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Système de Location en Ligne avec Interaction Multi-Utilisateurs et Gestion Dynamique des Réservations

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Thanks

I dedicate this work :

To my dear mother Zahida,
Thank you for your unconditional love and unwavering support that have guided me throughout this journey.
Your love has been the light that showed me the way, and I am forever grateful to you.

To my dear father Ali,
Your strength, hard work, and encouragement have always inspired me to give my best.
You have been a model of perseverance and determination.

To my brother Ahmed and my sister Tasnim,
Your presence and support have been invaluable to me.
Thank you for all the moments we have shared and for your precious care.

This work is dedicated to all of you, with all my gratitude and affection.

– Bayrem Boussaidi –

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List of Abbreviations

API = Application Programming Interface

CI/CD = Continuous Integration / Continuous Deployment

CRUD = Create, Read, Update, Delete

DB = Database

DoD = Definition of Done

DT = Development Team

ER = Entity-Relationship

GLSI = Software Engineering and Information Systems

HTTP = Hypertext Transfer Protocol

JWT = JSON Web Token

K8s = Kubernetes

MoSCoW = Must have, Should have, Could have, Won't have

MVC = Model-View-Controller

OAuth = Open Authorization

PB = Product Backlog

PDF = Portable Document Format

PO = Product Owner

QR = Quick Response (Code)

REST = Representational State Transfer

SB = Sprint Backlog

SM = Scrum Master

SMTP = Simple Mail Transfer Protocol

SOA = Service-Oriented Architecture

SP = Story Points

UI = User Interface

US = User Story

UX = User Experience

YAML = YAML Ain't Markup Language

General Introduction

The automotive rental industry has undergone significant transformation in recent years, driven by the increasing demand for digital solutions that streamline operations and enhance user experience. In this context, we developed **MyLoc**, a comprehensive car rental platform designed to connect administrators, rental agencies, and customers in a seamless digital ecosystem.

Our platform provides a complete solution for car rental management, enabling agencies to list their vehicles, manage their inventory, and process rental requests efficiently. Administrators oversee the entire platform, managing agencies, customers, and content while maintaining direct communication with agencies through an integrated real-time chat system.

The rental workflow is streamlined : when a customer submits a rental request for a specific vehicle, the responsible agency receives the request and can either approve or decline it. Upon approval, the customer receives an email containing a PDF rental contract with all booking details and a unique QR code for verification. In case of rejection, a notification email is sent to inform the customer of the decision. Additionally, in-app notifications keep customers informed of their request status in real-time.

The platform also features a blog section where administrators can publish news and special offers, with customers able to comment and engage with the content. A **Follower subscription system** allows visitors to enter their email in the website footer to receive automatic email notifications whenever new cars are added to the platform.

To enhance customer support, we integrated an AI-powered chatbot using **Flask API** (Python) connected to ChatGPT, providing instant answers to visitor and customer inquiries in multiple languages.

Our application is built with modern technologies : **Angular** for the frontend, **Spring Boot** (REST architecture) for the backend, and **MySQL** for data persistence. Security is managed through **Keycloak** for authentication, with AuthGuard protecting admin and agency routes based on user roles.

For deployment, the entire infrastructure is containerized using **Docker** and **Docker Compose**, then orchestrated on **Kubernetes** (Minikube) with dedicated deployment files for each service. A complete **CI/CD pipeline** using **GitLab CI** automates the build, test, and deployment processes.

Development was conducted using **Visual Studio Code** as the IDE, **XAMPP** for local database management, and **Postman** for API testing. The project followed the **Scrum** methodology with organized sprints and backlogs to ensure iterative and reliable delivery.

This report details the design, development, and deployment approaches adopted for the MyLoc platform. It is organized as follows :

- **Chapter 1** : Presents the project framework and general context, analyzes existing car rental solutions, and introduces the Scrum methodology adopted for project management.
- **Chapter 2** : Covers requirements analysis and specification, including actor identification, functional and non-functional requirements, use case diagrams, class diagrams, and system architecture.
- **Chapter 3** : Details the first release implementation focusing on user authentication (Keycloak integration), car management, and agency management features.
- **Chapter 4** : Presents the second release with rental request processing, email notifications, PDF contract generation with QR codes, and the real-time chat system.
- **Chapter 5** : Covers the third release including the AI chatbot integration, blog management, customer reviews, and notification system.
- **Chapter 6** : Describes the DevOps implementation with Docker containerization, Kubernetes deployment, and GitLab CI/CD pipeline setup.

Chapitre 1

Project Context

Plan

1.1 Introduction

This chapter presents the general context of the project. It introduces the host organization, **Myloc Agency**, analyzes existing methods, and describes the proposed solution. Additionally, it outlines the project architecture, design approaches, management methodology, and development environment.

1.2 Project Problematic

Before the development of this application, car rental agencies faced numerous challenges that hindered their efficiency, customer satisfaction, and business growth. This section identifies the key problems that motivated the creation of the MyLoc platform.

1.2.1 Challenges Faced by Agencies Before This Project

1.2.1.1 Manual and Time-Consuming Processes

Traditional car rental agencies relied heavily on manual processes :

- **Paper-based booking systems** : Agencies used physical logbooks or basic spreadsheets to track reservations, leading to errors, double bookings, and lost records.
- **Phone-only communication** : Customers had to call agencies during business hours to check availability, make reservations, or ask questions—limiting accessibility and creating bottlenecks.
- **Manual contract preparation** : Rental contracts were typed or handwritten for each customer, consuming significant time and prone to errors.
- **No real-time availability** : Agencies couldn't provide instant availability information, often requiring callbacks after checking physical records.

1.2.1.2 Poor Communication Channels

- **Disconnected stakeholders** : There was no unified platform for administrators, agencies, and customers to communicate efficiently.
- **Delayed responses** : Customer inquiries via email or phone often took hours or days to receive responses.
- **No instant messaging** : Agencies couldn't engage in real-time conversations with customers or administrators.
- **Language barriers** : International customers faced difficulties communicating with local

agencies.

1.2.1.3 Inefficient Request Management

- **No centralized request tracking** : Rental requests were scattered across emails, phone logs, and paper notes.
- **Slow approval process** : Agencies manually reviewed each request, often taking 24-48 hours to confirm or decline.
- **No automated notifications** : Customers had to repeatedly contact agencies to check their request status.
- **Lost opportunities** : Delayed responses led to customers booking with competitors.

1.2.1.4 Lack of Digital Presence

- **Limited visibility** : Small and medium agencies had minimal online presence, losing customers to larger competitors with websites.
- **No car showcase** : Agencies couldn't display their fleet with photos, specifications, and pricing online.
- **No filtering capabilities** : Customers couldn't search for specific car types, models, or price ranges.
- **No customer reviews** : Potential customers had no way to read feedback from previous renters.

1.2.1.5 Administrative Overhead

- **No centralized management** : Administrators managing multiple agencies had no unified dashboard.
- **Difficult reporting** : Generating reports on bookings, revenue, or customer activity required manual data compilation.
- **No subscriber management** : Agencies couldn't maintain lists of interested customers for marketing purposes.

1.2.2 Impact of These Problems

These challenges resulted in :

- **Revenue loss** : Slow processes and poor communication led to lost bookings.
- **Customer frustration** : Long wait times and lack of transparency drove customers away.
- **Operational inefficiency** : Staff spent excessive time on administrative tasks instead of

customer service.

- **Competitive disadvantage** : Agencies without digital tools fell behind tech-enabled competitors.
- **Scalability issues** : Manual processes couldn't handle growth in customer volume.

1.3 Project Objectives

The MyLoc platform was developed to address the problematic issues identified above. This section outlines the specific objectives that guided the development of the application.

1.3.1 Primary Objectives

1.3.1.1 Digitize the Car Rental Process

- Create a comprehensive web platform replacing manual booking systems.
- Enable 24/7 online access for customers to browse and book vehicles.
- Provide real-time car availability checking to prevent double bookings.
- Automate the entire rental workflow from request to contract generation.

