members

Mahdjoubi Roussafi

President

Benazi Makhlouf

Supervisor

Kamel Mohamed

Examiner

Academic year: 2023 / 2024



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Dedication

We dedicate this project to our parents, whose unwavering support and encouragement have been the bedrock of our success. Their sacrifices, guidance, and belief in our abilities have shaped us into the individuals we are today. Without their constant presence and inspiration, this achievement would not have been possible. We are forever grateful for their love and dedicate this work to them as a symbol of our gratitude.

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Table of Contents

List of Figures	8
List of Tables	9
General Introduction.....	11
1.1 Motivation.....	11
1.2 Problem Statement.....	11
1.3 Objectives	12
1.4 Proposed Solution.....	12
1.5 Outline	13
CHAPTER 1 THEORETICAL FOUNDATION.....	14
2.1 Introduction.....	14
2.2 Basic concepts.....	14
2.3 Legal and Financial Framework	18
2.4 Background.....	19
2.5 Similar Applications	21
2.6 Evaluation	24
2.7 Conclusion	26
CHAPTER 2 DESIGN AND ARCHITECTURE.....	27
3.1 Introduction.....	27
3.2 Methodology.....	28
3.3 System Design	32
3.4 Technology Stack.....	42
3.5 Conclusion	48
CHAPTER 3 Implementation.....	49
4.1 Introduction.....	49

4.2 Results.....	50
4.3 Perspective:.....	65
4.4 Conclusion	65
General Conclusion	67
References	69
Abstract.....	72
المخلص	72

List of Figures

Figure 2.1: Traffic Offence Reporting interface	21
Figure 2.2: Traffic Sentinel	22
Figure 2.3: Public Eye	23
Figure 3.1: TBH Use Case diagram.....	33
Figure 3.2: TBH Class Diagram	35
Figure 3.3: Report Submission Sequence Diagram.....	38
Figure 3.4: Report Validation Sequence Diagram	39
Figure 3.5: Conflict Resolution Sequence Diagram.....	40
Figure 3.6: Approval Process Sequence Diagram	41
Figure 3.7: Expo temporary Build Ban While Debugging.....	43
Figure 4.1: Created SSL Certificate.....	50
Figure 4.2: Traffic Officer Site login page	52
Figure 4.3: Traffic Officer Site Dashboard.....	53
Figure 4.4: Traffic Officer Map.....	54
Figure 4.5: TBH App Login Screen	55
Figure 4.6: TBH App Sign Up Screen.....	55
Figure 4.7: TBH App Dashboard.....	56
Figure 4.8: TBH App Side Bar/Rank display	57
Figure 4.9: Prompt TBH to Turn on Location.....	58
Figure 4.10: TBH App Video Trim Screen.....	59
Figure 4.11: Firebase Structure of The Report	62
Figure 4.12: Approved Report.....	63
Figure 4.13: Wanted Report.....	64
Figure 4.14: Qualified Report.....	64

List of Tables

Table 3.1 Ranking System	31
---------------------------------------	----

Abbreviations

COPPS: Community Oriented Policing and Problem Solving

TBH: Traffic Bounty Hunter

FFmpeg: Fast Forward Moving Picture Experts Group

SSL: Secure Sockets Layer

API: Application Programming Interface

CCTV: Closed-Circuit Television

General Introduction

1.1 Motivation

The prevalence of traffic violations and the resulting numbers in road accidents is a significant public safety threat. Last year in Algeria, 63 694 accidents resulted in 1 893 deaths and 79 771 injuries, reported The Algerian Directorate General of Civil Protection [1]. This isn't just a statistical anomaly; it represents shattered lives, lost loved ones, and a devastating burden on families. Low- and middle-income countries bear the brunt of this public health crisis, accounting for a staggering 93% of all road deaths. This disparity is further compounded by the fact that no low-income country has witnessed a decrease in road deaths since 2013 [2] affecting young and working-age groups of society in particular. Beyond the human cost treating road safety victims, damaged vital infrastructure and productivity hindrance are imposing an increasingly unbearable burden on these countries' economy and social well-being [3] thus the continuous cycle of tragedy. with no signs of improvement over the years. It's a clear call for innovative solutions.

1.2 Problem Statement

The existing methods of monitoring and deterring traffic violations face several challenges that hinder their effectiveness. Despite the efforts of law enforcement agencies their traditional methods, such as checkpoints and patrols, heavily rely on human resources, making them labor-intensive and susceptible to detection by offenders.

While surveillance cameras are found to be somewhat effective and can offer up to 25% drop in serious collisions in their vicinity [4], their implementation and maintenance can be prohibitively expensive, and their coverage is often limited, leaving many areas unmonitored [25]

Furthermore, conventional methods of reporting traffic violations, such as hotlines and in-person visits to police stations, are frequently characterized by lengthy wait times, bureaucratic hurdles, and an inherent vulnerability to fabricated claims or evidence. This is particularly concerning in the current era, where advancements in digital technology have facilitated the manipulation of photographic evidence submitted through these channels.

Moreover, a significant number of criminal acts go unreported due to a complex interplay of factors affecting victims and witnesses[5].

Current methods for addressing traffic violations face limitations. Law enforcement agencies are often stretched thin, making it challenging to effectively monitor and apprehend violators in real-time. Additionally, traditional methods of reporting, which may rely solely on anonymous tips, often lack concrete evidence to support claims, hindering enforcement efforts.

The consequences of these shortcomings are severe. Rampant traffic violations not only contribute to increased road accidents but also result in substantial financial losses for individuals, communities, and governments. More importantly, the loss of human lives due to preventable traffic incidents is a tragic and unacceptable.

1.3 Objectives

In an effort to address the pressing issues of rampant traffic violations and the consequent surge in road accidents, this project proposes the development of an innovative platform that empowers citizens to play an active role in promoting road safety and upholding traffic laws. The proposed platform aims to facilitate the reporting of traffic violations, increase citizen reporting of traffic violations to gain a more comprehensive understanding of driving behaviors on roads, ensure the integrity and validity of evidence, deter traffic violations through enhanced accountability measures and incentives for responsible citizen reporting and provide law enforcement agencies with a comprehensive and cost-effective solution to aid their existing efforts.

1.4 Proposed Solution

The platform centers around a mobile app called Traffic Bounty Hunter for citizens to report traffic violations while protecting their privacy. The user-friendly app allows capturing photos/videos of violations with geolocation data and submitting them seamlessly. Citizens' identities are kept private but not fully anonymous.

To encourage responsible reporting, the app incorporates a reward system where citizens receive a portion of the fines from violations they accurately report. A rank-based system incentivizes high-quality reports by rewarding top contributors.

Once a citizen submits a report through the app with photo/video evidence and geolocation, it undergoes a review process by law enforcement officers to validate the violation details. A majority voting mechanism by multiple officers ensures fairness and objectivity.

For law enforcement, a dedicated website provides access to reported traffic violations submitted by citizens. Officers can review evidence like photos/videos with geolocation and make decisions on the report's validity. The website enables streamlined evaluation of citizen reports.

Invalid or fabricated reports are rejected, with potential sanctions against the reporting citizen to maintain system integrity.

1.5 Outline

The central focus of this dissertation is the development of a mobile application that enables citizen reporting of traffic violations, with a specific emphasis on addressing this issue in developing countries. It commences by laying a theoretical foundation in the first chapter, examining pertinent concepts, legal frameworks, existing applications for traffic violation reporting, and potential issues and concerns. Thereafter, in chapter 2 it delves into the intricacies of the platform's design and architecture, employing visual aids to elucidate its functionalities and data flow mechanisms.

Ultimately, it chronicles the implementation journey in the third chapter, detailing the technology stack employed, and culminates with a presentation of the platform's testing outcomes and their consequent implications.

CHAPTER 1

THEORETICAL FOUNDATION

2.1 Introduction

This chapter aims to lay the groundwork for our dissertation, which proposes a mobile application for citizen reporting of traffic violations, with a focus on Algeria. We will begin by defining key concepts and terms related to traffic safety and citizen engagement, ensuring a common understanding for our research. Next, we will explore the legal framework in Algeria, particularly the regulations surrounding traffic violations and data privacy, to provide the necessary context for our app's design and implementation. Additionally, we will conduct an in-depth analysis of traffic violations, examining their various forms, associated risks, and their overall impact on road safety within Algeria. Furthermore, we will investigate existing solutions, including current enforcement methods and similar citizen engagement applications, critically evaluating their strengths and weaknesses to identify potential areas for improvement in our proposed app. Finally, before concluding the chapter, we will acknowledge and address potential problems and concerns that may arise with the implementation of our app, such as issues of false reporting and user privacy.

2.2 Basic concepts

2.2.1 Violation

The act of doing something that is not allowed by a law or rule, the act of ignoring or interfering with a person's rights [6].

2.2.2 Traffic Violation

A traffic violation occurs when a driver violates one of the laws that regulate motor vehicle operation on streets or highways, jeopardizing the safety of others on the road [7]. These regulations, established within state traffic codes, encompass a diverse range of offenses, and their specific definitions and classifications can vary across jurisdictions.

2.2.3 Fine

An amount of money that has to be paid as a punishment for not obeying a rule or law reword[8], the primary objective of traffic fines is not to generate revenue but to deter violations and promote compliance with traffic regulations.

2.2.4 Report

To convey information or a description of something to someone. This can involve presenting data, findings, or observations in a formal or informal setting. For example, a scientist might report their research results to a conference, or a student might report on a book they read in class. To formally lodge a complaint with an authority figure about something or someone. This typically involves outlining a perceived wrongdoing or violation of rules. For example, an employee might report a safety hazard to their manager, or a citizen might report a crime to the police. In essence, "report" signifies the act of providing information, either to share details or to initiate an official response.[9]

2.2.5 Evidence

Evidence is any kind of information, data, or document that helps us believe something is true. It serves as the foundation for building a strong case, whether it's verifying a statement, supporting a claim, or making an argument persuasive [10].

2.2.6 Forensic

The use of scientific methods to bring forth information about a crime [11].

2.2.7 Video surveillance

Refers to the use of security cameras to monitor and record activity in a specific area for security, safety, or monitoring purposes [12]. These cameras capture live footage that can be viewed in real-time or recorded for later review. Another term for video surveillance is CCTV (Closed-Circuit Television)[12].

2.2.8 Community-Oriented Policing & Problem Solving (COPPS)

Community-Oriented Policing and Problem Solving (COPPS) represents a transformative philosophy, management style, and organizational design within the law enforcement domain [13].

This multifaceted approach prioritizes proactive problem-solving and the cultivation of robust police-community partnerships to effectively address the root causes of crime and a broader spectrum of community issues [13]. COPPS stands in stark contrast to traditional reactive policing models that primarily focus on responding to crimes after they have already occurred.

2.2.8.1 Problem-Solving: A Collaborative Endeavor

The core tenet of COPPS lies within its problem-solving process. This iterative process emphasizes the collaborative identification of problems and community priorities through the implementation of coordinated community-police needs assessments [13]. Information concerning the identified problems is then meticulously gathered and analyzed in a comprehensive, yet efficient, manner. This analysis forms the foundation for the development or facilitation of innovative and customized responses that possess the optimal potential to either eliminate or significantly reduce the targeted problems [13]. The final stage of the problem-solving process entails a rigorous evaluation of the implemented response to determine its effectiveness in addressing the issue. Based on the evaluation results, the response can be modified and refined as necessary to ensure sustained progress [13].

2.2.8.2 Community Partnership: A Cornerstone of COPPS

The term community partnership, as employed within the context of COPPS, is deliberately flexible to encompass a diverse range of collaborative actors [13]. These actors can include, but are not limited to, neighborhood residents, schools, churches, businesses, community-based organizations, and various government agencies who work cooperatively with the police department to resolve identified problems that directly impact or hold significance for the community [13]. By fostering these partnerships and fostering open communication channels, COPPS empowers communities to take an active role in shaping public safety strategies and enhancing their overall well-being.

2.2.9 Decentralized systems

Represent a category of systems characterized by the autonomous decision-making capabilities of individual nodes within the network. In contrast to centralized systems with a single point of control, decentralized systems distribute decision-making authority among all participating nodes. The overall behavior of the system emerges as a cumulative effect of the independent decisions made by these individual nodes[14].

2.2.10 Media authentication

A critical process employed to verify the authenticity and integrity of digital media, specifically images and videos. This process aims to establish whether a digital media file has been altered or manipulated in any way since its creation [15].

2.2.11 Gamification

The process of using game elements in business and marketing strategies or the concept of applying game mechanics, elements, and principles to non-gaming applications to make them more interesting and engaging. Simply put, gamification is the practice of integrating game principles and mechanics into non-game experiences [16].

2.2.12 ID verification

Encompasses a suite of technological tools designed to confirm the validity and ownership of an individual's personal information [17]. This process typically focuses on verifying details such as name, address, age, and phone number [17]. A variety of technologies can be leveraged to achieve this objective, highlighting the multifaceted nature of ID verification solutions [17].

2.2.13 Bounty Hunter

An individual who engages in the pursuit and apprehension of criminals or fugitives in exchange for a pre-determined reward[18]. This profession traditionally involved tracking down outlaws who had evaded legal authorities [18].

2.3 Legal and Financial Framework

As this platform is being developed specifically for deployment in Algeria, we consulted official government sources and conducted an interview with a representative from the Algerian police force to ensure accurate information regarding traffic violations and associated penalties within the country.

Traffic violations in Algeria are classified into four degrees, each carrying different fines and procedures. Third-degree violations, which are the most common, involve infractions like speeding, failure to signal, and running a stop sign or red light. For example, exceeding the speed limit by 20 km/h or more (speeding), not using turn signals when changing lanes (failure to signal), or not coming to a complete stop at a stop sign or red light (running a stop sign/red light) can result in fines ranging from 2000 to 4000 Algerian dinars and potential suspension of the driver's license. More severe fourth-degree violations carry heavier fines from 4000 to 6000 dinars and possible license revocation. Instances of reckless driving, unsafely passing another vehicle on the right, fall under this category. Misdemeanors include violations such as leaving the scene of an accident (hit and run), or causing a fatal collision due to negligence (vehicular homicide). Violations under this category could lead through the judicial process to imprisonment. Minor infractions like parking violations and failure to use headlights at night constitute first and second-degree violations with fines ranging from 2000 to 3000 dinars [19].

While the Algerian government does not disclose the specific allocations, revenue generated from traffic violation fines and penalties is generally directed into the state budget. These funds can then be utilized for various purposes aimed at improving road safety and enforcement capacity. This includes funding for law enforcement agencies to upgrade equipment, provide training, and recruit personnel to enhance traffic policing capabilities. Additionally, investments can be made in road infrastructure development projects like maintenance, expansion, and implementation of safety measures such as barriers, signage, and lighting. Portions of the revenue may also support public safety initiatives, such as awareness campaigns, driver education programs, and research/development of new safety technologies.