1.3.1.2 Facilitate Communication Between Stakeholders

- Implement real-time chat between administrators and agencies for operational coordination.
- Enable instant email notifications for booking confirmations, rejections, and updates.
- Provide in-app notifications to keep customers informed of their request status.
- Integrate an AI-powered chatbot for instant customer support in multiple languages.
- Allow direct email contact between customers and administrators.

1.3.1.3 Streamline Request Management

- Create a centralized dashboard for agencies to view and manage all rental requests.
- Enable one-click approval or rejection of requests with automatic customer notification.
- Reduce response time from days to minutes through instant processing.
- Automatically generate PDF contracts with QR codes upon approval.

1.3.1.4 Enhance Customer Experience

- Provide intuitive car browsing with advanced filtering (type, model, price, availability).
- Display detailed car information with multiple photos.
- Allow customers to track their booking history and request status.
- Enable customers to leave reviews and comments on cars and blog posts.
- Send email updates to followers when new cars are added.

1.3.1.5 Empower Agency Management

- Provide dedicated dashboards for each agency to manage their fleet.
- Enable full CRUD operations on cars (add, edit, delete, upload photos).
- Give agencies control over their booking calendar and availability.
- Allow agencies to communicate directly with administrators.

1.3.1.6 Centralize Administration

- Create a comprehensive admin dashboard for platform oversight.
- Enable management of agencies, customers, and blog content from one interface.
- Provide tools for monitoring platform activity and user engagement.

1.3.2 Technical Objectives

1.3.2.1 Security and Authentication

- Implement hybrid authentication : Keycloak for administrator access control and Spring Security with JWT for customer/agency authentication.
- Protect admin and agency routes with AuthGuard.
- Ensure secure data transmission and storage.

1.3.2.2 Modern Architecture

- Build a scalable microservices architecture with clear separation of concerns.
- Use Angular for a responsive, dynamic frontend.
- Implement Spring Boot REST APIs for robust backend services.
- Integrate Flask for the AI chatbot service with OpenAI integration.

1.3.2.3 DevOps and Deployment

- Containerize all services using Docker.
- Orchestrate deployment with Docker Compose and Kubernetes (Minikube).
- Automate CI/CD pipelines using GitLab CI.
- Ensure consistent environments across development and production.

1.4 Solutions Provided by MyLoc Platform

This section details how the MyLoc platform addresses each of the identified problems, transforming the car rental experience for all stakeholders.

1.4.1 Transforming Communication

1.4.1.1 Real-Time Admin-Agency Chat

The platform includes an integrated instant messaging system that enables :

- Direct communication between administrators and agencies.
- Real-time message delivery without page refresh.
- Message history for reference and accountability.
- Coordination on operational matters, promotions, and issues.

1.4.1.2 Automated Email Notifications

The system automatically sends emails for :

- **Request Acceptance** : Customer receives a confirmation email with PDF contract and QR code.
- **Request Rejection** : Customer receives a polite notification explaining the decline.
- **New Car Alerts** : Followers and customers receive updates when new vehicles are added.
- **Contact Confirmations** : Acknowledgment emails for customer inquiries.

1.4.1.3 AI-Powered Chatbot

The integrated chatbot, built with Flask API and connected to ChatGPT, provides :

- **24/7 Availability** : Instant responses at any time, even outside business hours.
- **Multilingual Support** : Assistance in multiple languages for international customers.
- **Instant Answers** : Quick responses to common questions about cars, pricing, and booking.
- **Reduced Staff Workload** : Automated handling of routine inquiries.

1.4.1.4 In-App Notifications

Customers receive real-time notifications within the application for :

- Rental request status changes (pending, approved, declined).
- New messages or updates from agencies.
- Important platform announcements.

1.4.2 Streamlining the Booking Process

1.4.2.1 Smart Availability Checking

Before submitting a rental request, the system :

- Checks the car's availability for the selected date range.

- Prevents double bookings automatically.
- Shows real-time availability status on car listings.
- Suggests alternative dates if the car is unavailable.

1.4.2.2 One-Click Request Processing

Agencies can process requests efficiently :

- View all pending requests in a centralized dashboard.
- Accept or decline with a single click.
- Automatic email sent to customer upon decision.
- PDF contract generated instantly for approved requests.

1.4.2.3 Automated Contract Generation

Upon approval, the system automatically :

- Generates a professional PDF rental contract.
- Includes all booking details (dates, car info, customer info, pricing).
- Creates a unique QR code for verification.
- Sends the contract via email to the customer.

1.4.3 Enhancing Car Discovery

1.4.3.1 Advanced Filtering System

Customers can filter cars by :

- **Vehicle Type** : SUV, sedan, compact, luxury, etc.
- **Brand/Model** : Search for specific manufacturers.
- **Price Range** : Set minimum and maximum daily rates.
- **Availability** : Show only cars available for selected dates.
- **Features** : Air conditioning, GPS, automatic transmission, etc.

1.4.3.2 Rich Car Profiles

Each car listing includes :

- Multiple high-quality photos.
- Detailed specifications (engine, seats, fuel type, transmission).
- Daily rental price and any additional fees.
- Customer reviews and ratings.
- Real-time availability calendar.

1.4.4 Saving Time for All Users

Task	Before MyLoc	With MyLoc
Check car availability	Phone call, wait for callback	Instant online check
Submit rental request	Visit agency or phone	2-minute online form
Get request response	24-48 hours	Minutes (instant notification)
Receive rental contract	Visit agency to sign	Auto-generated PDF via email
Ask a question	Phone during business hours	24/7 chatbot or contact form
Browse available cars	Visit multiple agencies	Filter and compare online
Agency-Admin communication	Email chains, phone calls	Real-time chat

Tableau 1.1 : Time Savings Comparison : Before vs. After MyLoc

1.4.5 Empowering Agencies

1.4.5.1 Dedicated Agency Dashboard

Each agency has access to :

— **Fleet Management** : Add, edit, delete cars with full details and photos.

— **Request Center** : View and process all rental requests.

— **Communication Hub** : Chat with administrators, receive notifications.

— **Profile Management** : Update agency information and settings.

1.4.5.2 Increased Visibility

Agencies benefit from :

— Online presence without building their own website.

— Exposure to all platform visitors and customers.

— Customer reviews that build trust and reputation.

— Email marketing through the follower system.

1.4.6 Follower Subscription System

The platform includes a unique follower feature :

— Visitors enter their email in the website footer to subscribe.

— Followers receive automatic email notifications when new cars are added.

— No account creation required—low barrier to engagement.

— Keeps potential customers informed and engaged with the platform.

— Helps agencies reach interested customers with new offerings.

1.5 Presentation of the Host Organization : Myloc Agency

This section provides an overview of the host organization, its mission, activities, and products, highlighting its innovative approach and global impact.

1.5.1 Host Organization

Myloc Agency leverages expertise in car rental services to offer customized solutions that provide reliable and affordable transportation options for clients. Founded by Amine Ben Chaabane, it consists of a passionate and dedicated team of skilled professionals who work closely with clients to deliver transportation solutions tailored to their specific needs.

1.5.2 Activities and Products

As part of this project, I developed a full-featured car rental web application that supports three main user roles : Admin, Agencies, and Customers, with additional functionalities for visitors and followers. The application implements a hybrid security architecture : Keycloak handles administrator authentication and role management, while Spring Security with JWT tokens secures customer and agency authentication. It was built using Spring Boot (backend), Angular (frontend), Flask (AI chatbot backend with OpenAI integration), all containerized with Docker, orchestrated with Docker Compose, deployed on Kubernetes (K8s), and integrated with GitLab CI/CD pipelines for continuous deployment.

1.6 Project Frame

This section delves into the framework of the project, starting with an analysis of existing systems to identify their strengths and weaknesses. By understanding gaps and opportunities in current solutions, we propose an innovative approach that addresses these shortcomings and enhances the overall user experience.

1.6.1 Study of Existing Systems

This section explores existing car rental platforms to identify their functionalities, strengths, and limitations. The aim is to evaluate how current systems handle administrative, agency, and customer interactions, and to highlight areas where improvements can be made.

- **Traditional Car Rental Websites** : Many companies offer web platforms where users can search and book vehicles. These platforms often lack real-time availability checks, multi-role management, or automated document generation. Interaction between customers and agencies is usually limited or entirely missing.

- **Aggregator Platforms (e.g., Kayak, Rentalcars)** : These platforms centralize listings from multiple rental agencies, allowing users to compare prices and availability. While convenient for users, they do not provide backend control for agencies or real-time request management. Personalized communication is also limited.
- **Custom Enterprise Systems** : Some large agencies have internal systems for managing cars, customers, and payments. These solutions are often closed-source, expensive, and not scalable for small or medium-sized agencies. Many lack modularity, chat features, or automated workflows like PDF contract generation and QR code integration.
- **Limitations Identified** :
  - Lack of real-time communication between agencies and customers.
  - No integrated notification or email system for status updates.
  - Limited role-based access (admin, agency, customer).
  - Absence of automation in rental confirmation workflows (e.g., contract generation, online payment).
  - Poor support for multi-agency environments within a single system.

1.6.2 Gaps and Opportunities

This section identifies the key limitations in existing car rental systems and highlights opportunities for technical and functional improvement.

- **Lack of Multi-Role Interaction** : Most platforms do not support smooth interaction between different types of users. A robust role-based system with protected routes and custom dashboards is necessary.
- **Insufficient Real-Time Communication** : Many systems lack instant messaging features. Adding a built-in chat system can improve customer service and speed up booking confirmation.
- **Limited Automation** : Automated PDF contract generation, QR code creation, and email notifications are rarely offered. These features streamline workflows and enhance user satisfaction.
- **Weak Integration of Notifications and Updates** : Timely updates for bookings, new cars, and promotions are missing. An integrated notification system (email + in-app) is essential.
- **Lack of Dynamic Availability Checking** : Users can book cars without real-time validation, creating double bookings. Implementing date-based availability checks resolves this.
- **Limited Customization for Agencies** : Smaller agencies often lack control over fleet management or platform display. Individual dashboards with CRUD capabilities are an

opportunity.

- **Underuse of Modern Deployment Practices** : Few platforms use CI/CD pipelines, containerization, or Kubernetes, making scaling and maintenance difficult. Leveraging Docker, Docker Compose, K8s, and GitLab CI/CD ensures stability and faster updates.

Gap	**Exists in current platforms**
Multi-role management with custom permissions	LIMITED
Real-time messaging between users	RARE
Automatic notifications and email updates	LIMITED
Dynamic car availability checking	NO
PDF contracts with QR code generation	NO
Online payment integration with validation flow	LIMITED
Scalable deployment (CI/CD, Docker, K8s)	NO

Tableau 1.2 : Identified Gaps in Existing Car Rental Platforms

1.6.3 Proposed Solution

The proposed solution addresses the gaps identified in current rental platforms :

- **Hybrid Security Architecture** : Keycloak for admin authentication and role management ; Spring Security with JWT for customer and agency authentication.
- **Admin-Agency Chat System** : HTTP polling-based chat (30-second refresh) for real-time communication between administrators and agencies.
- **Automated Notification and Email System** : Sends automatic updates for bookings, new cars, and account activities.
- **Contract Generation with QR Code** : PDF rental agreements generated and sent via email upon booking approval.
- **Smart Availability Checker** : Validates car availability before confirming bookings.
- **Modern Infrastructure and Deployment** : Deployed using Docker Compose, Kubernetes, and GitLab CI/CD for scalability and maintainability.
- **Integrated AI Chatbot** : Flask-based chatbot using OpenAI GPT for car recommendations and customer assistance.

1.7 Project Architectures and Design Approaches

1.7.1 System Architecture : Microservices with Three-Tier Logical Structure

The system follows a modern microservices architecture with clear separation of concerns across multiple tiers. The architecture ensures scalability, maintainability, and security through containerized deployment and CI/CD practices.

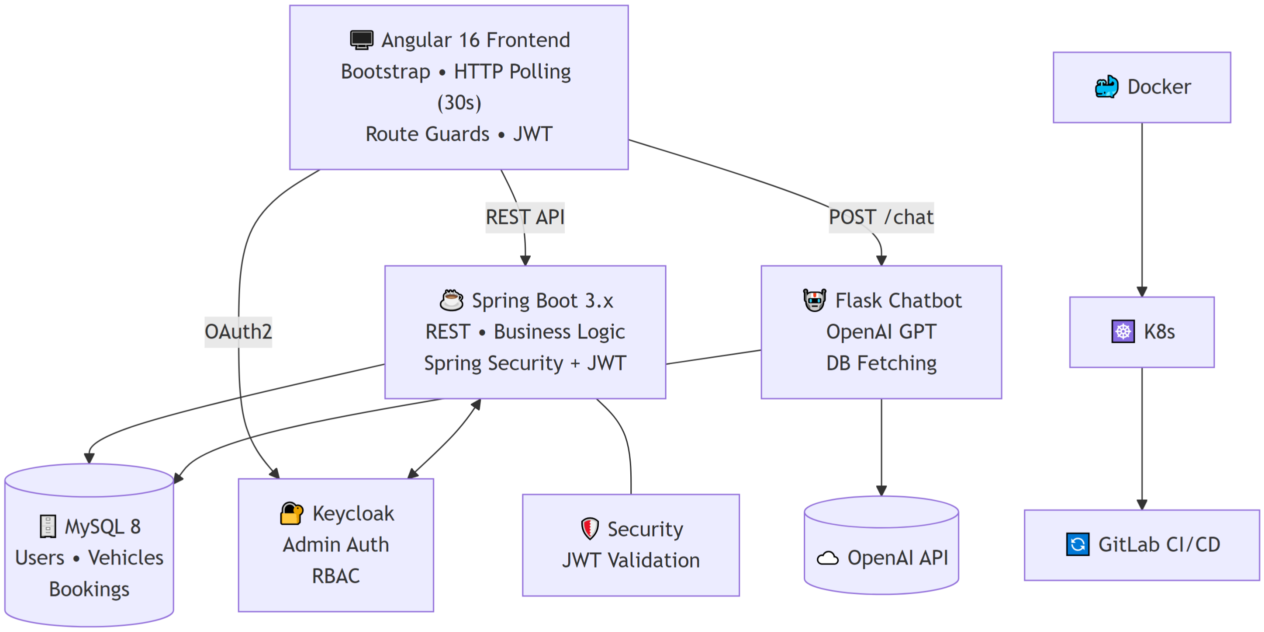


Figure 1.1 : System Architecture Overview - Myloc Agency Car Rental Platform

1.7.1.1 Architecture Layers

- **Presentation Layer (Frontend)** : Angular 16+ application providing responsive UI for all user roles. Features include dynamic routing, lazy loading, and role-based component rendering. Protected by AuthGuard for secure route access.
- **Business/Application Layer (Backend Services)** :
  - **Main API (Spring Boot)** : Core backend handling cars, agencies, customers, bookings, comments, and notifications via RESTful endpoints.
  - **Payment Service (Spring Boot)** : Separate microservice for payment processing, contract generation, and QR code creation.
  - **Chatbot Service (Flask)** : AI-powered assistant integrated with OpenAI GPT API for car recommendations, FAQ responses, and customer support.
- **Security Layer** :
  - **Keycloak** : OAuth2/OpenID Connect server for administrator authentication and role management (RBAC).
  - **Spring Security + JWT** : Token-based authentication for customers and agencies, with password encryption and CORS configuration.
- **Data Layer** : MySQL relational database ensuring data integrity, referential constraints, and complex queries for bookings and availability checks.