Traffic tickets in Algeria are usually issued using the information from the driver's license and vehicle registration documentation. However, in certain scenarios involving more severe fourth-degree violations and above, an Algerian police officer informed us that law enforcement

has mechanisms that allow them to issue tickets and create reports about fleeing perpetrators using the license plate number, vehicle brand, and model name, even without immediate access to other documentation.

There are three main ways for citizens to report crimes in Algeria. Firstly, they can make an anonymous call to the authorities. Secondly, they can approach a police or gendarmerie officer in person, who will then create an official report and send it to the corresponding public prosecutor. Alternatively, citizens can create the report themselves and submit it directly to the public prosecutor's office.

In summary, Algeria employs a comprehensive system for classifying and penalizing traffic violations, ranging from minor infractions to severe criminal offenses. By consulting official sources and law enforcement representatives, we have obtained accurate information regarding the violation degrees, associated fines, potential license suspensions or revocations, and the handling of violations involving fleeing perpetrators. Additionally, we have insights into the allocation of violation revenue towards enhancing road safety infrastructure and enforcement capabilities. Furthermore, citizens have multiple avenues to report violations, either anonymously or through formal channels involving law enforcement or prosecutors. This understanding of Algeria's legal framework surrounding traffic violations, coupled with citizen reporting mechanisms, lays a robust foundation for the development and deployment of our platform tailored to the nation's specific context and requirements.

2.4 Background

Enhancing public safety requires a multifaceted approach that leverages various crime prevention and deterrence strategies. The effectiveness of surveillance cameras in reducing crime rates remains an ongoing debate. Proponents argue for their deterrent effect, while critics raise privacy concerns and question the overall impact. A significant contribution to this discourse comes from Piza et al.'s 2019 systematic review and meta-analysis, which encompassed 40 years of research. Their findings suggest a modest but statistically significant association between CCTV surveillance and decreased crime rates, indicating that surveillance cameras may contribute to curbing criminal activity [20].

Complementing technological surveillance is the community-oriented policing (COP) model, which has emerged as a prominent strategy within law enforcement. COP emphasizes collaboration and proactive problem-solving to address crime and enhance public safety. Advocates argue for its effectiveness in reducing crime rates, fostering trust between police and communities, and promoting a more collaborative approach to public safety. A notable contribution to this discussion is the 1999 book "COPPS: Community Oriented Policing and Problem Solving NOW AND BEYOND" by the Crime and Violence Prevention Center, California Attorney General's Office, and Bill Lockyer [13]. This work asserts that community-oriented policing and problem-solving are major contributors to the dramatic decrease in crime rates, suggesting a positive correlation between COP implementation and reduced crime levels.

Citizen engagement plays a crucial role in comprehensive crime prevention and reporting efforts. Gamification constitutes a powerful method for incentivizing user participation, with studies showing increased motivation and user experience when leveraging game-like elements for desired behaviors or processes [21]. However, ensuring complete and accurate crime reporting hinges on the principle of protecting user identity. A significant number of criminal acts go unreported due to a complex interplay of factors affecting victims and witnesses [5], ranging from fear of retaliation or social stigma to the perception of the crime being insignificant or a personal matter. A lack of trust in law enforcement or difficulty accessing reporting mechanisms can also deter individuals from coming forward. By prioritizing user anonymity, platforms can create a safe space for individuals to report criminal activity, fostering a more comprehensive understanding of crime trends and enabling law enforcement to develop targeted prevention and intervention strategies. This, in turn, can contribute to a safer and more secure society for all.

2.5 Similar Applications

Our research benefits from examining several existing crime reporting applications that share functionalities relevant to our project. These applications, Traffic Offence Reporting, Public Eye – Official BTP App, and Traffic Sentinel, all empower citizens to report traffic violations to the authorities.

2.5.1 Traffic Offence Reporting

This application focuses on streamlining the reporting process for traffic violations by allowing users to submit photographic evidence directly to law enforcement for verification and subsequent action. While the platform information is unavailable here, its emphasis on user-friendliness and focus on traffic violations make it a valuable reference point for our research.

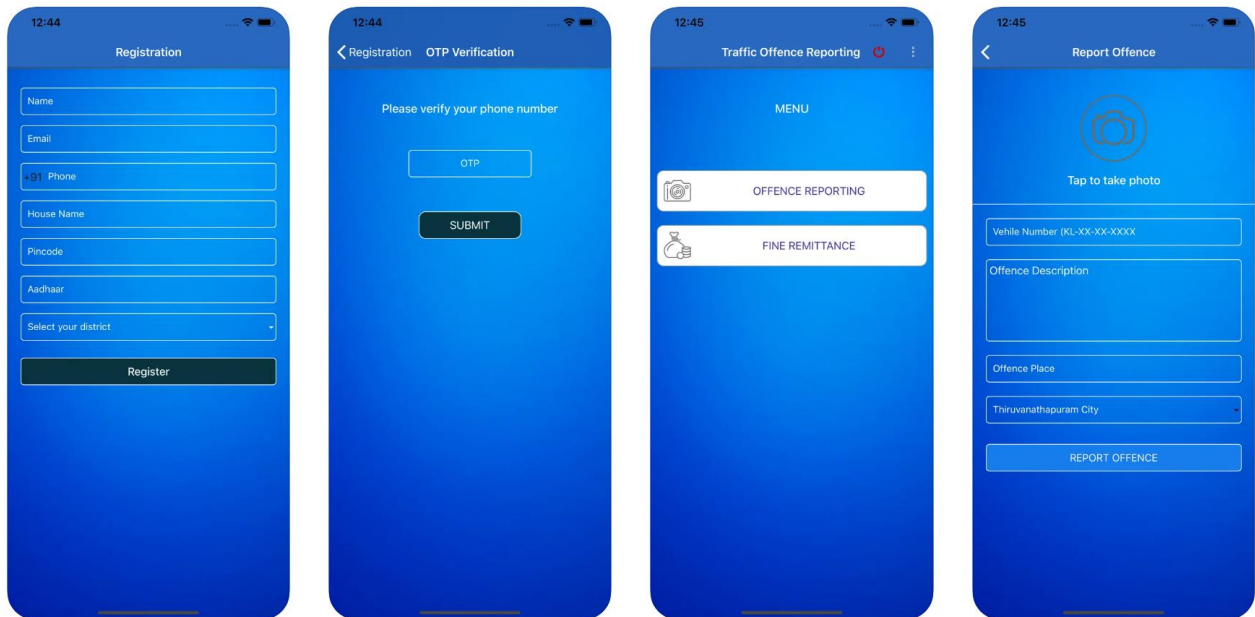


Figure 2.1: Traffic Offence Reporting interface [26]

2.5.2 Traffic Sentinel

Launched by Delhi Traffic Police, this application goes beyond simple reporting by incentivizing citizen participation. It empowers users to report traffic violations through the Delhi Police Mobile App and offers a reward system based on accumulated points for reported offenses. While the platform information remains unavailable, Traffic Sentinel highlights the potential of gamification and reward structures to encourage user engagement in crime reporting.

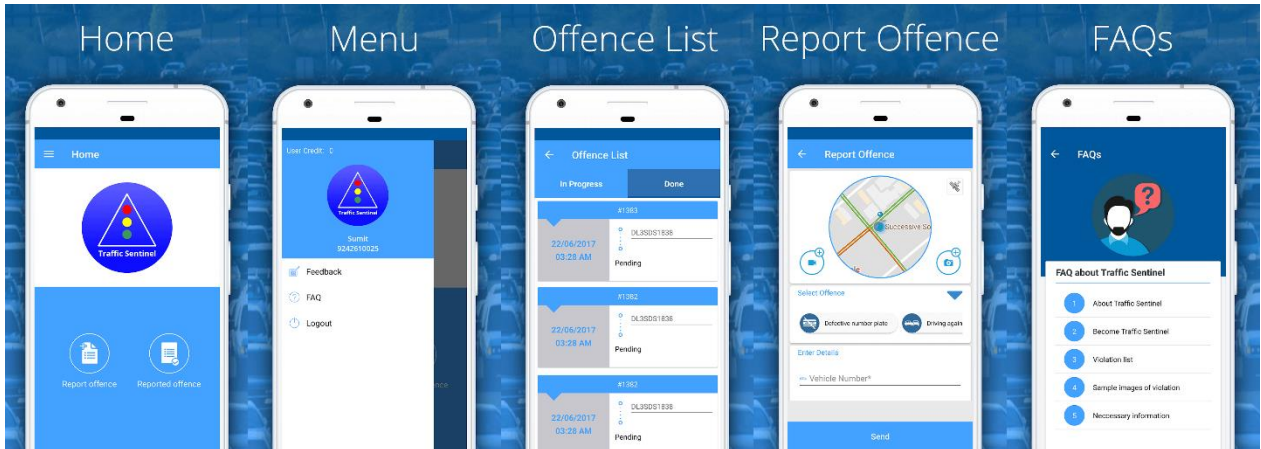


Figure 2.2: Traffic Sentinel [27]

2.5.3 Public Eye – Official BTP App

Developed collaboratively by Bangalore Traffic Police and ichangemycity.com, this application allows users to capture photos or videos of specific traffic violations (including no parking, riding on footpaths, using mobile phones while driving, etc.) and submit them electronically. The app caters specifically to Android platforms and offers a defined list of reportable offenses, which provides valuable insights into the types of traffic violations users are most likely to report. Additionally, the app's stated timeframe for police response (within 48 hours) suggests a focus on user feedback and efficient communication.

These applications not only share the functionality of reporting traffic violations, but also offer valuable insights into user experience considerations, platform choices, and potential strategies for promoting active citizen participation.

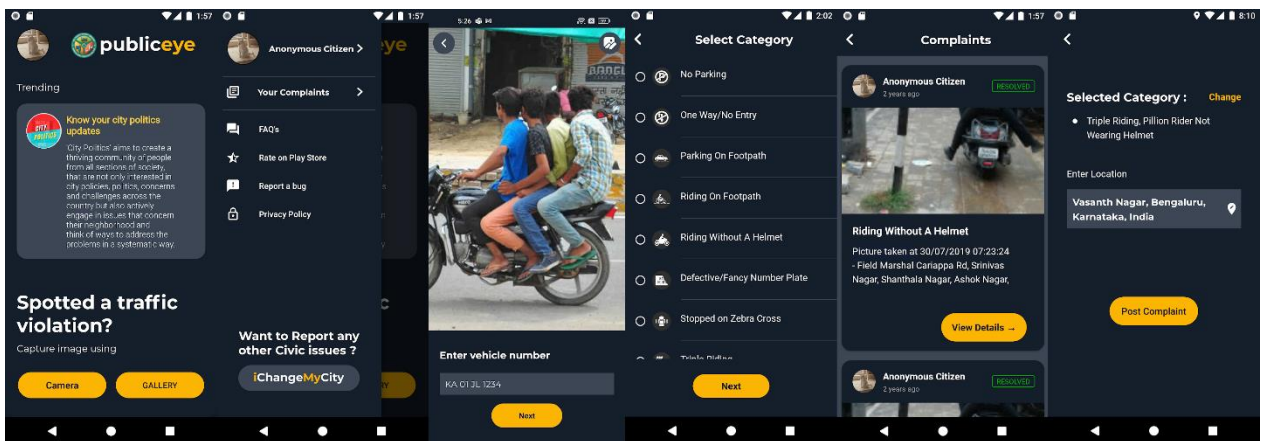


Figure 2.3: Public Eye [28]

2.6 Evaluation

Our research effort critically examined these existing applications and identified several key elements that are crucial for the success of such applications:

2.6.1 Balancing Incentives and Security

While gamification techniques can be a powerful tool to motivate user participation and reporting activity, experiences with cheating in video games highlight the potential for misuse within these systems. Therefore, applications offering monetary rewards or game-like features must incorporate robust verification measures to prevent fraud. This may involve user ID authentication and evidence validation techniques, such as image analysis or location verification, to ensure the legitimacy of reported violations and prevent manipulation of the reward system.

2.6.2 Prioritizing User Privacy

When dealing with sensitive matters like crime reporting, it is paramount to safeguard user identities and protect them from potential retaliation or harassment [5]. Applications must implement strong data protection protocols that comply with relevant privacy regulations. This includes anonymizing user data whenever possible and ensuring secure storage and transmission of reported information. Transparency regarding data collection and usage practices is also crucial for building user trust.

2.6.3 Leveraging Forensic Technologies

Object detection and tracking technologies employed in computer vision hold significant promise for enhancing traffic violation reporting applications. These technologies can facilitate accurate identification and analysis of offenses within images and video evidence. For instance, applications could integrate with automated license plate recognition systems to streamline data collection and improve the efficiency of the reporting process. Furthermore, advanced video analytics could be employed to detect specific traffic violations, such as running red lights or improper lane usage, even in low-visibility conditions[22].

2.6.4 Rewarding Accuracy over Volume

The value of crime reporting applications hinges on the veracity of reported data. Reward systems should be structured to incentivize accurate reporting [23]and mitigate the risk of misuse,

such as generating false reports for personal gain. This could involve implementing mechanisms to verify the accuracy of submitted evidence, potentially through integration with law enforcement databases or through community moderation processes. Reward structures could then be weighted towards confirmed violations, encouraging users to invest time and effort into capturing high-quality evidence and promoting a more reliable data collection system.

2.6.5 Fostering Collaborative Partnerships

Effective traffic violation reporting necessitates a collaborative effort between citizens and law enforcement authorities [13]. Applications should be designed to facilitate seamless communication and data exchange between these stakeholders. This could involve features that allow users to report violations directly to law enforcement agencies, with clear procedures for follow-up investigations and feedback mechanisms to keep users informed about the outcome of their reports. Additionally, anonymized data collected through the application can provide valuable insights to law enforcement officials, enabling them to identify high-risk areas and tailor enforcement strategies more effectively.

The transparency and fairness of the evidence evaluation process in a crime reporting app is indeed crucial for ensuring a positive user experience and upholding principles of justice [5]. A decentralized system can offer several advantages in this regard [24].

However, it's important to note that the implementation of a decentralized system for evidence evaluation in a crime reporting app requires careful design and governance to ensure that the system remains secure, efficient, and aligned with legal and ethical principles. Additionally, user education and adoption are critical factors in realizing the full potential of such a system.

Overall, the advantages of decentralized systems, such as transparency, auditability, and distributed authority, can play a crucial role in guaranteeing justice by ensuring a fair and trustworthy evidence evaluation process in a crime reporting app, ultimately enhancing the user experience and upholding the principles of due process and fairness.

Our analysis of existing applications, including Traffic Offence Reporting, Public Eye – Official BTP App, and Traffic Sentinel, revealed that while they offer valuable functionalities, none can be considered a comprehensive solution. These applications often lack a holistic integration of the aforementioned critical elements. By addressing these shortcomings and incorporating the

identified success factors, our research aims to develop a next-generation traffic violation reporting application that promotes user engagement through a balanced gamification approach, ensures data accuracy through robust verification methods, and fosters a collaborative partnership between citizens and law enforcement for safer roads. This application will contribute to a more secure and efficient traffic management system, ultimately leading to a reduction in traffic violations and creating a safer environment for all road users.

2.7 Conclusion

This chapter has established a comprehensive theoretical foundation for the development of a traffic violation reporting platform specifically designed for the Algerian context. We began by defining key concepts and exploring the legal and financial framework surrounding traffic violations in Algeria. This analysis included the four-degree classification system, associated penalties, and revenue allocation strategies. Subsequently, we reviewed existing literature on traditional enforcement methods and citizen engagement strategies. This highlighted the gaps that our proposed platform aims to address, namely through features like gamification and anonymity to encourage reporting. Furthermore, an examination of existing technological solutions and citizen reporting avenues in Algeria provided valuable insights into user behavior and platform functionalities. By drawing on this comprehensive theoretical foundation encompassing legal frameworks, enforcement strategies, citizen engagement principles, and the technology landscape, we are well-positioned to proceed with the design and architecture of our traffic violation platform in the next chapter.

CHAPTER 2

DESIGN AND ARCHITECTURE

3.1 Introduction

The previous chapter outlined the goals and requirements of the proposed traffic violation reporting platform. This chapter describes the methodology used to design the structure and architecture of the platform. The design approach utilizes Unified Modeling Language (UML) diagrams to visually represent the platform's components and their relationships. The chapter also identifies the specific technologies and software tools that will be employed to implement the designed platform.

The design methodology involved analyzing the requirements and conceptualizing an overall system architecture. Key components were identified and their interactions were mapped out. UML diagrams were then created to formally document the design in a standardized visual language.

Different UML diagram types were used, including use case, class, and sequence diagrams. Use case diagrams captured the platform's functionality from the user's perspective. Class diagrams modeled the system's static structure in terms of classes and relationships. Sequence diagrams specified the dynamic behavior and messaging patterns.

After establishing the logical design via UML, the chapter discusses the specific technologies selected to construct the physical implementation. Web and mobile development frameworks, databases, cloud services, and other tools are examined based on criteria like performance, scalability, security and cost-effectiveness. The rationale for chosen technologies is provided.

In summary, this chapter bridges the conceptual vision from the previous chapter to a technical specification by using standard design practices and preparing for actual implementation in subsequent stages.

3.2 Methodology

Drawing upon the critical insights gleaned from Chapter 1 regarding limitations in existing traffic violation reporting platforms, this section outlines the methodological framework employed to design and develop our novel solution. Here, we delve into the specific research methods and techniques utilized to bridge the identified gaps and ultimately foster a robust and user-centric platform tailored to the Algerian context.

3.2.1 Engagement

To incentivize sustained user participation, our platform incorporates a gamified reward system that financially compensates users for submitting accurate and verifiable traffic violation reports. This approach departs from traditional "violation reporting" branding, potentially burdened by negative connotations or associations with informants. Instead, we conceived the application under the moniker "Traffic Bounty Hunter." This nomenclature aims to foster a sense of civic pride and social responsibility within users. It subtly shifts the focus from reporting solely for personal gain to contributing to a safer society. Furthermore, the financial incentive reinforces the user's role as a vital component of law enforcement, akin to a "camera for hire," analogous to the idiom "gun for hire." This terminology subtly reframes the perception of reporting and potentially attracts a wider user base.

3.2.2 Trust Deficits and Validation Accuracy

Prior research has identified a critical challenge related to citizen engagement in traffic violation reporting: a lack of trust in the police force's capacity to effectively address reported violations. To mitigate this concern, our platform incorporates a decentralized validation system designed to ensure fairness and accuracy.

This system mandates that each report be reviewed and categorized by a minimum of two law enforcement officers. In the event of a discrepancy between the initial assessments, a conflict resolution protocol is triggered, involving a third officer as a tie-breaker. A two-thirds majority vote determines the final report disposition. This approach fosters transparency and minimizes the potential for bias within the validation process. Additionally, upon report approval, the designated officer is immediately prompted to initiate the corresponding paperwork. This time-sensitive action aims to address a commonly observed behavior – procrastination in initiating official procedures.

The perceived burden of paperwork is leveraged as a deterrent against unnecessary delays in addressing validated reports. In essence, this robust validation mechanism strives to instill trust in the system and ensure the swift and equitable resolution of reported traffic violations.

3.2.3 Combating Misuse and Ensuring Data Authenticity:

Analogous to social media and online gaming platforms, decentralized validation systems are inherently susceptible to spam and malicious manipulation. To address these concerns, our platform implements a multi-pronged approach safeguarding data integrity and deterring misuse.

First, mandatory user registration necessitates the provision of verifiable identification and credit card information. This aligns with the conceptual framework of a "hired worker" model, wherein users are financially compensated for accurate reporting, akin to receiving bounties for their efforts. However, deliberate submission of fabricated evidence constitutes a violation of our platform's terms of service and warrants user termination, essentially resulting in dismissal from their position within the system.

Second, to authenticate the veracity of reported evidence, our platform employs a multifaceted strategy. This includes embedding location data within the metadata of media files (photos and videos), incorporating a covert digital watermark for additional verification, and transmitting all data in an encrypted format. The embedded location data establishes the geographical context of the reported violation. The covert watermark serves as a unique identifier, allowing for the tracking and authentication of evidence origin. Furthermore, data encryption safeguards against unauthorized access and manipulation during transmission. In essence, the mobile application embeds location and timestamp information within the media file's metadata. Subsequently, a hidden watermark is applied, and the entire data package is encrypted before transmission over a secure network to our server. The server then verifies the authenticity of the report's media using a combination of the watermark and location data. If the data matches the expected parameters and originates from our authorized phone application, a report is generated within our database. Conversely, if discrepancies are detected, the user responsible for the submission faces potential sanctions, including termination of their access to the platform.

3.2.4 Incentivizing Accurate Reporting

3.2.4.1 Enhancing Evidence Accuracy Through Server-Side Media Processing:

To bolster the veracity of user-submitted evidence, our platform incorporates a dedicated media processing module on the server side. This module leverages object detection algorithms to analyze photos and videos captured by users. Upon submission, the user is presented with a selection of vehicle types depicted within the media. This user-assisted classification further refines the object detection process. Furthermore, the media processor attempts to extract vehicle speed data from video evidence whenever feasible. The extracted data serves as an ancillary element to support the user's report and potentially expedite the validation process.

Additionally, upon request by the validating officer, the platform can deliver frame-by-frame playback functionality for the submitted video evidence. This granular analysis empowers law enforcement personnel to meticulously scrutinize the evidence and corroborate the reported violation details.

3.2.4.2 Through Gamified Rewards

To encourage users to submit high-fidelity traffic violation reports, our platform incorporates a gamified reward system. This system assigns user ranks based on a multifaceted criterion, encompassing both the quantity and veracity of submitted reports. Users with demonstrably accurate reporting histories ascend through the ranking hierarchy, consequently qualifying for enhanced bounty rewards. As user participation expands and the platform fosters a competitive environment, the potential for incorporating additional tiers of rewards specifically designated for top-ranking user's merits exploration.

I Operationalization of the Ranking System:

The user ranking algorithm factors in two primary variables:

- **Number of Reports:** The sheer volume of reports submitted by a user contributes to their overall ranking. However, quantity alone is insufficient for achieving a high rank.
- **Report Accuracy:** The platform meticulously evaluates the accuracy of each submitted report. Veracity is demonstrably established through a combination of factors, potentially including

corroborating evidence from multiple users or law enforcement validation. Reports confirmed as accurate significantly bolster a user's ranking.

II Theoretical Underpinnings

This gamified approach to user engagement draws upon the well-established psychological principles of operant conditioning. By directly linking accurate reporting behavior with the potential for increased rewards (higher bounty percentages and potential exclusive rewards for top-ranked users), the platform seeks to cultivate a user base that consistently strives for accuracy and fosters a culture of responsible civic engagement.







Badge						
Rank	Officer	Detective	Sergeant	Lieutenant	Captain	Chief
Number of reports	>=10	>=10	>=10	>=25	>=30	>=50
Accuracy	20%...40%	41%...60%	61%...70%	71%...80%	81%...90%	91%...100%
Bounty Percentage	3%	6%	9%	12%	15%	20%

Table 3.1 Ranking System

3.2.5 User Data Privacy and Security Measures

Our platform prioritizes the protection of user data and adheres to a stringent privacy policy and comprehensive terms of service. These legal instruments safeguard user identities and prevent unauthorized disclosure. The user registration process collects a national identification number as the sole element retained from the identification information. This limited data point is solely utilized for internal administrative purposes, such as enforcing the platform's terms of service. In the event of a user breaching the terms of service, their access to the platform may be suspended or permanently terminated, analogous to dismissal from employment. However, under no circumstances is the user's national identification number ever disclosed to external entities or employed for any purpose beyond internal platform administration.

3.3 System Design

The cornerstone of any technological solution lies within its architectural design. This section delves into the system architecture of the Traffic Bounty Hunter platform, meticulously outlining the interconnected components that orchestrate its functionalities. Employing the Unified Modeling Language (UML), we present a series of diagrams that visually represent the actors, their interactions, and the underlying class structure. These diagrams serve as a blueprint, elucidating the system's operational logic and facilitating a comprehensive understanding of its inner workings. Through this analysis, we aim to demonstrate how the Traffic Bounty Hunter platform translates theoretical concepts into a cohesive and effective solution for fostering citizen engagement in traffic violation reporting.

3.3.1 Use Case Diagram

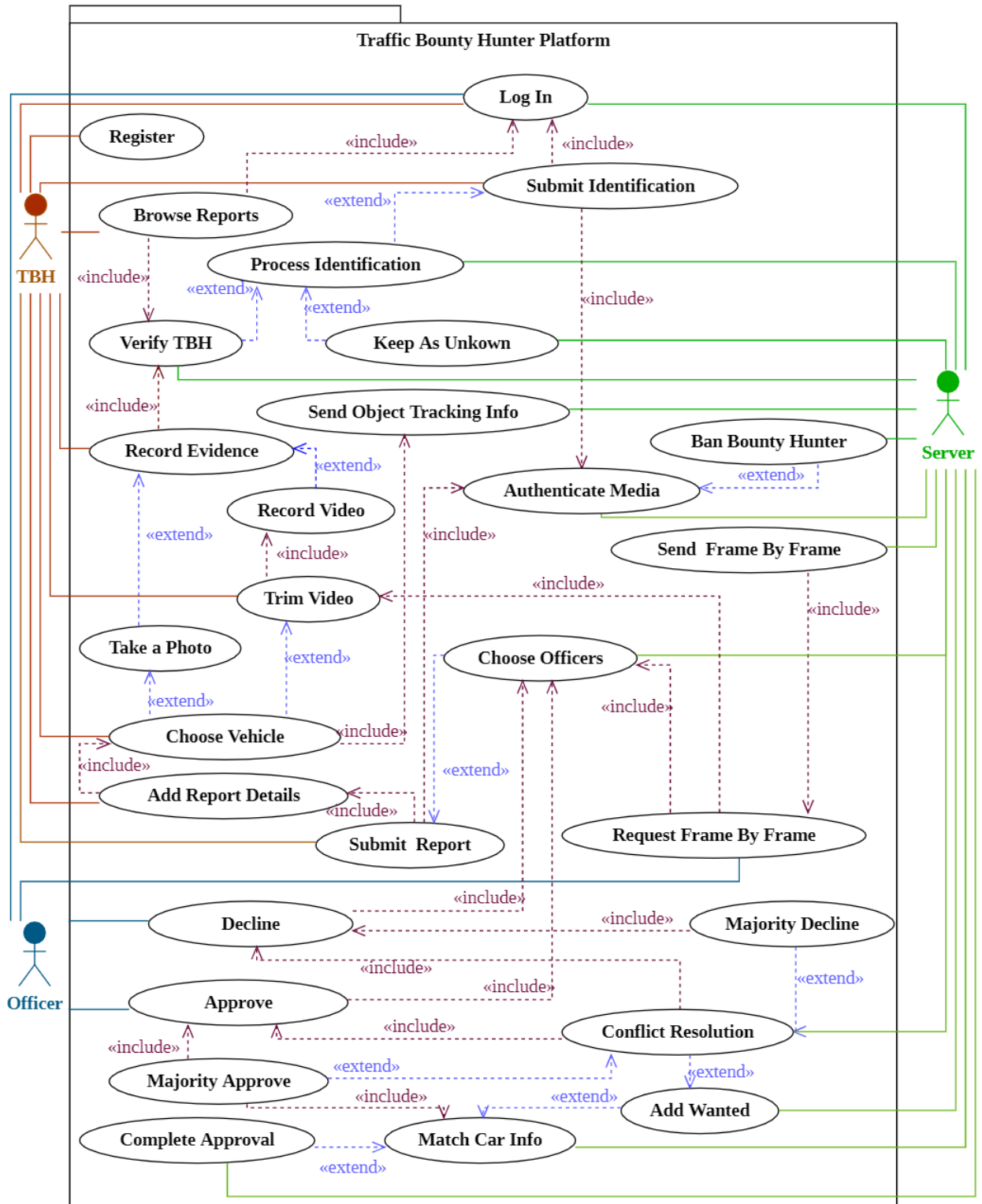


Figure 3.1: TBH Use Case diagram

The image represents a use case diagram for the "Traffic Bounty Hunter Platform", The diagram illustrates the various actors, use cases, and their relationships within this platform.

The primary actors in this system are the Traffic Bounty Hunter (TBH), and the Officer. The TBH initiates the process by registering, logging in, and submitting identification credentials. Subsequently, the TBH can perform various actions, such as browsing reports, verifying their TBH status, recording evidence (including video and photos), choosing a vehicle, and adding report details.

Once the report is submitted, the Server component of the system comes into play. The Server authenticates the submitted media and sends frame-by-frame information to the Officers. The Officers can then review the report, request additional frame-by-frame information, and make a decision to approve, decline, or initiate a conflict resolution process.

The conflict resolution process involves multiple Officers, where a majority decision is required for approval or decline. If approved, the system matches the car information and potentially adds the car to a wanted list. If declined, the process ends.

The diagram illustrates the various use cases, their relationships (includes and extends), and the flow of actions between the different actors and components of the system. It provides a high-level representation of the functionality and interactions within the Traffic Bounty Hunter Platform.

3.3.2 Class Diagram

In this class diagram, we observe a comprehensive system architecture for the Traffic Bounty Hunter platform.

The primary actors are the Traffic Bounty Hunter -TBH for short- and the Officer, while the Server acts as the central repository and orchestrator of the entire process.

The User entity encompasses three attributes Id, Identifier, Email, Password, and two methods Login and GetId.