1.7.1.2 Service Communication Flow

1. User interacts with Angular frontend.
2. Frontend sends HTTP requests to Spring Boot API with JWT token.
3. For Admin : Backend validates token with Keycloak server.
4. For Customer/Agency : Spring Security validates JWT token internally.
5. Business logic executes, database queries processed.
6. For AI assistance : Frontend calls Flask chatbot API (HTTP POST).
7. For Admin-Agency chat : HTTP polling every 30 seconds retrieves new messages.
8. Responses returned to frontend, UI updated.

1.7.1.3 Containerization and Deployment

- **Docker** : Each service (Angular, Spring Boot, Flask Chatbot, MySQL, Keycloak) containerized separately.
- **Docker Compose** : Orchestrates all containers locally with defined networks and volumes.
- **Kubernetes (Minikube)** : Production-like orchestration with pods, services, deployments, and ingress controllers.
- **GitLab CI/CD** : Automated pipeline for testing, building Docker images, and deploying to Kubernetes.

1.7.2 Design Pattern : RESTful Service-Oriented Architecture (SOA)

- Stateless interactions, resource-oriented endpoints, loose coupling, reusability, and clear separation of concerns.

1.7.3 Design Pattern : MVC for Payment Service

- Model : Data entities and payment logic.
- View : JSON responses and webhook callbacks.
- Controller : API request handling, transaction validation, and workflow triggering (PDF/QR).

1.7.4 Flask AI Chatbot Microservice

- Lightweight REST API for AI-powered chatbot interactions.
- Integrated with OpenAI GPT for car recommendations and FAQ responses.
- Modular architecture for easy maintenance and scaling.
- Containerized via Docker, deployed alongside other services.

1.8 Project Management and Design Methodology

1.8.1 Traditional vs Agile Approaches

Before selecting a methodology for this project, it is essential to understand the fundamental differences between traditional (classical) and agile approaches to project management.

Traditional methodologies (such as Waterfall, V-Model) follow a linear, sequential approach where each phase must be completed before the next begins. Requirements are defined upfront, and changes are difficult to incorporate once development starts. This approach works well for projects with stable, well-defined requirements but struggles with evolving needs.

Agile methodologies embrace change and iterative development. Work is divided into short cycles (sprints or iterations), allowing for continuous feedback, adaptation, and improvement. Agile prioritizes working software, customer collaboration, and responding to change over rigid planning.

Given the dynamic nature of our car rental platform—with multiple user roles, evolving features, and the need for frequent stakeholder feedback—an agile approach was clearly more suitable.

1.8.2 Methodology Selection : Why Scrum ?

The choice of the Scrum methodology for our project is based on several fundamental considerations. Before detailing the advantages of Scrum, it is relevant to compare this methodology with other recognized agile approaches, such as **Kanban** and **Extreme Programming (XP)**.

1.8.2.1 Comparative Analysis of Agile Methods

Criteria	**Scrum**
Structure	Fixed sprints (2-4 weeks), defined roles (PO, SM, Daily Scrum)
Flexibility	Priorities revised at sprint end
Collaboration	Strong via ceremonies and retrospectives
Tracking	Burndown charts, Daily Scrum
Ideal For	Frequent feature deliveries
Adaptability	At sprint boundaries

Tableau 1.3 : Comparative Analysis of Agile Methods : Scrum, Kanban, and XP

1.8.2.2 Justification for Choosing Scrum

After careful analysis, **Scrum** was selected as the project management methodology for the following reasons :

1. **Clear Structure with Flexibility** : Scrum provides a well-defined framework with sprints, roles, and ceremonies, while still allowing adaptation at each iteration. This balance was

essential for managing a complex multi-module platform.

2. **Regular Deliveries** : Our project required frequent delivery of functional increments to stakeholders. Scrum's sprint-based approach ensured that new features (authentication, car management, booking system, chat, chatbot) were delivered and validated regularly.
3. **Stakeholder Collaboration** : The platform involves multiple actors (Admin, Agency, Customer, Visitor, Follower). Scrum ceremonies—especially Sprint Reviews and Retrospectives—facilitat continuous feedback and alignment with user needs.
4. **Risk Management** : By breaking the project into 8 sprints, we could identify and address risks early. Each sprint delivered tested, working functionality, reducing the risk of major failures at the end.
5. **Team Coordination** : Daily Stand-ups ensured that blockers were identified and resolved quickly, maintaining project momentum.
6. **Transparency** : Scrum artifacts (Product Backlog, Sprint Backlog, Burndown Charts) provided clear visibility into project progress for all stakeholders.

Why not Kanban ? While Kanban offers excellent flexibility, it lacks the structured iterations needed for our project, which required planned releases and defined milestones.

Why not XP ? Extreme Programming emphasizes technical practices like pair programming and test-driven development, which are valuable but require a highly disciplined team. Our project needed a broader project management framework, not just development practices.

1.8.3 Scrum Framework Overview

Scrum is an agile framework that enables teams to work together to deliver high-value products iteratively and incrementally. It provides a structured yet flexible approach to project management, emphasizing collaboration, accountability, and continuous improvement. Figure 2.6 illustrates the complete Scrum process flow.

The Scrum framework consists of three main components : **Roles**, **Events** (Ceremonies), and **Artifacts**. Each component plays a crucial role in ensuring the successful delivery of the project.

1.8.3.1 Scrum Team Roles

The Scrum Team is composed of three distinct roles, each with specific responsibilities that contribute to the project's success. The team is self-organizing and cross-functional, meaning members have all the skills necessary to deliver the product increment.

figures/scrum-process-flow.png

Figure 1.2 : Scrum Methodology Framework

The Product Owner (PO) The Product Owner is the guardian of the project and the representative of the client and their needs. The PO serves as the single point of contact between the development team and stakeholders, ensuring that the team always works on the most valuable features.

Key Responsibilities :

— **Vision Management** : Defines and communicates the product vision to ensure all team members understand the project goals.

— **Backlog Management** : Creates, maintains, and prioritizes the Product Backlog, ensuring items are clearly defined with acceptance criteria.

— **Stakeholder Communication** : Acts as the liaison between stakeholders and the development team, gathering requirements and feedback.

— **Value Maximization** : Makes decisions that maximize the value delivered by the team in each sprint.

— **Acceptance** : Accepts or rejects completed work based on the Definition of Done.

In our MyLoc project, the Product Owner was responsible for :

- Gathering requirements from different user perspectives (Admin, Agency, Customer).
- Prioritizing features like authentication, car management, booking, and chatbot.
- Validating completed increments during Sprint Reviews.

The Scrum Master (SM) The Scrum Master is a facilitator and servant-leader who ensures the team follows Scrum practices correctly. The SM is focused on the framework itself and removes any obstacles that prevent the team from achieving their sprint goals.

Key Responsibilities :

- **Process Facilitation** : Ensures all Scrum events take place and are productive, time-boxed, and positive.
- **Impediment Removal** : Identifies and removes obstacles that block the team's progress.
- **Team Protection** : Shields the team from external interruptions and distractions during the sprint.
- **Coaching** : Helps team members understand Scrum theory, practices, and rules.
- **Continuous Improvement** : Facilitates retrospectives and drives process improvements.
- **Collaboration** : Works with the Product Owner to ensure the backlog is well-maintained and understood.

In our project, the Scrum Master :

- Facilitated Daily Stand-ups and ensured they stayed within 15 minutes.
- Resolved blockers related to environment setup, API integration, and deployment.
- Ensured smooth communication between frontend and backend developers.

The Development Team The Development Team is responsible for delivering potentially shippable product increments at the end of each sprint. The team is multidisciplinary, self-organized, and collectively accountable for the work delivered.

Key Characteristics :

- **Cross-Functional** : The team possesses all skills needed to create the product increment (frontend, backend, database, DevOps, testing).
- **Self-Organizing** : Team members decide how to accomplish their work without being directed by others.
- **Collaborative** : Members work together, share knowledge, and help each other overcome challenges.
- **Accountable** : The entire team is responsible for delivering the sprint commitment, not

individual members.

- **Optimal Size** : Typically 3-9 members to ensure effective communication and productivity.