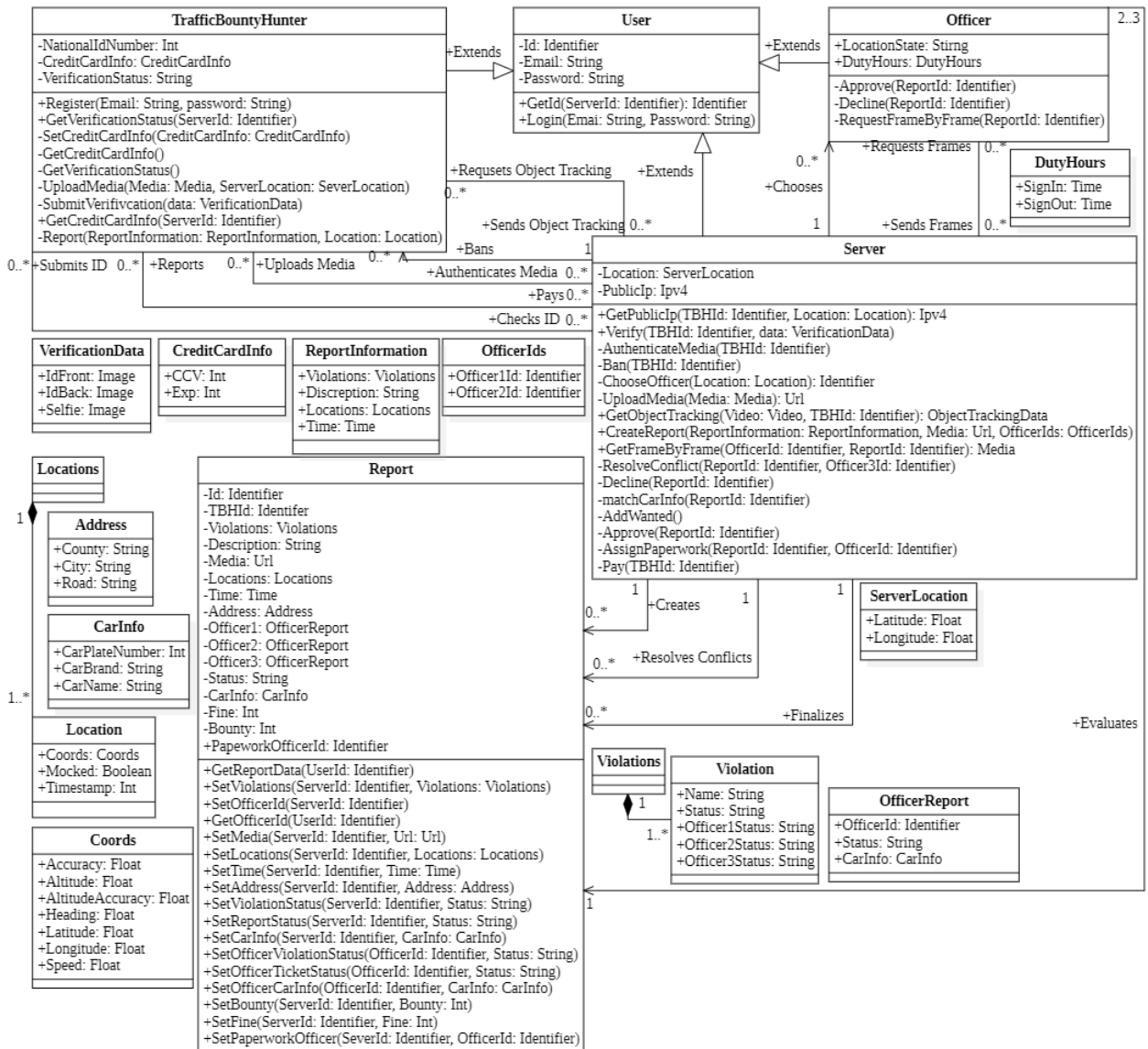


Figure 3.2: TBH Class Diagram

Each one of our three actors are users. Their role determines their privileges, functions and specific attributes.

Traffic bounty hunters can interact with the system by Uploading Media and Requesting Object Tracking data from the Server.

The Server is responsible for authenticating TB, validating their identification credentials (ChecksID), and authorizing their actions. It maintains a PublicIpv4 attribute and provides methods for GetPublicIp, Verify, AuthenticateMedia, Ban, and ChooseOfficer. The Server also manages the creation and retrieval of object tracking data (CreateReport, GetObjectTracking) and facilitates the review and approval process (DeclineReport, MatchCarInfo, AddWanted, ApproveReport, AssignPapework, Pay).

The Officer entity inherits from the User class and extends its functionality with two attributes LocationState and DutyHours, and methods such as ApproveReportId, DeclineReportId, and RequestFrameByFrame. Officers can request frames from the Server for review and analysis.

The Report class encapsulates information related to traffic violations, including Id, TBHId, Violations, Descriptions, Locations, Time, Address, and CarInfo. It also maintains references to OfficerReport instances, which capture the individual assessments and status updates from each assigned Officer.

The CarInfo class represents the details of the vehicle involved in a reported violation. CarPlateNumber, CarBrand and CarName.

The Location class models the geographical coordinates and metadata associated with a reported violation; Coords, Mocked status, and Timestamp.

The VerificationData class encapsulates the identification credentials of a User, such as IdFront, IdBack, and Selfie images.

The CreditCardInfo class stores the credit card information of a Traffic Bounty Hunter, including Exp, and CVV.

The Violation class represents the type and details of a reported traffic violation, including Name, Status, OfficerStatus strings.

The OfficerReport class captures the assessment and status updates provided by an Officer for a specific violation case.

The ServerLocation class models the geographical coordinates (Latitude, Longitude) of the Server's physical location.

Overall, this class diagram outlines a comprehensive part of the system architecture for the Traffic Bounty Hunter platform.

3.3.3 Sequence Diagrams

3.3.3.1 Verification

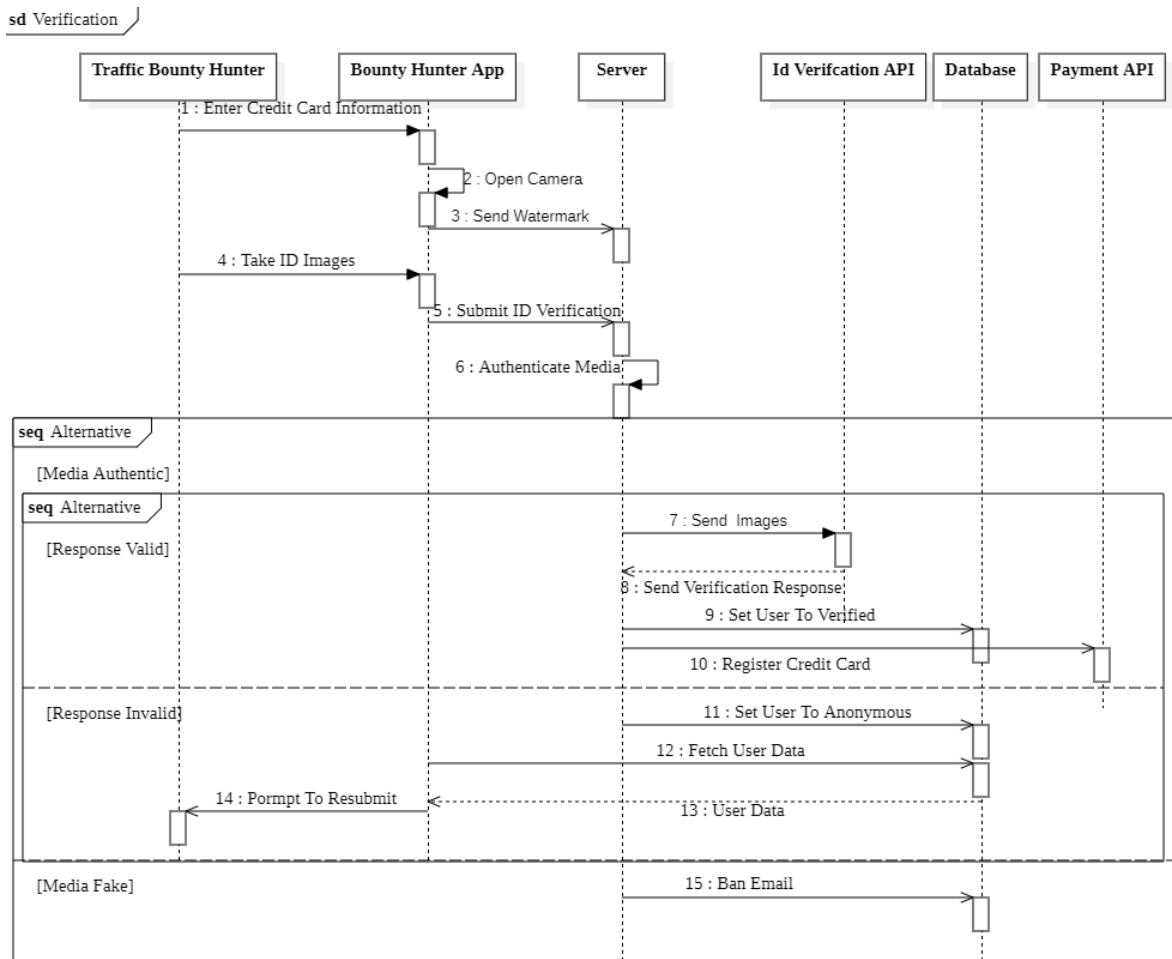


Figure 3.3: Verification Sequence Diagram

The figure depicts the initial identity verification and reporting submission process. TBHs must first register by providing credit card information and undergoing an ID verification process with the Server (steps 1-6). Once verified, TBHs can submit reports by capturing images through the Bounty Hunter App, which are authenticated by the Server (steps 5-6). Depending on the

authentication result, the user's status is updated as either verified or anonymous (steps 7-9). The Server fetches and provides user data to the App (steps 10-11).

3.3.3.2 Report Submission

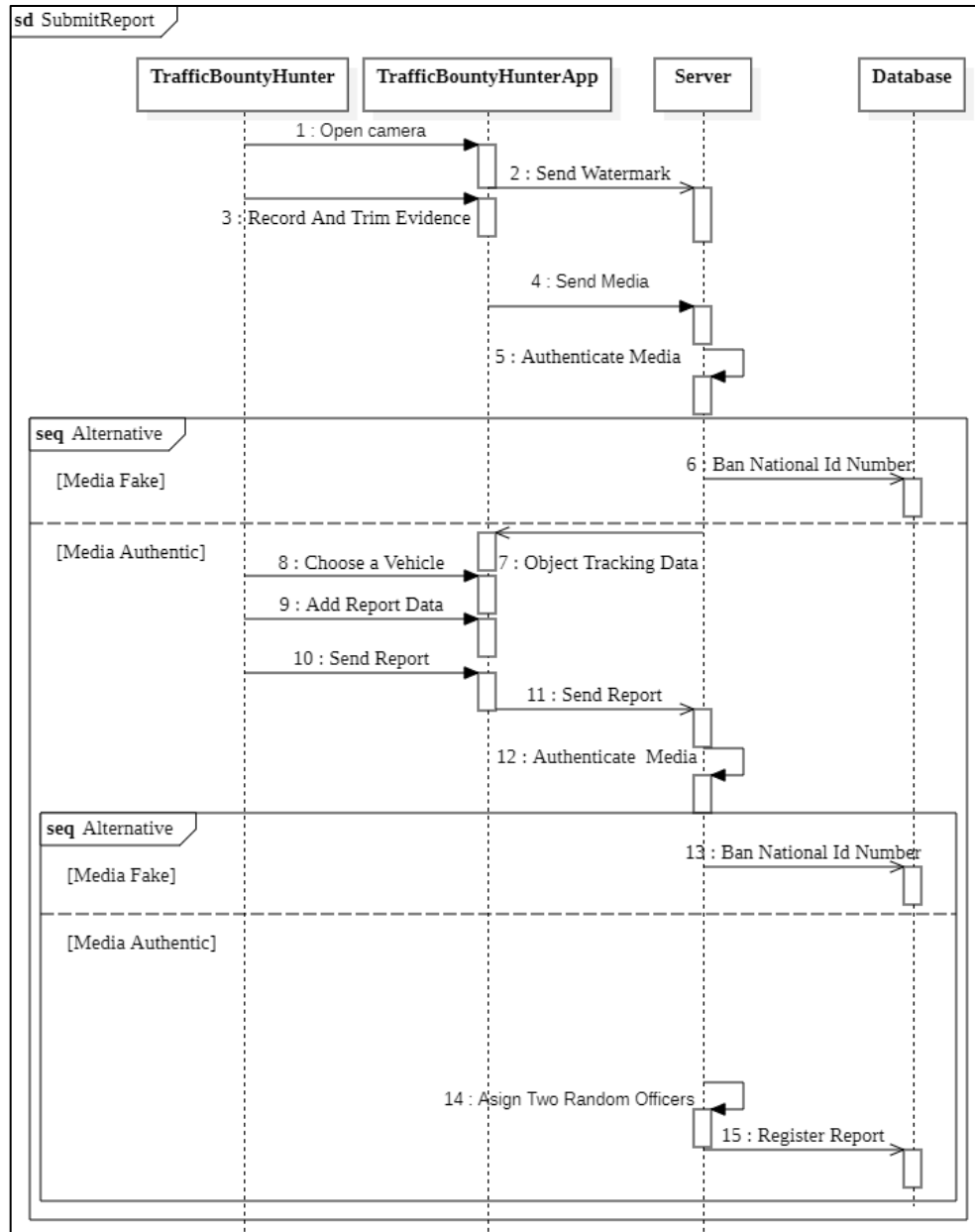


Figure 3.3: Report Submission Sequence Diagram

The figure illustrates the report submission process. TBHs record and send media evidence to the Server (steps 1-2), which authenticates the media (step 3). If the media is deemed inauthentic, the TBH's national ID number is banned (step 4). Otherwise, the TBH proceeds to choose a vehicle, add report data, and submit the report (steps 6-9). The Server authenticates the media again (step

10) and either bans the TBH's national ID number (step 11) or assigns two random officers and registers the report (steps 12-13).