Responsibilities :

- Transform backlog items into working software increments.
- Estimate the effort required for backlog items.
- Participate actively in all Scrum ceremonies.
- Maintain code quality through testing and code reviews.
- Deploy and document completed features.

In our MyLoc project, the Development Team handled :

- Frontend development (Angular) : UI components, routing, guards, services.
- Backend development (Spring Boot) : REST APIs, business logic, database operations.
- AI Service (Flask) : Chatbot integration with ChatGPT API.
- DevOps : Docker containerization, Kubernetes deployment, GitLab CI/CD pipelines.

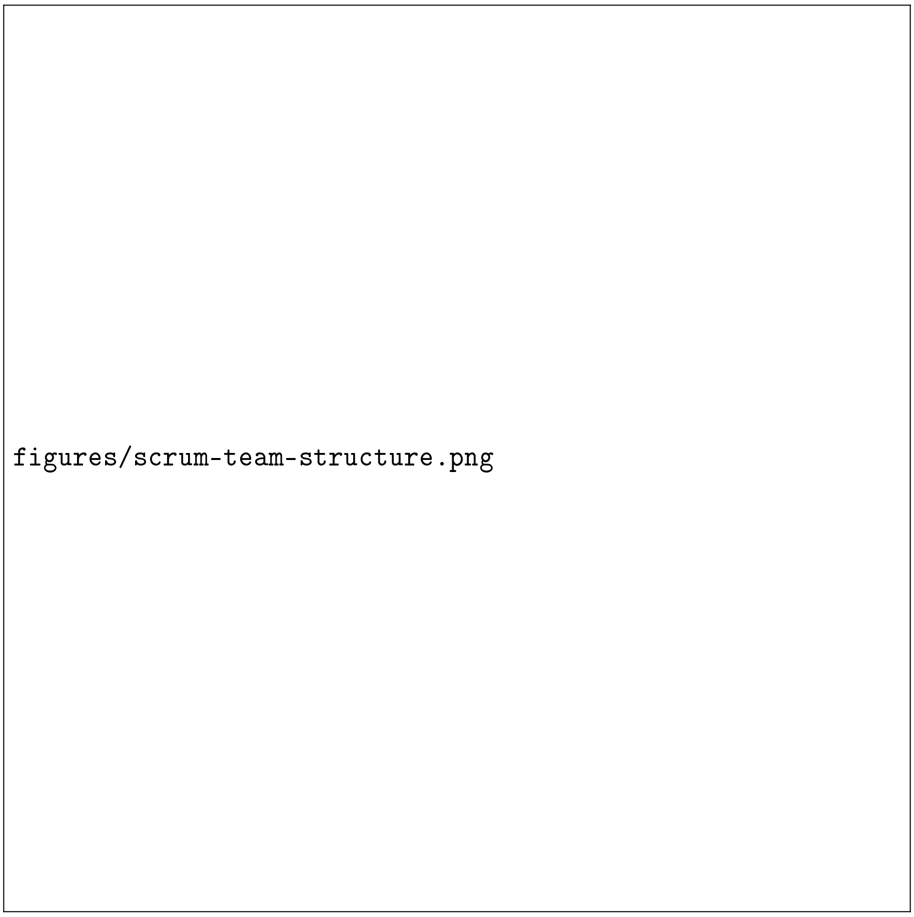


Figure 1.3 : Scrum Team Structure and Interactions

1.8.3.2 Scrum Events (Ceremonies)

Scrum defines five key events (ceremonies) that create regularity and minimize the need for meetings not defined in Scrum. Each event is time-boxed, meaning it has a maximum duration that ensures efficient use of time.

Sprint The Sprint is the heart of Scrum—a time-boxed iteration during which a "Done", usable, and potentially releasable product increment is created. Sprints have consistent durations throughout development and a new sprint starts immediately after the previous one concludes.

Key Characteristics :

- **Duration** : Fixed length of 1-4 weeks (our project used 10-15 day sprints).
- **Consistency** : Sprint length remains constant throughout the project for predictability.
- **Protection** : No changes are made during the sprint that would endanger the Sprint Goal.
- **Scope Flexibility** : Scope may be clarified and re-negotiated between the PO and Development Team.
- **Cancellation** : Only the Product Owner can cancel a sprint if the Sprint Goal becomes obsolete.

During a sprint, the team :

- Develops the selected features from the Sprint Backlog.
- Attends Daily Scrum meetings to synchronize work.
- Refines backlog items for future sprints.
- Prepares for the Sprint Review and Retrospective.

Our project was divided into **8 sprints**, each focusing on specific modules :

- Sprint 0 : Project setup, environment configuration, Keycloak integration.
- Sprints 1-2 : User authentication, role management, admin dashboard.
- Sprints 3-4 : Agency management, car CRUD operations, image upload.
- Sprints 5-6 : Customer features, booking system, availability checking.
- Sprint 7 : Chat system, chatbot integration, notifications.
- Sprint 8 : Payment integration, PDF contracts, QR codes, final testing.

Sprint Planning Meeting Sprint Planning is a collaborative meeting that initiates the sprint. The entire Scrum Team participates to define what can be delivered in the upcoming sprint and how the work will be achieved. This meeting should not exceed 4 hours for a 2-week sprint.

Meeting Structure :

1. **Part 1 - What ?** : The Product Owner presents the highest priority items from the Product Backlog. The team discusses and selects items they can commit to completing.
2. **Part 2 - How ?** : The Development Team plans the work needed to deliver the selected items, breaking them into tasks.

Inputs :

— Prioritized Product Backlog

— Team velocity (historical data on work completed per sprint)

— Team capacity (availability considering holidays, other commitments)

— Definition of Done

Outputs :

— Sprint Goal : A clear objective for the sprint

— Sprint Backlog : Selected items + plan for delivering them

— Team commitment to deliver the increment

Daily Scrum (Stand-up) The Daily Scrum is a 15-minute time-boxed event held every day at the same time and place. It is designed to synchronize activities, identify impediments, and plan the next 24 hours of work. Only the Development Team members participate actively, though others may attend as observers.

The Three Questions : Each team member answers three questions :

1. **What did I do yesterday ?** - Progress report on completed tasks.
2. **What will I do today ?** - Planned tasks for the current day.
3. **Are there any impediments ?** - Blockers preventing progress.

Key Rules :

— Same time, same place every day (consistency).

— Standing up to keep it short (hence "stand-up").

— No problem-solving during the meeting—issues are taken offline.

— Focus on progress toward the Sprint Goal, not status reporting.

Benefits :

— Improves communication and team cohesion.

— Quickly surfaces blockers for resolution.

— Eliminates the need for other meetings.

— Promotes quick decision-making and accountability.

In our project, Daily Scrums helped identify :

- API endpoint mismatches between frontend and backend.
- Docker configuration issues.
- Keycloak token validation problems.
- Database schema updates needed for new features.

Sprint Review The Sprint Review is held at the end of the sprint to inspect the increment and adapt the Product Backlog if needed. The team presents what was accomplished during the sprint, and stakeholders provide feedback. This meeting should not exceed 2 hours for a 2-week sprint.

Participants :

- Scrum Team (PO, SM, Development Team)
- Key stakeholders (invited by the Product Owner)

Meeting Activities :

1. The Product Owner explains what backlog items have been "Done" and what has not been "Done".
2. The Development Team demonstrates the completed work and answers questions.
3. The Product Owner discusses the current state of the Product Backlog and projects likely completion dates.
4. The entire group collaborates on what to do next, providing input for the next Sprint Planning.
5. Review of timeline, budget, and marketplace for the next anticipated product release.

Outputs :

- Updated Product Backlog based on feedback.
- Acceptance or rejection of completed items.
- Input for the next sprint's planning.

Sprint Retrospective The Sprint Retrospective is an opportunity for the Scrum Team to inspect itself and create a plan for improvements to be implemented during the next sprint. It occurs after the Sprint Review and before the next Sprint Planning. The meeting should not exceed 1.5 hours for a 2-week sprint.

Focus Areas :

- **People** : How well did the team collaborate ?
- **Relationships** : How was the communication within the team and with stakeholders ?
- **Processes** : Were the Scrum practices followed effectively ?

- **Tools** : Did the tools support or hinder the work ?

Common Format (Start-Stop-Continue) :

- **Start** : What should we start doing ?
- **Stop** : What should we stop doing ?
- **Continue** : What should we continue doing ?

Alternative Format (Liked-Learned-Lacked-Longed For) :

- **Liked** : What did we enjoy this sprint ?
- **Learned** : What new knowledge did we gain ?
- **Lacked** : What was missing or insufficient ?
- **Longed For** : What do we wish we had ?

Outputs :

- Identified improvements for the next sprint.
- Action items with owners and deadlines.
- Updated team working agreements if needed.

In our project, retrospectives led to improvements such as :

- Better Git branching strategy (feature branches).
- More thorough API documentation.
- Earlier integration testing between frontend and backend.
- Improved Docker compose configurations for faster local development.

Backlog Refinement (Grooming) Backlog Refinement is an ongoing activity where the Product Owner and Development Team collaborate to add detail, estimates, and order to Product Backlog items. This is not an official Scrum event but is essential for maintaining a healthy backlog.

Activities :

- Adding details and acceptance criteria to user stories.
- Estimating effort using story points or hours.
- Splitting large items into smaller, more manageable ones.
- Re-prioritizing items based on new information.
- Removing obsolete items.

Best Practice : The Development Team should spend no more than 10% of their capacity on refinement activities.

1.8.3.3 Scrum Artifacts

Scrum artifacts represent work or value and are designed to maximize transparency and provide opportunities for inspection and adaptation. The three primary artifacts are the Product Backlog, Sprint Backlog, and Increment.

Product Backlog The Product Backlog is an ordered list of everything that is known to be needed in the product. It is the single source of requirements for any changes to be made to the product. The Product Owner is responsible for the Product Backlog, including its content, availability, and ordering.

Characteristics :

- **Dynamic** : Constantly evolves as new requirements emerge.
- **Ordered** : Items are prioritized based on value, risk, dependencies, and need.
- **Detailed Appropriately** : Higher priority items are more detailed ; lower priority items are less refined.
- **Estimated** : Items have size estimates provided by the Development Team.
- **Living Document** : Never complete—it grows and changes with the product.

Backlog Item Structure (User Story Format) :

As a [type of user], I want [goal/desire] so that [benefit/value].

Prioritization Methods :

- **MoSCoW** : Must have, Should have, Could have, Won't have.
- **Value vs. Effort** : Prioritize high-value, low-effort items first.
- **WSJF (Weighted Shortest Job First)** : Cost of delay divided by duration.

In our project, the Product Backlog contained 40 user stories organized by epic :

- Authentication & Authorization (US-01 to US-05)
- Admin Management (US-06 to US-12)
- Agency Management (US-13 to US-19)
- Customer Features (US-20 to US-30)
- Communication & Notifications (US-31 to US-35)
- Payment & Contracts (US-36 to US-40)

Sprint Backlog The Sprint Backlog is the set of Product Backlog items selected for the Sprint, plus a plan for delivering the product Increment and realizing the Sprint Goal. It is a forecast by the Development Team about what functionality will be in the next Increment and the work needed to deliver it.

Components :

- Selected Product Backlog items (user stories).
- Tasks breakdown for each item.
- Estimated effort for each task.
- Task assignments (self-selected by team members).
- Sprint Goal.

Characteristics :

- Owned exclusively by the Development Team.
- Updated daily as work progresses.
- Only the Development Team can add or modify items during the sprint.
- Highly visible to all stakeholders.

Increment The Increment is the sum of all the Product Backlog items completed during a sprint and the value of the increments of all previous sprints. At the end of a sprint, the new Increment must be "Done," meaning it must be in usable condition and meet the Scrum Team's Definition of Done.

Definition of Done (DoD) : Our project's Definition of Done included :

- Code is written and follows coding standards.
- Code is reviewed by at least one other team member.
- Unit tests are written and passing.
- Integration tests are passing.
- Feature is documented (API endpoints, user guide).
- Feature is deployed to staging environment.
- Feature is demonstrated and accepted by Product Owner.

Burndown Chart The Burndown Chart is a visual representation of work left to do versus time. It shows the progress of the team toward completing the Sprint Backlog and helps predict whether the team will complete all planned work by the end of the sprint.

Reading the Burndown Chart :

- **Ideal Line** : The theoretical progression if work is completed evenly throughout the sprint.
- **Actual Line** : The real progress based on completed work.
- **Above Ideal** : Team is behind schedule.
- **Below Ideal** : Team is ahead of schedule.
- **Plateau** : No progress—possible blockers or impediments.

Velocity Chart Velocity is the amount of work a team completes during a sprint, measured in story points or hours. Tracking velocity helps the team forecast how much work they can complete in future figures/project-burndown-chart.png

Figure 1.4 : Example Sprint Burndown Chart

sprints.

Uses of Velocity :

- Capacity planning for Sprint Planning.
- Release forecasting (when will feature X be ready ?).
- Identifying trends (improving or declining productivity).
- Detecting process problems (sudden velocity drops).

1.8.4 Agile Methodology Implementation

Development was organized in 8 sprints of 10-15 days each, encouraging feedback, team collaboration, and continuous improvement. The project followed these Scrum practices :

- **Sprint Planning** : Each sprint began with planning sessions to select user stories and define acceptance criteria.
- **Daily Stand-ups** : Brief daily meetings to synchronize team activities and identify blockers.
- **Sprint Reviews** : Demonstrations of completed features to validate functionality with stakeholders.
- **Retrospectives** : Team reflections to improve processes and address challenges.

figures/velocity-chart.png

Figure 1.5 : Team Velocity Chart Across Sprints

- **Continuous Integration** : Automated builds and tests via GitLab CI/CD to ensure code quality.

1.8.5 Development Environment

1.8.5.1 Hardware Environment

Component	Specification
Processor	Intel Core i7
RAM	16 GB DDR4
Storage	512 GB SSD
Operating System	Windows 10 + WSL2
Display	15.6-inch Full HD

Tableau 1.4 : Development Machine Specifications

1.8.5.2 Software Environment

- Programming Languages : Java, Python, TypeScript, HTML/CSS/JS.
- Frameworks : Spring Boot, Flask, Angular, Keycloak.
- Containerization : Docker, Docker Compose.

- Orchestration : Kubernetes (K8s).
- CI/CD : GitLab CI/CD.
- Database : MySQL.
- Testing : Postman, XAMPP.
- IDE : Visual Studio Code.
- Version Control : Git, GitLab.
- Project Management : Scrum, Trello/GitLab Issues.

1.8.5.3 Deployment Tools

- Docker Compose for local service orchestration.
- Kubernetes (K8s) for scalable microservice deployment.

1.9 Conclusion

This chapter established the foundation of the MyLoc project by thoroughly examining the problematic situation faced by car rental agencies before digitalization, defining clear objectives for the platform, and demonstrating how the proposed solution addresses each identified challenge. The analysis of existing systems revealed significant gaps in multi-role management, real-time communication, and automation—all of which our platform solves through modern technologies and best practices.

The Scrum methodology was selected after careful comparison with other agile approaches, providing the structured yet flexible framework needed for delivering a complex, multi-stakeholder platform. The development environment, combining Angular, Spring Boot, Flask (AI chatbot), Keycloak, Spring Security, Docker, Kubernetes, and GitLab CI/CD, ensures a scalable, secure, and maintainable solution.

The next chapter will detail the requirements analysis, including a comprehensive study of actors, functional and non-functional requirements, and use case specifications for each user role.

Chapitre 2

Needs Analysis and Specification

Plan

2.1 Introduction

This chapter formally defines and analyzes the functional and non-functional needs of the car rental platform. By identifying limitations in existing systems, this section translates user expectations into specific system requirements, focusing on secure, real-time, and scalable services for car rentals, including role-based interactions, authentication, booking workflows, communication, and deployment. Following the context and problem analysis outlined in Chapter 1, this chapter ensures that the platform meets real user needs efficiently and securely.