3.3.3.3 Report Validation

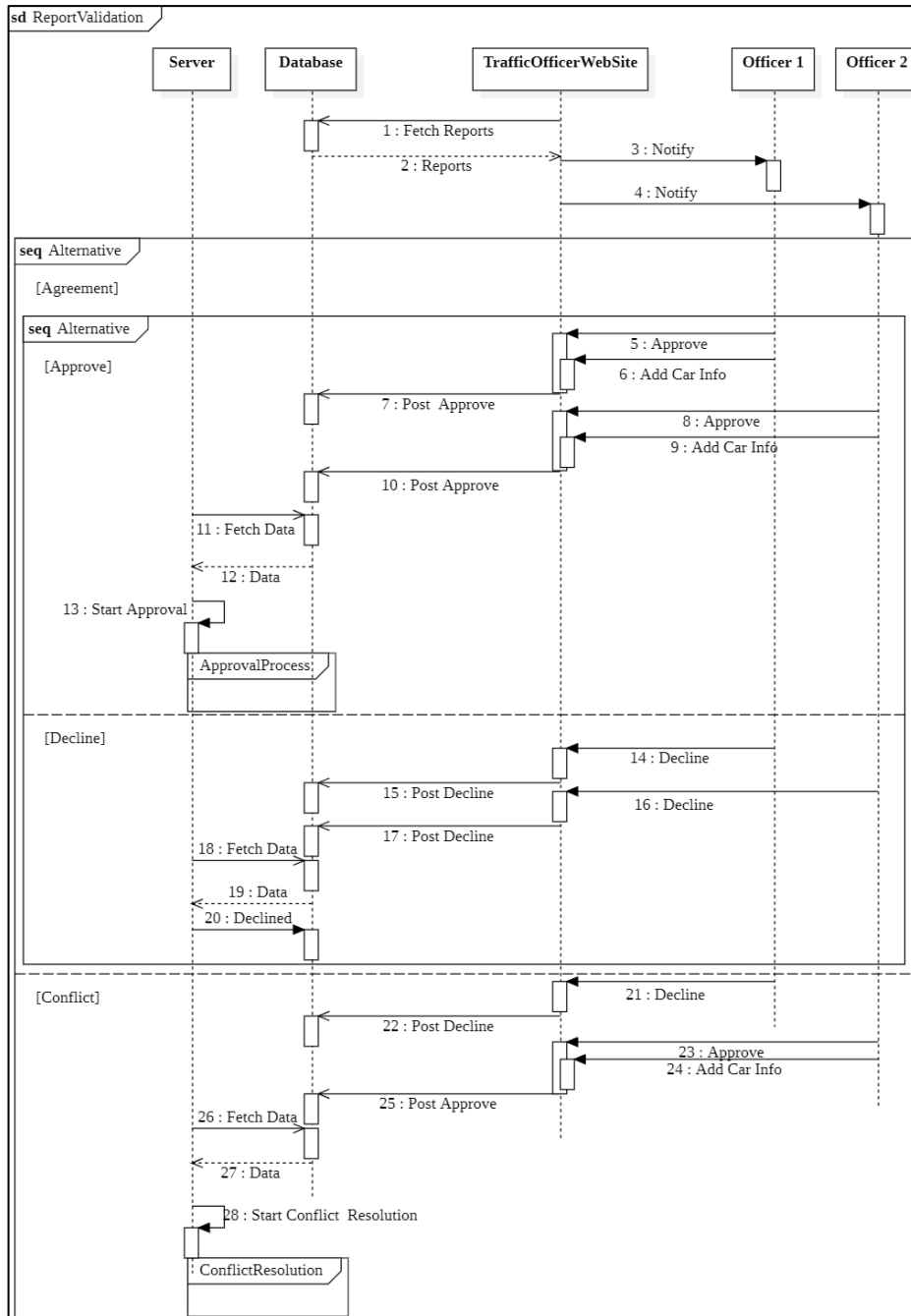


Figure 3.4: Report Validation Sequence Diagram

The figure depicts the report validation process. The Server fetches reports (steps 1-2) and notifies the assigned Officers (steps 3-4). Officers can either approve or decline the report. If both Officers approve, they add car information (steps 5-6, 8-9), and the Server posts the approval (steps 7, 10). If one Officer approves and the other declines, a conflict resolution process is initiated (steps 21-28). If both Officers decline, the Server posts the decline (steps 14-17).

3.3.3.4 Conflict Resolution

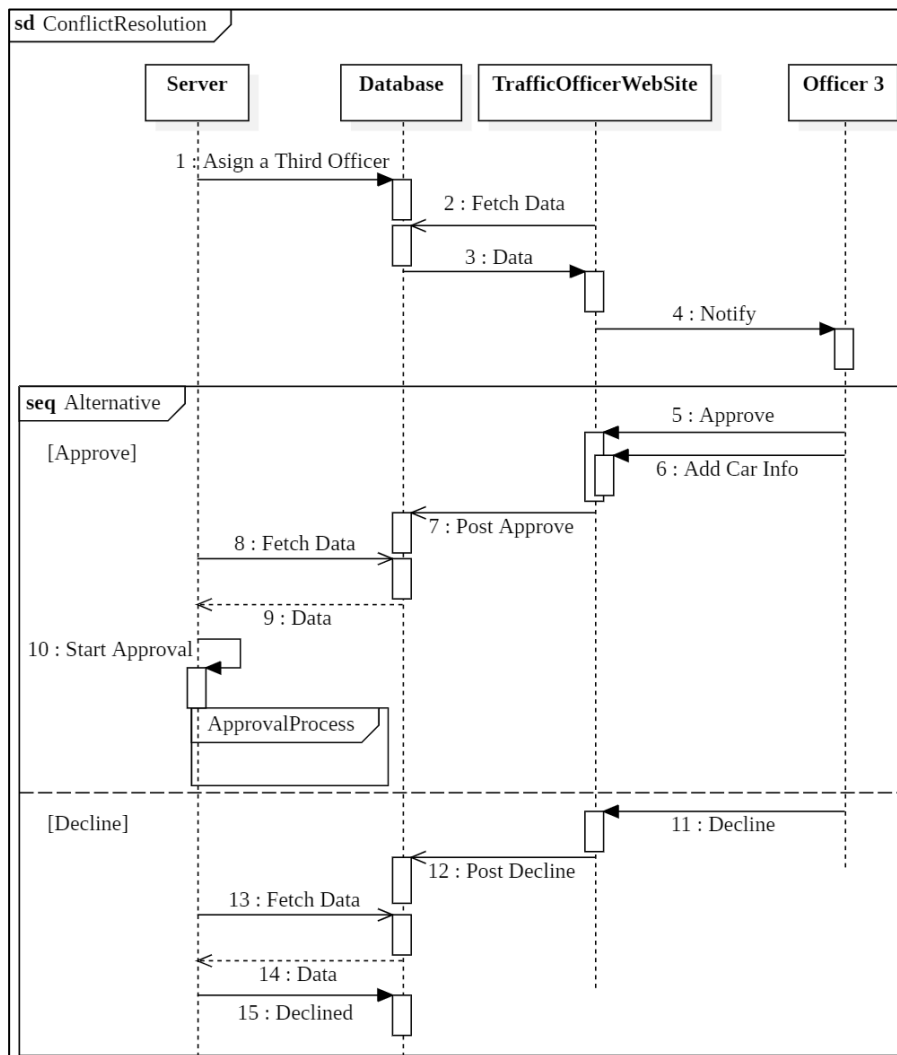


Figure 3.5: Conflict Resolution Sequence Diagram

Figure 3.5 illustrates the conflict resolution process. The Server assigns a third Officer (step 1), who is notified with report data (steps 2-4). The third Officer can approve or decline the report. If approved, car information is added, and the approval is posted (steps 5-7). If declined, the decline is posted (steps 11-12).

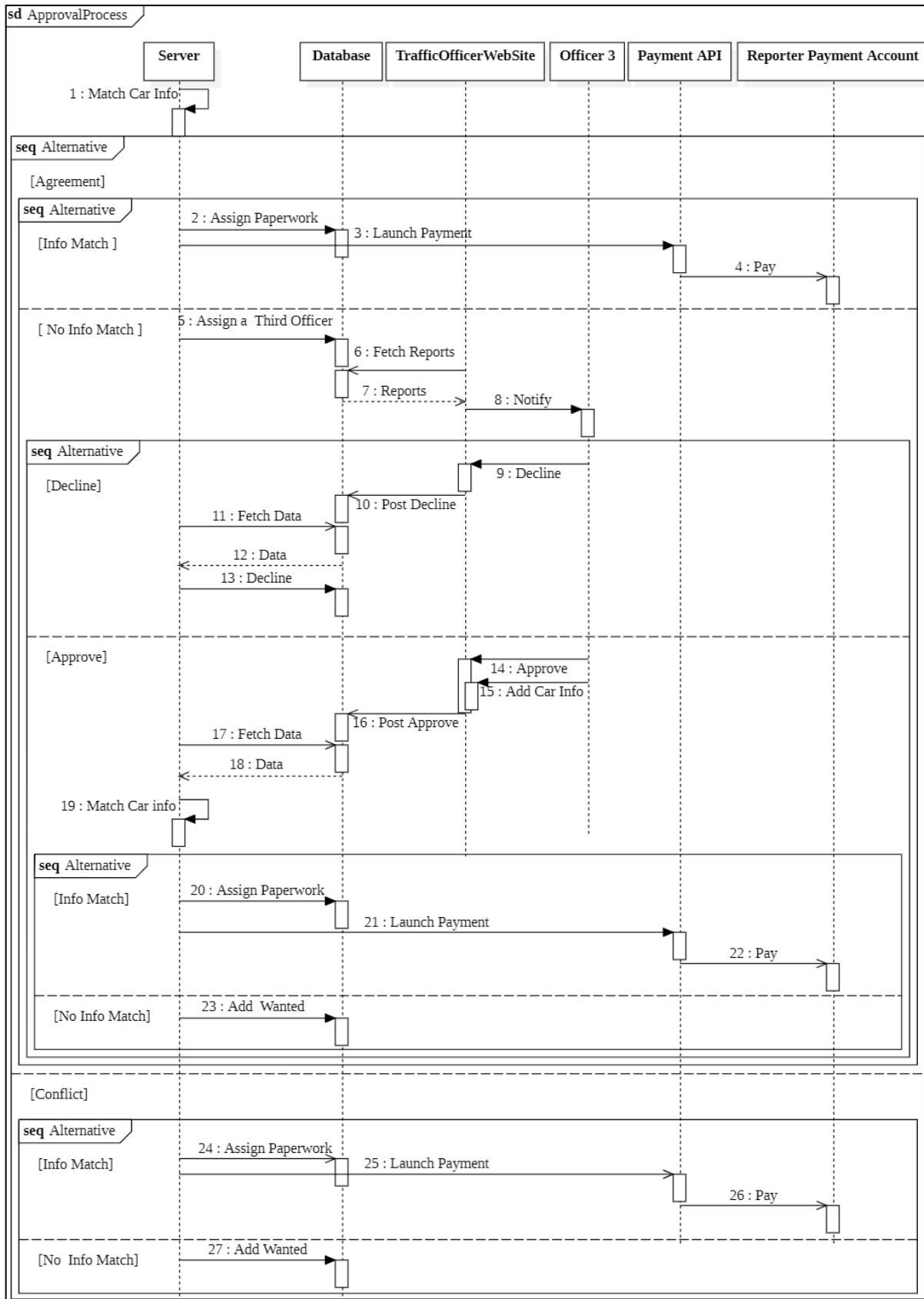


Figure 3.6: Approval Process Sequence Diagram

And figure 3.6 depicts the approval process. The Server matches the car information provided by Officers (step 1). If the information matches, paperwork is assigned, and the payment process is launched (steps 2-4). If the information does not match, a third Officer is assigned (step 5), who can approve, decline, or initiate conflict resolution (steps 6-28). If approved, the payment process is launched (steps 21-22, 25-26). If declined, the reported party is added to the wanted list (steps 23, 27).

3.4 Technology Stack

This section meticulously dissects the technological foundation upon which the Traffic Bounty Hunter platform is constructed. A well-chosen technology stack is paramount to ensuring the platform's functionality, scalability, and user experience. We delineate the specific technologies employed within the front-end, back-end, and development toolsets, along with a rationale for their selection.

3.4.1 Front-End Technologies:

3.4.1.1 Website Front-End

I React.js

This JavaScript library serves as the cornerstone of the website's front-end development. React.js facilitates the creation of dynamic and interactive user interfaces, enabling the seamless presentation of information and navigation elements within the Traffic Bounty Hunter platform. Furthermore, React.js empowers the implementation of engaging animations, enhancing user experience and fostering a visually appealing platform.

II Leaflet

Leveraging the React Leaflet library, we incorporate Leaflet, a popular open-source JavaScript library, to render an interactive map within the website's front-end. While initial considerations involved Google Maps and its corresponding API, the process of acquiring an API key presented unforeseen complexities. Leaflet, in conjunction with JawgLab, offered a viable alternative, allowing us to construct and display custom maps that effectively meet the platform's requirements.

3.4.1.2 Mobile App Front-End

I React Native

Building upon the success of React.js in the website's front-end, we extend its reach to the mobile application through React Native. This JavaScript framework empowers the development of cross-platform mobile applications, enabling a unified user experience across various operating systems. React Native's extensive documentation and readily available packages streamline the development process, accelerating the creation of a robust mobile application for the Traffic Bounty Hunter platform.

II Expo

Recognizing the advantages of well-documented and readily available development tools, we opted to utilize Expo for the mobile application development process. Expo provides a streamlined environment for building, testing, and deploying React Native applications. However, during development hours, the build times within Expo presented a minor obstacle.

To circumvent this challenge, we implemented Windows Subsystem for Linux 2 (WSL2) within the Windows development environment. This integration allowed us to leverage the efficiency of Expo's development tools while mitigating the limitations imposed by build times during working hours.

```
PS C:\Users\Coda.Ox\AllPolice> eas build --platform android
Loaded "env" configuration for the "production" profile: no environment variables specified. Learn more: https://docs.expo.dev/build-reference/variables/
✓ Using remote Android credentials (Expo server)
✓ Using Keystore from configuration: Build Credentials TNSzBzGlQ0 (default)

Compressing project files and uploading to EAS Build. Learn more: https://expo.fyi/eas-build-archive
✓ Compressed project files 6s (202 MB)
Your project archive is 202 MB. You can reduce its size and the time it takes to upload by excluding files that are unnecessary for the build process in .easignore file. Learn more: https://expo.fyi/eas-build-archive
✓ Uploaded to EAS 2m 59s
✓ Created project metadata file
✓ Uploaded to EAS
This account has used its builds from the Free plan this month, which will reset in 19 hours (on Sat Jun 01 2024). Upgrade your plan for more builds with shorter wait times and longer timeouts, and to run more builds concurrently with a subscription plan. https://expo.dev/accounts/coda.brk/settings/billing
Error: build command failed.
```

Figure 3.7: Expo temporary Build Ban While Debugging

III React Native Vision Camera:

The mobile application's core functionality hinges upon the ability to capture traffic violation evidence. React Native Vision Camera seamlessly integrates with React Native, providing a robust and native-like camera experience within the mobile application. This library empowers users to capture photos and videos of traffic violations, forming the backbone of the evidence collection process within the Traffic Bounty Hunter platform.

IV Expo Location

Accurately pinpointing the location of reported violations is crucial for effective law enforcement action. Expo Location grants the mobile application access to the user's device location, enabling the precise geospatial tagging of submitted reports. This functionality ensures that reported violations are appropriately linked to their geographical context.

V React Native WebView

In specific instances, the need to integrate external web content within the mobile application arises. React Native WebView facilitates the seamless embedding of web pages within the native mobile application, offering flexibility in content presentation when necessary.

VI FFmpeg through React Native FFmpegKit and FFmpegKit

The ability to trim captured videos evidence is paramount for ensuring a and suitability for use within the platform. We integrated FFmpeg, a powerful multimedia framework, through React Native FFmpegKit and FFmpegKit. This integration empowers the mobile application to perform essential tasks such as video trimming, potentially watermarking media for added security, and potentially embedding additional metadata within the media files.

VII Crypto-js

As a security measure, the platform may explore the implementation of watermarks within submitted media evidence. Crypto-js, a JavaScript library for cryptographic operations, offers the potential to create encrypted watermarks that bolster the tamper-proof nature of the evidence.

3.4.2 Back-End Technologies

3.4.2.1 Firestore

Managing the vast amount of data associated with user accounts, report details, and other platform elements necessitates a robust and scalable database solution. Firestore, a NoSQL document database offered by Google Firebase, proves advantageous in this context. Its non-relational structure offers flexibility in data storage and retrieval, particularly well-suited for the dynamic nature of the Traffic Bounty Hunter platform. Furthermore, Firestore's scalability ensures that the platform can accommodate a growing user base and increasing data volume without compromising performance.

3.4.2.2 Node.js

Serving as the foundation for the back-end server infrastructure, Node.js, an open-source JavaScript runtime environment, empowers the platform to handle incoming server requests efficiently. Node.js's event-driven architecture and asynchronous nature make it adept at managing a high volume of concurrent user interactions within the Traffic Bounty Hunter platform.

I ID Analyzer API

User authentication and verification are paramount for platform security. The ID Analyzer API integrates with the platform to verify user identification. This API securely validates the authenticity of user-provided identification documents, mitigating the risk of fraudulent activity within the Traffic Bounty Hunter platform.

II Chargily API

The Traffic Bounty Hunter platform may potentially incorporate a reward system to incentivize user participation in reporting traffic violations. Chargily API, a potential component within the back-end, offers a solution for managing CIB and Dahabia ATM cards transaction within the platform.

III OpenCV

To bolster the accuracy and efficiency of evidence processing, the platform may leverage OpenCV, an open-source library for real-time computer vision. OpenCV's object detection

capabilities can be integrated within the back-end to potentially automate the identification of specific objects within submitted photos and videos. This automation can expedite the processing of evidence and potentially assist in filtering out irrelevant or low-quality reports.

IV FFmpeg

As previously mentioned within the front-end technology discussion, FFmpeg plays a crucial role in manipulating videos. In the back-end context, FFmpeg's frame-by-frame analysis capabilities can be harnessed for more in-depth video processing. This functionality can potentially support tasks such as anomaly detection or extracting additional forensic details from submitted video evidence.

3.4.3 Development Tools

3.4.3.1 Webpack

While React Native is adept at mobile application development, specific scenarios may necessitate the creation of custom JavaScript bundles for rendering within the mobile application. Webpack serves as a module bundler, facilitating the efficient creation of optimized JavaScript bundles that can be seamlessly integrated with React Native WebView for rendering within the mobile application. This empowers developers to leverage custom JavaScript functionalities when required within the Traffic Bounty Hunter mobile application.

3.4.3.2 WSL2 (Windows Subsystem for Linux 2)

As discussed within the mobile app front-end section, Expo offered a streamlined development environment but presented challenges with build times during working hours. WSL2 provided a solution by establishing a Linux subsystem within the Windows development environment. This integration allowed us to leverage the efficiency of Expo's development tools while mitigating the limitations imposed by build times during specific working hours.

By meticulously selecting and integrating these diverse technologies, the Traffic Bounty Hunter platform will establish a robust and scalable foundation. This technology stack will empower the platform to deliver a seamless user experience, ensure secure data storage and transmission, and facilitate efficient evidence processing. The platform's architecture is designed

to accommodate future growth and adapt to evolving technological advancements, ensuring its continued effectiveness in promoting responsible traffic reporting behavior.

3.5 Conclusion

In this chapter, we elucidated the overarching methodology and system design paradigm underpinning the Traffic Bounty Hunter Platform. Through a rigorous and systematic approach, we devised a comprehensive blueprint that delineates the intricate interplay of actors, use cases, and their interdependencies within the platform's ecosystem.

Our meticulous planning process encompassed a holistic examination of the platform's functional requirements, spanning the gamut of user registration, authentication, incident reporting, evidence gathering, and adjudication procedures. Guided by principles of robustness, scalability, and user-centricity, we architected a modular and extensible system that harmoniously integrates the disparate components into a cohesive whole.

The overarching design philosophy embraced a judicious balance between empowering the Traffic Bounty Hunters with streamlined reporting mechanisms while ensuring stringent checks and balances to maintain the integrity of the adjudication process. This delicate equilibrium was achieved through a meticulously crafted workflow that seamlessly orchestrates the interactions between the Bounty Hunters, the Server, and the Officers.

Furthermore, we expounded on the intricate decision-making algorithms that govern the resolution of contested incidents, incorporating robust conflict resolution protocols and majority voting mechanisms. These safeguards are pivotal in upholding the system's credibility and fostering trust among all stakeholders.

In summation, the comprehensive system design and methodology delineated in the preceding chapter lay the foundation for the successful implementation and deployment of the Traffic Bounty Hunter Platform. The subsequent chapter will elucidate the tangible manifestation of these plans, detailing the realized functionalities, performance metrics, and empirical validation of the platform's efficacy in the real-world context.

CHAPTER 3

Implementation

4.1 Introduction

In the preceding exposition, we meticulously delineated the theoretical underpinnings and architectural blueprint that served as the bedrock for the conception and design of the Traffic Bounty Hunter Platform. Having established a robust methodological framework, we now embark upon an empirical odyssey, delving into the manifestation of our rigorously formulated plans in the realm of tangible implementation.

Chapter three marks a pivotal juncture in our discourse, where we traverse the chasm from abstraction to realization, scrutinizing the outcomes of our endeavors through the uncompromising lens of empirical evidence. Herein, we shall unveil the triumphs and tribulations that emerged during the actualization of our envisioned system, offering an unflinching account of the accomplishments and shortcomings that characterized this arduous endeavor.

Through a comprehensive evaluation of the platform's performance metrics, we shall quantify its efficacy in fulfilling the prescribed functional requirements, underscoring its strengths and identifying areas that necessitate further refinement. This critical analysis will not only elucidate the system's current capabilities but also illuminate the inherent limitations that circumscribe its operational scope.

Moreover, we shall embark on a retrospective journey, dissecting the implementation process itself, extracting valuable insights and lessons that can inform and fortify future endeavors of a similar nature. By candidly examining the challenges encountered and the strategies employed to surmount them, we aim to contribute to the collective knowledge repository, enabling subsequent generations of innovators to navigate analogous undertakings with greater adroitness.

Ultimately, this chapter will serve as a testament to the indomitable spirit of scientific inquiry, where hypotheses are put to the crucible of empirical validation, and the boundaries of knowledge are continually expanded. Through a judicious amalgamation of quantitative data,

qualitative observations, and critical introspection, we shall paint a comprehensive portrait of the Traffic Bounty Hunter Platform's real-world manifestation, laying the groundwork for its continued evolution.

4.2 Results

This section delves into the realized functionalities of our traffic violation reporting platform, encompassing both the mobile app and website. We'll dissect the achievements - how our theoretical concepts translated into real-world functionalities - alongside the challenges encountered during development. This analysis sheds light on areas for improvement and paves the way for future iterations designed to optimize traffic safety reporting.

4.2.1 Challenges and Limitation

4.2.1.1 Server Development Obstacles

During the server development phase, the project encountered significant challenges due to time constraints and Android security protocols. Attempts to establish a connection between the server and the TBH app proved unsuccessful, even after the implementation of a custom SSL certificate installed on the test subject. Further research led to the exploration of Heroku as a potential solution.

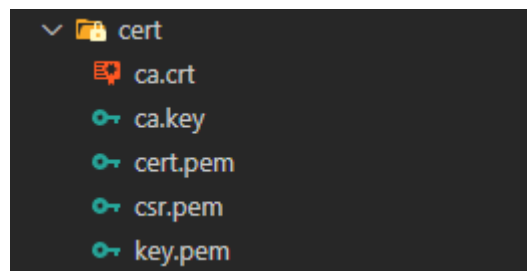


Figure 4.1: Created SSL Certificate

4.2.1.2 Heroku Deployment Considerations

Deploying the server on Heroku revealed a quota-based system that posed concerns, especially in light of the previous experience with Expo EAS, which resulted in a temporary ban due to excessive app building. Moreover, the system under development was expected to be resource-intensive, involving object detection, media manipulation, and media authentication, which are computationally demanding processes.

4.2.1.3 Current Backend Functionality

At present, the backend server and its associated features are non-functional. However, the platform's primary purpose has been achieved through front-end implementation, albeit without robust security measures, which is acceptable for the development stage. Critical functionalities such as ID verification, media authentication, object detection, video frame dissection, and a comprehensive security system remain unavailable.

4.2.1.4 Firestore Security

Due to the impending deadline, the Firestore database has not yet been secured with Firestore security rules, rendering the system highly vulnerable to potential threats.

4.2.1.5 Monetary Transaction Limitations

A significant obstacle encountered during the project was the inability to facilitate money transfers through the Algerian monetary system from the server to TBH's. Inquiries made to the support team of the leading payment API provider in Algeria, "ChargilyPay," yielded a response of "not yet," indicating that this functionality is currently unavailable.

4.2.2 Achievements

4.2.2.1 Interface

I Web Site

To facilitate efficient report evaluation, the platform provides officers with a dedicated web portal featuring a user-friendly interface.

I.I Login Page

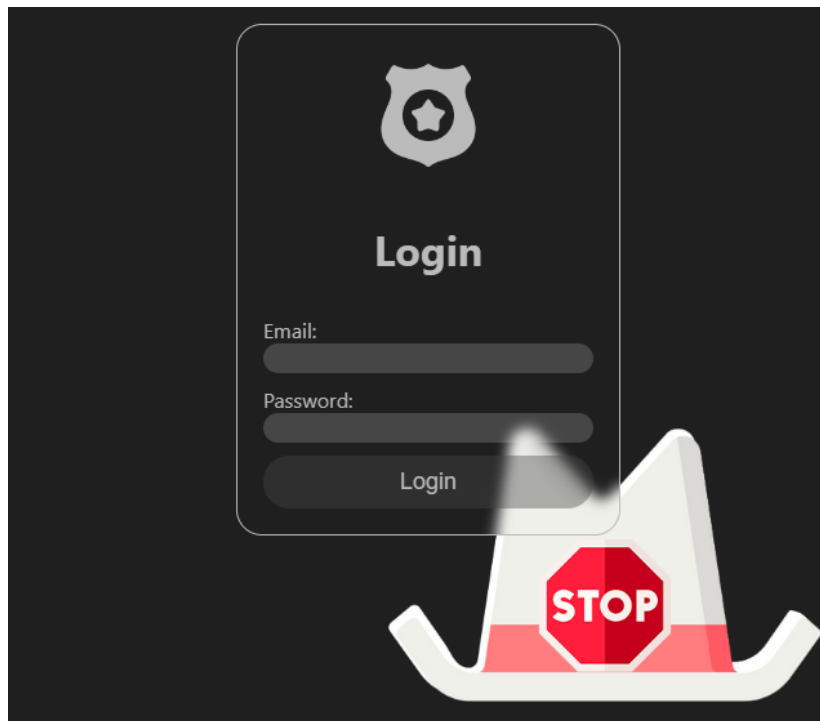


Figure 4.2: Traffic Officer Site login page

The secure login page safeguards the platform with essential credentials: email and password. Registration is handled exclusively by the governing body to maintain user access control.

I.II Dashboard

The Dashboard Page of the Traffic Bounty Hunter Platform adopts a paradigm akin to contemporary social media interfaces, presenting a dynamic, scrollable feed that aggregates incident reports. Each report is structured with a hierarchical information architecture, prominently displaying the violation details at the apex, followed by a visual evidence module that encapsulates a geospatial representation powered by the Leaflet library and pertinent multimedia artifacts such as videos or images. To facilitate efficient data management and decision-making processes, the interface equips officers with an array of interactive controls, including evaluation buttons, sorting mechanisms, search functionalities, and filtering options, all conveniently accessible via a top navigation bar. Furthermore, a sidebar component provides seamless navigation to various subpages within the platform, ensuring a cohesive and intuitive user experience.