The requirements analysis follows a systematic approach :

1. **Actor Identification** : Defining who interacts with the system and their responsibilities.
2. **Functional Requirements** : Specifying what the system must do for each actor.
3. **Non-Functional Requirements** : Defining quality attributes like performance, security, and scalability.
4. **Use Case Modeling** : Visualizing interactions between actors and the system.
5. **Class Modeling** : Defining the data structures and relationships.

2.2 Actors Identification

An actor represents an external entity that interacts with the system. Actors can be humans (users with different roles) or systems (automated services). Understanding actors is crucial for defining system boundaries and requirements.

The MyLoc platform supports the following primary actors :

2.2.1 Human Actors

2.2.1.1 Administrator

The Administrator is the highest-privilege user responsible for the overall management and oversight of the platform.

Role Description :

- Manages the entire platform ecosystem including agencies, customers, and content.
- Ensures platform security and enforces access control policies.
- Monitors system health and performance metrics.
- Coordinates with agencies through the built-in chat system.
- Manages blog content to engage users and promote services.

Key Permissions :

- Full CRUD operations on agencies, customers, and blog posts.
- Access to all dashboards and administrative panels.
- System configuration and settings management.
- Direct communication with all agencies.

2.2.1.2 Agency

Agencies are the car rental businesses that list their vehicles on the platform and manage customer bookings.

Role Description :

- Represents car rental companies that offer vehicles for rent.
- Manages their own fleet of cars with full control over listings.
- Processes customer rental requests (approve/reject).
- Communicates with administrators for support and coordination.
- Tracks booking history and manages availability calendars.

Key Permissions :

- Full CRUD operations on their own cars only.
- View and process rental requests for their vehicles.
- Chat with administrators.
- Manage agency profile and settings.

2.2.1.3 Customer

Customers are registered users who browse cars and make rental requests.

Role Description :

- Primary consumers of the car rental service.
- Can browse the full catalog and make informed decisions.
- Submit rental requests with date ranges and preferences.
- Track their booking history and request status.
- Engage with the platform through comments, reviews, and the chatbot.

Key Permissions :

- Browse all public content (cars, blogs).
- Submit and manage their rental requests.
- View their booking history and notifications.
- Post comments and reviews.
- Contact administrators via email.

- Use the AI chatbot for assistance.

2.2.1.4 Visitor

Visitors are unauthenticated users exploring the platform before registration.

Role Description :

- Potential customers browsing the platform without an account.
- Can explore available cars and read blog content.
- Can interact with the chatbot for information.
- May subscribe as a Follower to receive updates.
- Can initiate registration to become a Customer.

Key Permissions :

- View public car listings (limited details).
- Read blog posts.
- Use the chatbot.
- Subscribe as a Follower.
- Register for a full account.

2.2.1.5 Follower

Followers are visitors who subscribe to receive email updates without creating a full account.

Role Description :

- Interested users who want to stay informed about new offerings.
- Subscribe by entering their email in the website footer.
- Receive automatic notifications when new cars are added.
- Represents a marketing channel for the platform.
- Low-commitment engagement method to attract potential customers.

Key Permissions :

- Subscribe to new car alerts.
- Receive email notifications.
- Unsubscribe at any time.

2.2.2 System Actors

2.2.2.1 Chatbot (AI Assistant)

The Chatbot is an automated AI-powered assistant that provides instant support to users.

System Description :

- Built with Flask backend connected to OpenAI GPT API.
- Provides 24/7 automated assistance to visitors and customers.
- Answers common questions about cars, bookings, and platform usage.
- Supports multiple languages for international users.
- Reduces workload on human support staff.

Capabilities :

- Natural language processing for user queries.
- Context-aware responses based on conversation history.
- Integration with platform data for accurate information.
- Fallback to human support for complex issues.

2.2.3 Actor Hierarchy Diagram

Figure 2.1 shows the relationships between different actors and their inheritance of permissions.

img/actor-hierarchy.png

Figure 2.1 : Actor Hierarchy and Permission Inheritance

2.3 Needs Identification

2.3.1 Functional Needs

Functional requirements define what the system must do—the features and capabilities it provides to each actor. These requirements are derived from user stories and stakeholder interviews.

2.3.1.1 Customer Functional Requirements

Customers are the primary end-users of the platform. Their requirements focus on ease of use, transparency, and efficient booking processes.

- **Browsing and Discovery :**
  - Browse available cars and blogs without logging in.
  - Search and filter cars based on availability, type, price, and specifications.
  - View detailed car information including photos, features, and pricing.
  - Read reviews and ratings from other customers.
- **Account Management :**
  - Register with email verification for security.
  - Log in securely using Keycloak authentication.
  - Update profile information and preferences.
  - Reset password through secure email link.
- **Booking and Rental :**
  - Check real-time car availability for selected dates.
  - Submit rental requests with date range selection.
  - Receive immediate validation of date availability.
  - Track rental request status (pending, approved, rejected).
  - Cancel pending requests before processing.
  - View complete booking history.
- **Communication and Support :**
  - Receive email notifications on rental request status changes.
  - Receive PDF contract with QR code upon approval.
  - Contact admin directly via email within the app.
  - Interact with the AI chatbot for instant support.
  - Receive in-app notifications for important updates.
- **Engagement :**
  - Comment and provide reviews on cars and blog posts.
  - Receive updates via email when new cars are added.
  - Share content on social media platforms.

2.3.1.2 Agency Functional Requirements

Agencies require tools to efficiently manage their fleet and customer interactions.

- **Account and Profile :**
  - Register as an agency with business details.
  - Log in securely with role-based authentication.
  - Manage agency profile, logo, and contact information.
- **Fleet Management :**
  - Add new cars with complete details (name, model, type, price, features).
  - Upload multiple photos for each car.
  - Edit car information and availability.
  - Delete cars from the platform.
  - Manage car availability calendars.
- **Booking Management :**
  - View all rental requests for their cars.
  - Accept or decline requests with one click.
  - Automatic email sent to customers upon decision.
  - Track booking history and statistics.
- **Communication :**
  - Chat with administrators in real-time.
  - Receive notifications of new rental requests.
  - View message history for reference.

2.3.1.3 Administrator Functional Requirements

Administrators need comprehensive control over all platform aspects.

- **Agency Management :**
  - Add new agencies to the platform.
  - Edit agency information and status.
  - Delete or suspend agency accounts.
  - View agency performance metrics.
- **Customer Management :**
  - View all registered customers.
  - Edit customer information if needed.
  - Delete or suspend customer accounts.
  - Handle customer complaints and issues.
- **Content Management :**
  - Create blog posts with rich content.

  - Edit and update existing blogs.
  - Delete inappropriate content.
  - Moderate comments and reviews.
- **Communication :**
  - Chat with agencies for coordination.
  - Send platform-wide announcements.
  - Respond to customer contact emails.
- **System Administration :**
  - Monitor system health and performance.
  - Manage security settings via Keycloak.
  - Configure platform settings and preferences.
  - Access logs and audit trails.

2.3.1.4 Follower Functional Requirements

- Subscribe to updates by entering email in the website footer.
- Receive automatic email notifications when new cars are added.
- Stay informed about new offerings without a full account.
- Unsubscribe from notifications at any time via email link.

2.3.1.5 System-wide Functionalities

- Secure authentication and role-based authorization via Keycloak.
- Instant messaging system enabling admin-agency communication.
- Email notification system for updates, rental request status, and confirmations.
- PDF generation with QR codes for confirmed rental contracts.
- Integration of chatbot powered by Flask API for user assistance.
- Deployment automation using GitLab CI/CD pipelines, Docker Compose, and Kubernetes.
- Real-time availability checking for cars during rental request submission.

2.3.2 Non-Functional Needs

- **Performance :**
  - The system must respond to user actions (e.g., browsing cars, submitting rental requests) within 2 seconds under normal load.
  - Rental availability checks must provide real-time feedback during request submission.
  - Email notifications and PDF generation should be triggered within 2 minutes after any

change in request status.