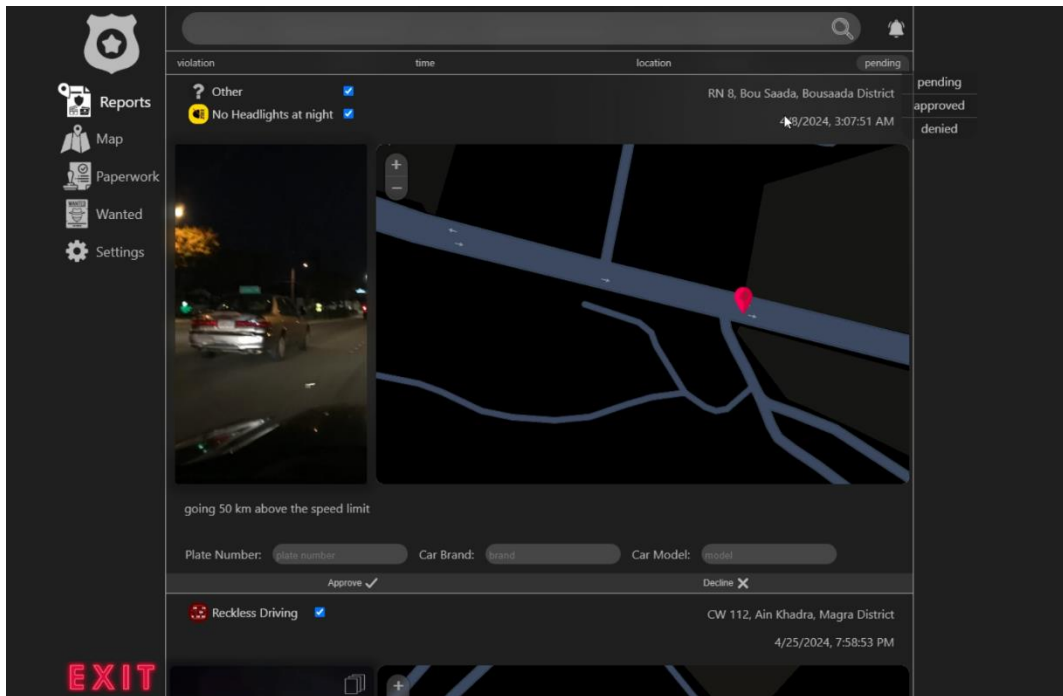


Figure 4.3:Traffic Officer Site Dashboard

I.III Map

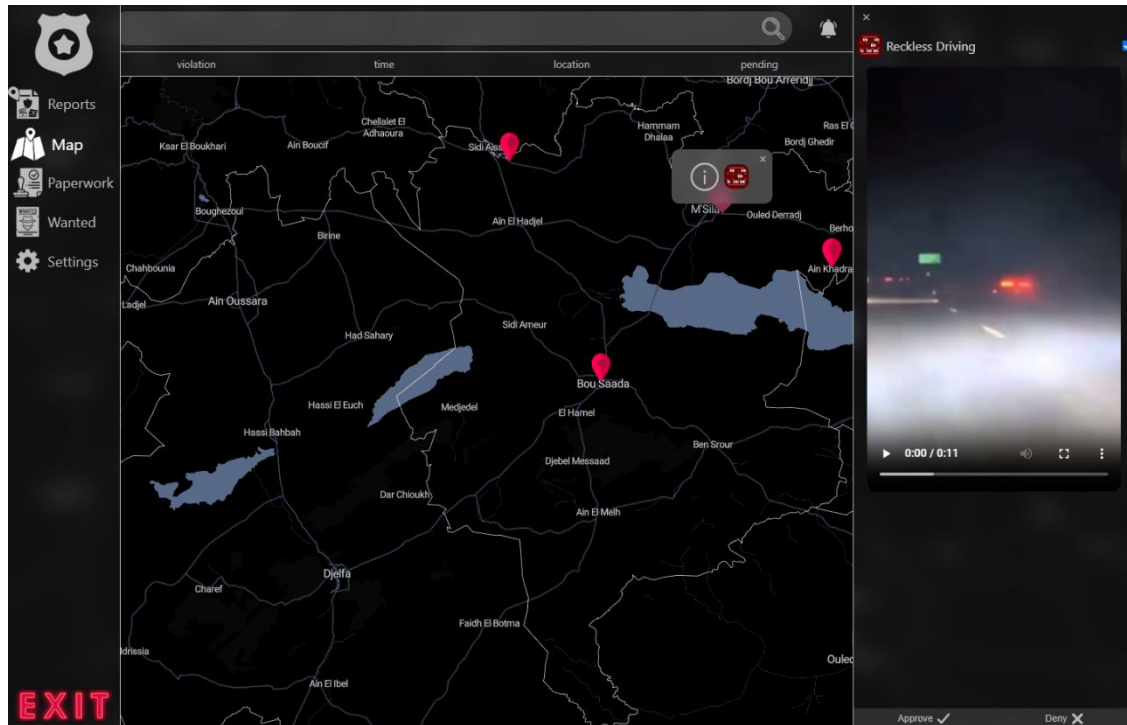


Figure 4.4: Traffic Officer Map

The Map Page of the Traffic Bounty Hunter Platform harnesses the power of geospatial visualization to provide officers with a holistic, top-down perspective of reported violations. By leveraging the robust capabilities of the Leaflet library, this interface renders a comprehensive, interactive map that enables users to intuitively explore and analyze incident data. Officers can employ a suite of data management tools, including sorting, searching, and filtering functions, conveniently located within a top navigation bar, to efficiently navigate and interrogate the information landscape. Additionally, a dedicated section of the page prominently showcases detailed information about reported incidents, fostering a deeper understanding of the spatial distribution and context of violations. The Map Page also incorporates a sidebar navigation component, ensuring seamless traversal between various subpages of the platform, thereby promoting a unified and fluid user experience.

II Mobile App

II.I Sign Up & Login Screen

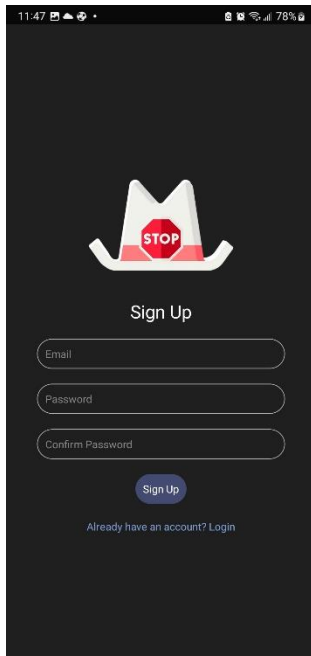


Figure 4.6: TBH App Sign Up Screen

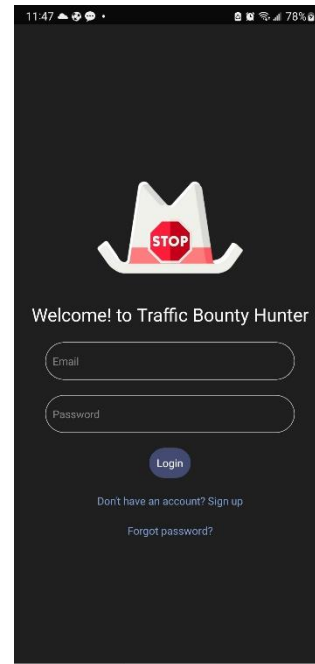


Figure 4.5: TBH App Login Screen

The Login Screen of the Traffic Bounty Hunter Platform's mobile application serves as a multifunctional gateway, amalgamating both login and signup functionalities into a unified interface. This holistic approach streamlines user onboarding and authentication processes, facilitating seamless access to the platform's features and services.

II.II Dashboard

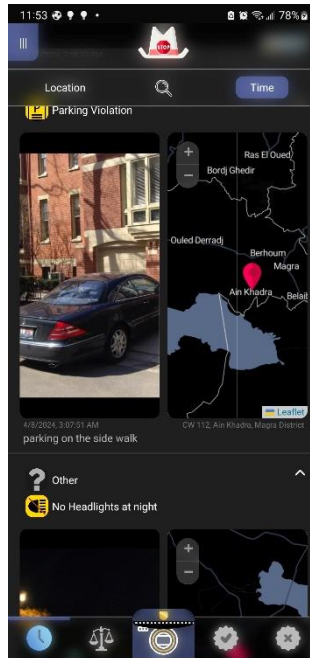


Figure 4.7: TBH App Dashboard

The Dashboard Screen of the mobile application draws inspiration from its web-based counterpart, presenting a scrollable list of incident reports in a manner reminiscent of contemporary social media platforms. Each report is structured with a hierarchical information architecture, displaying a concise summary of the violation at the top, followed by a comprehensive evidence module. This module incorporates a Webview component, which seamlessly integrates a Leaflet map, rendered using the Webpack build system, alongside pertinent multimedia artifacts. To facilitate efficient navigation and data management, the Dashboard Screen offers a suite of sorting (time/location), searching (top bar), and filtering (bottom bar) functionalities. The filtering mechanism allows users to categorize reports based on their status, including pending, qualified, unqualified, and approved designations. Furthermore, a prominently positioned camera button provides direct access to the camera screen, enabling users to capture and submit evidence efficiently.

The mobile application incorporates a collapsible sidebar situated strategically on the left side. This user interface element, when expanded, reveals a hierarchical structure of functionalities. The topmost section prominently displays the user's rank within the platform's Traffic Bounty Hunter (TBH) community. Further expansion unveils a dedicated section showcasing the TBH's performance metrics. This section provides valuable insights into the user's effectiveness, including details like report accuracy and the number of reports submitted. Nestled beneath the performance metrics lies a navigation hub. This section offers buttons that grant access to various functionalities

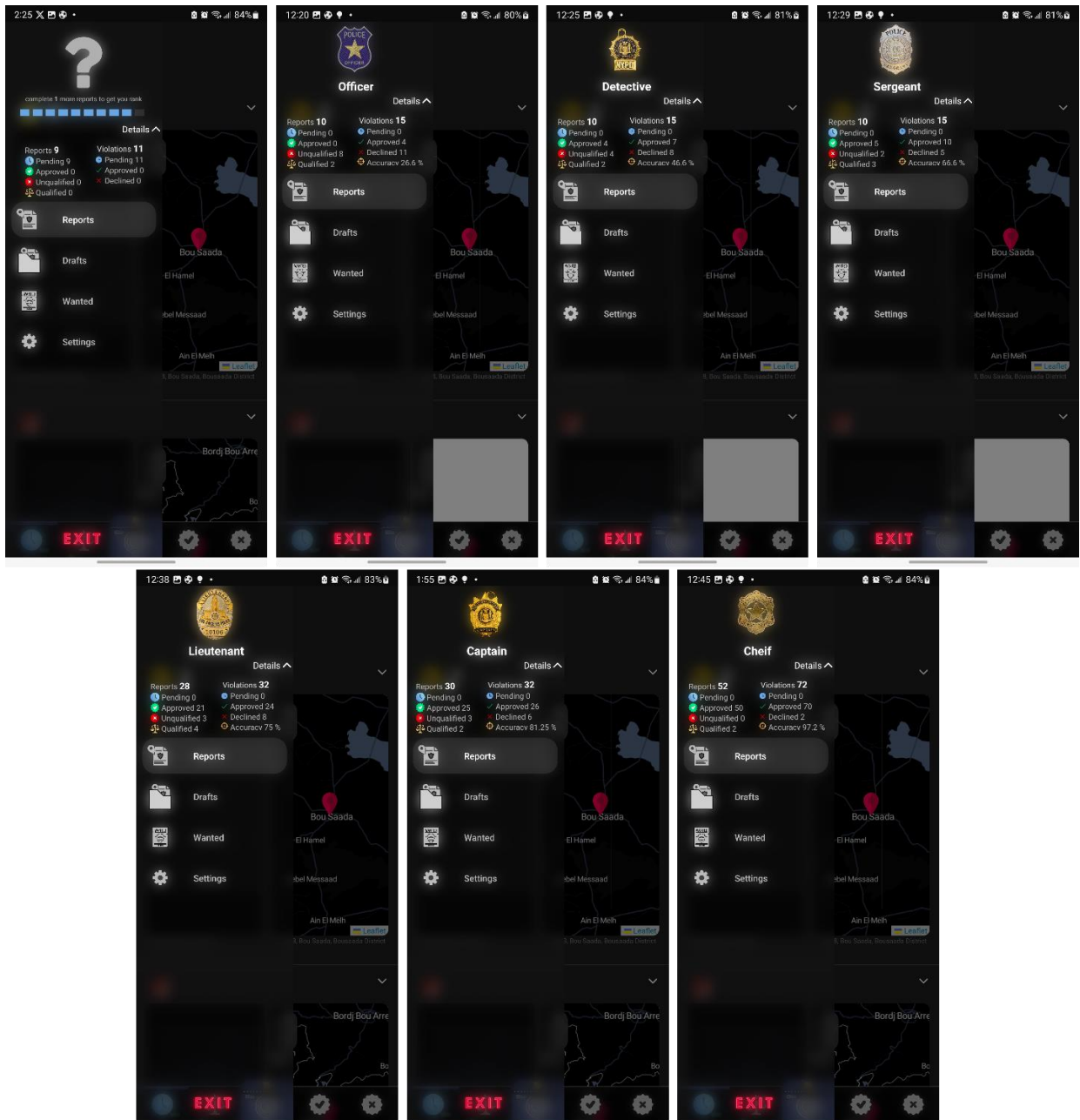


Figure 4.8: TBH App Side Bar/Rank display

within the application, such as drafts, wanted lists, and account settings. By incorporating this collapsible sidebar, the mobile application streamlines user navigation and provides a centralized location for accessing critical functionalities.

II.III Camera

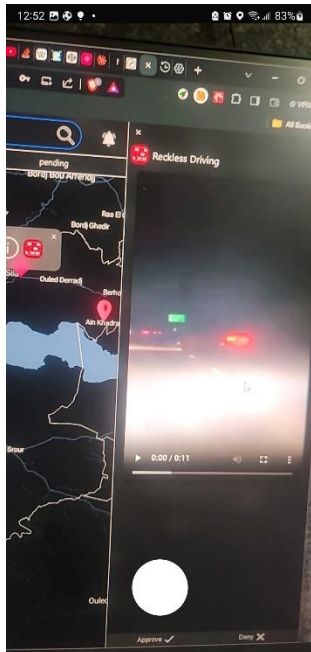


Figure 4.9: TBH App
Camera Screen

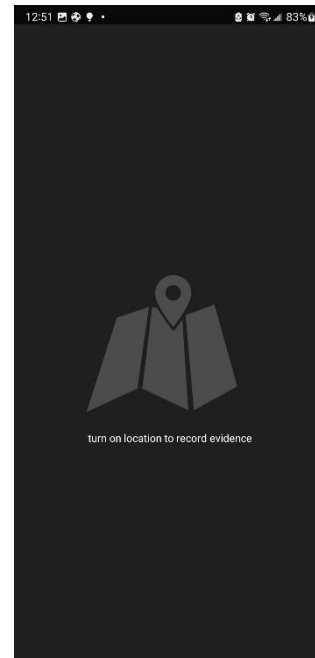


Figure 4.9: Prompt TBH
to Turn on Location

The Camera module of the Traffic Bounty Hunter Platform's mobile application adopts a minimalist design philosophy, prioritizing simplicity and intuitive user interaction. This streamlined interface offers a binary input mechanism, where a prolonged press of the capture button initiates video recording, while a regular tap triggers image capture. To ensure the integrity and accuracy of the collected evidence, the Camera module mandates the activation of location services, thereby geo-tagging all captured media.

II.IV Video Trimmer (FFmpeg)

The Video Trimmer screen represents a bespoke interface design, meticulously crafted to emulate the aesthetic and functional paradigms of contemporary social media platforms. This custom implementation, powered by the FFmpeg multimedia framework, empowers users with a trio of essential video manipulation functionalities. Users can precisely trim the captured video


```

1:02
...
} else if (violation.type === 'other') {
  return 0;
}
}

const before = (item, index) => {
  const approve = async (item, index) => {
    let totalLine = 0;
    let totalLine = 0;
    const thresh = checked[index].find(v) === true;
    let signed = true;
    const carInfo = {plateNum: plateNum[index], brand: carBrand[index]};
    if (thresh) {
      console.log('at least one violation should be approved');
      return;
    }
    if (carInfo.brand) {
      console.log('car brand is required');
      return;
    }
    if (carInfo.model) {
      console.log('car model is required');
      return;
    }
    if (carInfo.plateNum) {
      console.log('plate number is required');
      return;
    }
    else if (carInfo.plateNum.length !== 10) {
      console.log('enter a valid plate number');
      return;
    }
  };
  if (item.operationId === 'approve') {
    let violation = item.violation.map(v => {return {opStatus: checked[index].map(v1) => {
      if (v1) {
        violation[i].opStatus = 'approved';
        if (violation[i].status === 'approved') {
          totalLine += getLine(item, violation, find(v1));
        }
      } else if (v1.opStatus === 'declined') {
        signed = false;
        violation[i].opStatus = 'declined';
        if (violation[i].status === 'declined') {
          totalLine -= getLine(violation[i]);
        }
      }
    }});
  }
}

```

Figure 4.11: TBH App Confirm Image

II.VI Reporting Screen

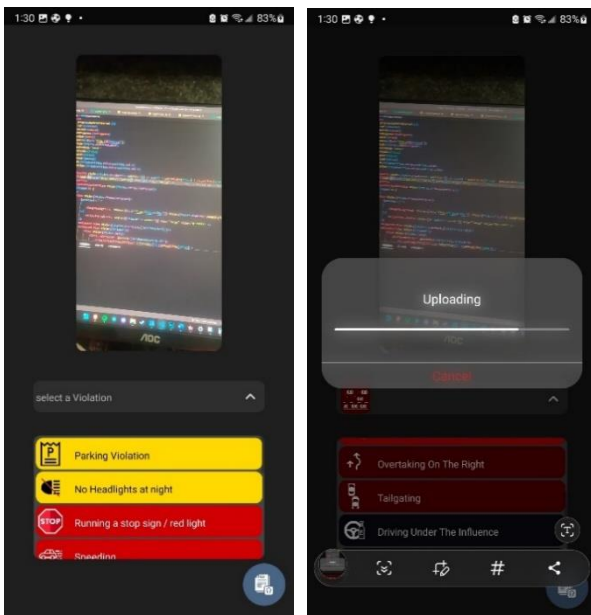


Figure 4.12: TBH App Reporting Screen



Figure 4.13: Violations List

The reporting screen facilitates the submission of traffic violation reports. This interface presents the user's recorded media, muted with looping playback for video evidence. A collapsible list categorizes potential violations using the Algerian fine system, employing color-coded icons for ease of identification. Users can provide additional details through a dedicated description field

and submit their reports via clearly labeled buttons. This streamlined design optimizes the reporting process by fostering efficient collection of evidence and violation categorization.

4.2.2.2 Database

The transformation of our class diagram into a Firebase Firestore database represents a paradigm shift from the realm of object-oriented relational methodology to the domain of non-relational data management. This metamorphosis, far from being a Herculean task, proved to be one of the most straightforward and seamless undertakings in our development journey.

The inherent flexibility and scalability of the non-relational data model, exemplified by Firebase Firestore, allowed us to effortlessly map the intricate relationships and hierarchies encapsulated within our class diagram onto a more fluid and adaptable data structure. The schema-less nature of Firestore liberated us from the rigid constraints of traditional relational databases, enabling us to dynamically evolve our data model in harmony with the ever-changing requirements of our application.

The screenshot displays the Firebase console interface. On the left, a sidebar shows a project named '(default)' with a 'tickets' collection selected. The main area is divided into three panels:

- Left Panel:** Shows the 'tickets' collection with a list of document IDs. The document ID 'jsMQ4AF3ivLuLk1346F6' is highlighted.
- Middle Panel:** Shows the 'Add document' interface for the selected document, listing several other document IDs.
- Right Panel:** Shows the detailed structure of the document 'jsMQ4AF3ivLuLk1346F6'. The document is a JSON object with the following fields:
 - address:** city: "Ain Khadra", county: "Magra District", road: "CW 112"
 - description:** "parking on the side walk"
 - location:** An array containing one object:
 - coords:** accuracy: 22, altitude: 0, altitudeAccuracy: 0, heading: 0, latitude: 35.544761, longitude: 4.9774761, speed: 0, mocked: false, timestamp: 1712542070687
 - media:** "https://firebasestorage.googleapis.com/v0/b/allcops-alt=media&token=2d3b09d4-e911-45b8-a745-3608b7979615"
 - operator1:** id: "cUAvrJ1EuKOFihCcil78oFQqUBJ3", status: "approved"
 - operator2:** id: "sFrKcG3Jo6aiXXoD5v3DytUriGy2", status: "pending", reporter: "DnAFEIFE8PapXfn1pXfHg1JnmZF3", status: "pending", time: "4/8/2024, 3:07:51 AM", type: "image"
 - violation:** An array containing one object:
 - name:** "Parking Violation", op1status: "approved", op2status: "pending", status: "pending"

Figure 4.11: Firebase Structure of The Report

4.2.2.3 Decentralized Process of Evaluation

A system has been engineered wherein the determination of any particular outcome is not contingent upon the actions of a singular entity. This ingenious design incorporates a series of checks and balances, ensuring that the final result is a product of the collective decisions made by the officers tasked with assessing the report. To elucidate the concepts introduced in the preceding chapter, the forthcoming examples will be presented in a distinctive scientific writing style, offering readers a comprehensive understanding of this innovative methodology.

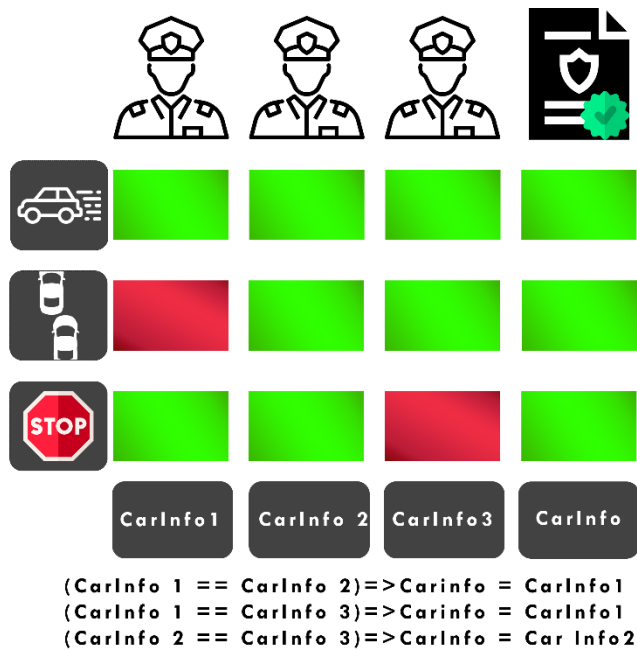


Figure 4.12: Approved Report

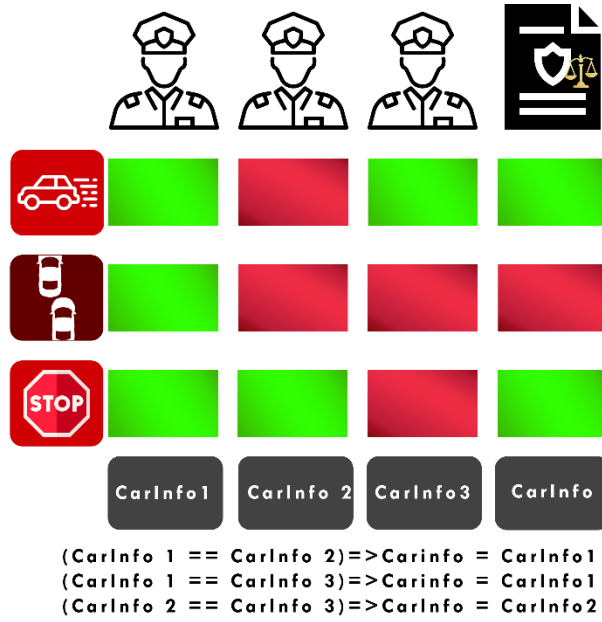


Figure 4.14: Qualified Report

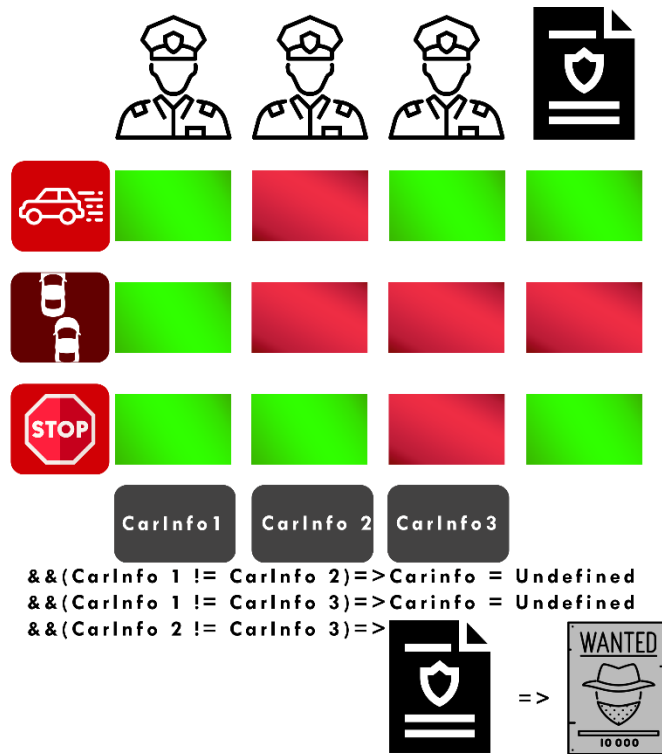


Figure 4.13: Wanted Report

4.3 Perspective:

The application presented in this study holds immense potential for integration with artificial intelligence (AI) systems, offering a transformative approach to traffic violation detection and management. One compelling scenario envisions a synergistic collaboration between privately-owned security cameras and government entities. In this model, camera owners could rent their surveillance systems to the government, with the compensation determined by the number and types of violations captured by the cameras. An AI-powered algorithm would analyze the footage, identifying potential traffic infractions and forwarding the relevant data to traffic officers for further review. This innovative approach could significantly enhance the efficiency and effectiveness of traffic law enforcement while providing a novel revenue stream for camera owners.

Moreover, the data collected through this platform could yield invaluable insights into the patterns and trends of traffic violations. A distinctive feature of the system is its ability to record and count violations regardless of whether sufficient information is available to generate a ticket. This comprehensive data collection approach enables a more accurate assessment of the overall state of traffic safety, facilitating data-driven decision-making and policy formulation.

Furthermore, this project could serve as a catalyst for governments to explore the untapped potential of remote freelancing. By leveraging the power of technology and the expertise of freelancers, government agencies could overcome resource limitations and enhance their operational capabilities. This paradigm shift could pave the way for a more agile, responsive, and cost-effective public sector, ultimately benefiting both the government and the citizens it serves.

4.4 Conclusion

In this chapter, we have presented the significant achievements and the challenges encountered during the development of our innovative application. It is essential to acknowledge that the pursuit of perfection, while admirable, proved to be a major obstacle in our methodology. This relentless quest for flawlessness hindered our progress and led to the unnecessary recreation of existing functionalities, such as the video trimmer, solely to align with the application's design aesthetic.

Moreover, our efforts to elevate the application to a publishable state diverted our focus from the core objectives, resulting in the exploration of numerous methods that ultimately failed to deliver the desired outcomes. In retrospect, it is evident that a more pragmatic approach, one that prioritizes functionality and user experience over perfection, would have been more conducive to success.

As we reflect on the journey undertaken, we are reminded of the profound words of Steve Jobs: "The same common stones that had gone in, through rubbing against each other, creating a little bit of friction, creating a little bit of noise, had come out these beautiful polished rocks." This analogy aptly describes the transformative power of the challenges we faced, as they served to refine our skills, sharpen our insights, and shape the final product into a more polished and effective solution.

In conclusion, while we celebrate the achievements realized throughout this chapter, we must also acknowledge the valuable lessons learned from the challenges encountered. By embracing a more balanced approach, one that seeks excellence without sacrificing practicality, we can continue to drive innovation and deliver impactful solutions in the field of traffic violation detection and management.

General Conclusion

The development of the Traffic Bounty Hunter platform has been an extraordinary journey filled with challenges, triumphs, and invaluable learnings. Throughout this project, we have witnessed the power of innovation and collaboration in addressing the pressing issue of traffic violation management. By creating a platform that empowers citizens to actively contribute to road safety and enables officers to review and validate reported violations, we have taken a significant step towards bridging the gap between research and practical implementation.

The achievements of this project are numerous and noteworthy. We successfully developed a mobile application that allows users to capture and report traffic violations, providing a user-friendly interface and streamlined reporting process. Additionally, we implemented a robust review system that ensures the accuracy and fairness of violation assessments through a majority vote mechanism involving multiple officers.

However, we also encountered challenges that tested our resolve and pushed us to adapt and grow. The pursuit of perfection, while admirable, proved to be a hindrance at times, leading us to recreate existing functionalities and explore methods that ultimately failed to deliver the desired results. Despite these setbacks, we learned valuable lessons about the importance of striking a balance between innovation and practicality.

While we were unable to fully implement certain advanced features such as media authentication, object detection, user verification, and the supply of video frames to officers due to technical constraints and time limitations, we acknowledge that these functionalities hold immense potential for enhancing the platform's capabilities and effectiveness. These challenges serve as opportunities for future research and development, as we continue to push the boundaries of what is possible in the realm of traffic violation management.

As we reflect on this incredible journey, we are reminded of the transformative power of perseverance and collaboration. The challenges we faced, like the common stones that rub against each other, have shaped us into a stronger, more resilient team. The friction and noise we encountered along the way have polished our skills, knowledge, and determination, leaving us with

a profound sense of accomplishment and a renewed commitment to making a positive impact on road safety.

In conclusion, the Traffic Bounty Hunter project has not only contributed to the advancement of traffic violation management but has also left an indelible mark on our team. The learnings, achievements, and challenges we experienced have forever changed us, fueling our passion for innovation and our dedication to creating solutions that make a difference. As we move forward, we carry with us the invaluable lessons learned, ready to tackle new challenges and continue pushing the boundaries of what is possible in the pursuit of safer roads for all.

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Abstract

This dissertation presents the Traffic Bounty Hunter platform, an innovative solution addressing traffic violations and enhancing road safety in Algeria. The platform combines a mobile app for citizen reporting with a web interface for law enforcement validation. Our research explores theoretical foundations of traffic safety, citizen engagement, and existing technologies, forming the basis for the platform's architecture. UML diagrams detail the system's structure and component interactions. The technology stack (React Native, React.js, Firebase Firestore) ensures scalability and performance. Features include a gamified reward system, encouraging citizens to become "traffic bounty hunters," and a decentralized evaluation process involving multiple officers for fair assessment. Despite challenges in server development and monetary transactions, the project achieved significant milestones in user interface design and database implementation. This research contributes to traffic safety management by demonstrating a viable citizen-centric approach to violation reporting and fine issuance.

Keywords: Traffic Bounty Hunter, citizen reporting, law enforcement, traffic violations, road safety, mobile application, web interface, gamification, decentralized evaluation, fine issuance, all police.

المخلص

تقدم هذه الأطروحة منصة "صائد المكافآت المرورية"، حلاً مبتكراً لمعالجة انتهاكات المرور وتعزيز السلامة على الطرق في الجزائر. تجمع المنصة بين تطبيق للهواتف المحمولة لإبلاغ المواطنين وواجهة ويب للتحقق من قبل أجهزة إنفاذ القانون. يستكشف بحثنا الأسس النظرية للسلامة المرورية ومشاركة المواطنين والتقنيات الموجودة، مشكلاً أساساً لهيكلية المنصة. توضح مخططات UML بنية النظام وتفاعلات مكوناته. تضمن مجموعة التقنيات (React Native، React.js، Firebase Firestore) قابلية التوسع والأداء. تتضمن الميزات نظام مكافآت قائم على الألعاب، وعملية تقييم لامركزية لضمان التقييم العادل. رغم التحديات في تطوير الخادم (server) والمعاملات المالية، حقق المشروع إنجازات مهمة. يساهم هذا البحث في إدارة السلامة المرورية من خلال إظهار نهج فعال يركز على المواطن للإبلاغ عن الانتهاكات وإصدار الغرامات.

الكلمات المفتاحية: صائد المكافآت المرورية، إبلاغ المواطنين، إنفاذ القانون، انتهاكات المرور، السلامة على الطرق، تطبيق الهاتف المحمول، واجهة الويب، التلعيب، التقييم اللامركزي، إصدار الغرامات، الكل شرطة.