- **Security :**
  - Authentication and authorization must be enforced using Keycloak, with role-based access control (Admin, Agency, Customer).
  - All sensitive data (e.g., passwords, personal information) must be securely stored and transmitted using encryption protocols (HTTPS, password hashing).
  - All API endpoints must be protected from unauthorized access using AuthGuard and secure access control mechanisms.
  - The application must defend against common security threats such as SQL injection, cross-site scripting (XSS), and cross-site request forgery (CSRF).
- **Usability :**
  - The user interface must be intuitive, user-friendly, and responsive across desktop, tablet, and mobile devices.
  - Customers must be able to easily browse, search for cars, submit rental requests, and track their status.
  - Agencies and administrators should have dedicated dashboards for managing cars, requests, blogs, and communication.
- **Reliability and Availability :**
  - The system should ensure 99.9% uptime, with robust error handling and recovery mechanisms.
  - All rental and user data must be reliably saved and backed up regularly.
- **Maintainability and Extensibility :**
  - The codebase must follow clean architecture principles and separation of concerns to facilitate future updates.
  - Continuous integration and deployment (CI/CD) pipelines using GitLab must support automated testing and deployment.
  - Comprehensive documentation should be maintained for the API, deployment process, and system usage.
- **Scalability :**
  - The system must support increased user traffic and rental activity without performance degradation.
  - Kubernetes-based deployment must allow for horizontal scaling of services as demand grows.
- **Interoperability :**
  - The system must integrate seamlessly with external services, including the Flask-based

chatbot API and payment gateways.

- Email services must be compatible with SMTP or third-party providers to ensure reliable communication.

2.4 System Design

This section presents the visual models that describe the system's structure and behavior. These diagrams follow the Unified Modeling Language (UML) standard and serve as blueprints for development.

2.4.1 Use Case Diagrams

Use case diagrams describe the functional requirements of the system from the user's perspective. They show what the system does, not how it does it. Each diagram represents the interactions between a specific actor and the system.

2.4.1.1 Global Use Case Overview

The global use case diagram represents the overall interactions between primary actors (Customer, Agency, Administrator, Visitor, Follower) and the car rental platform. It highlights the key functionalities accessible to each actor, offering a high-level overview of the system's capabilities.

Key System Boundaries :

- **Public Area** : Accessible to all users (visitors, customers, followers) - includes car browsing, blog reading, and chatbot interaction.
- **Customer Area** : Requires customer authentication - includes booking, history, notifications.
- **Agency Area** : Requires agency authentication - includes fleet management, request processing.
- **Admin Area** : Requires administrator privileges - includes full platform management.

2.4.1.2 Customer Use Case Diagram

The customer use case diagram illustrates the primary interactions between customers and the car rental platform. It shows how registered customers can manage their profiles, search and book vehicles, interact with the AI chatbot, and engage with the platform's content system.

Primary Use Cases for Customer :

- **UC-C01 : Browse Cars** - Customer explores the available car catalog with filtering options.
- **UC-C02 : View Car Details** - Customer examines detailed information, photos, and pricing.

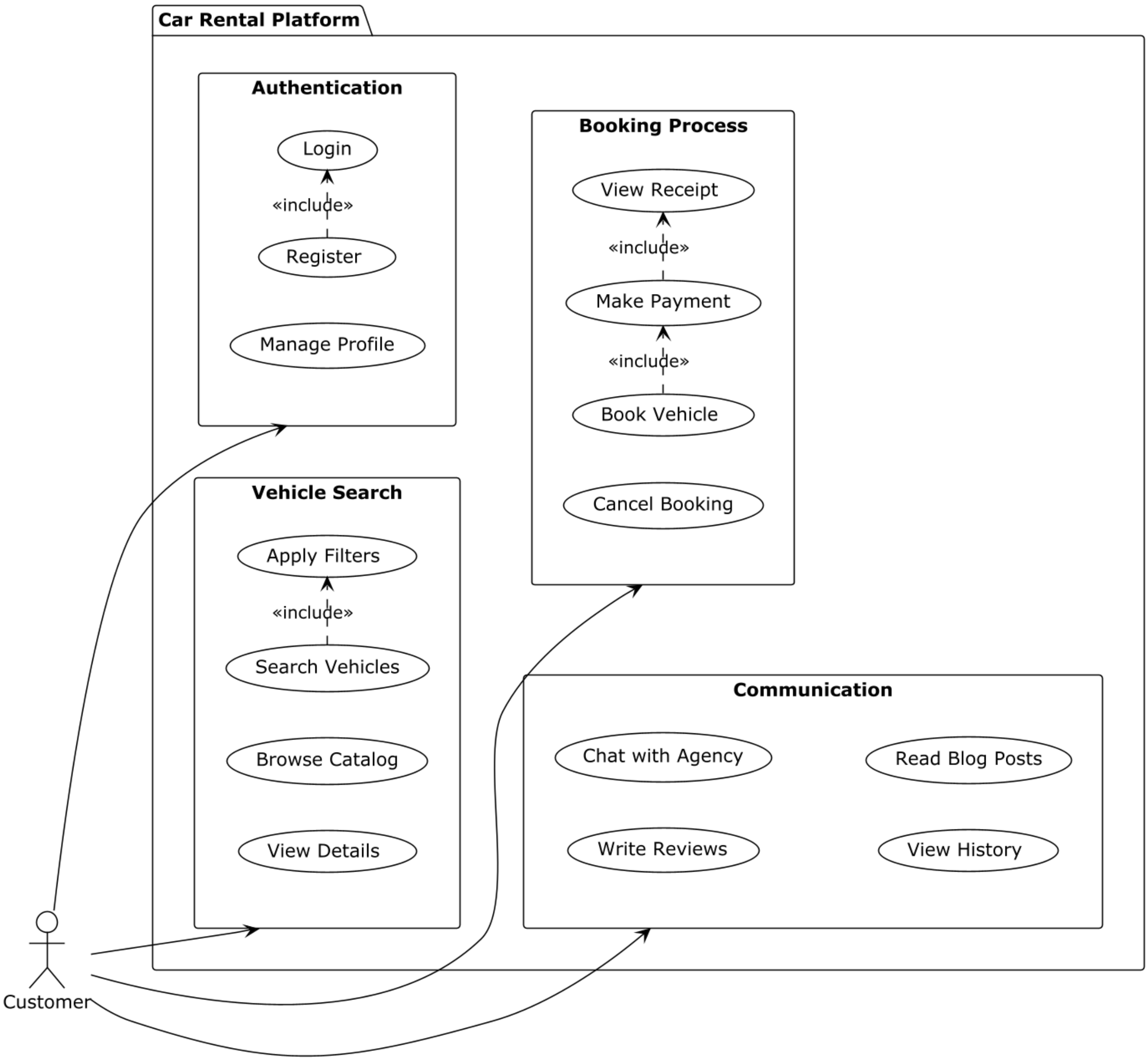


Figure 2.2 : Use Case Diagram for Customer - Myloc Agency Platform

- **UC-C03 : Check Availability** - System validates car availability for selected dates.
- **UC-C04 : Submit Rental Request** - Customer submits a booking request for a specific car and date range.
- **UC-C05 : Track Request Status** - Customer monitors the status of submitted requests.
- **UC-C06 : View Booking History** - Customer accesses past and current bookings.
- **UC-C07 : Receive Notifications** - Customer receives email and in-app notifications.
- **UC-C08 : Use Chatbot** - Customer interacts with AI assistant for support.
- **UC-C09 : Post Comments** - Customer leaves reviews on cars and blogs.
- **UC-C10 : Contact Admin** - Customer sends direct email to administrators.

2.4.1.3 Agency Use Case Diagram

The agency use case diagram demonstrates how car rental agencies interact with the platform to manage their fleet, handle customer bookings, and maintain their business operations through the comprehensive agency dashboard.

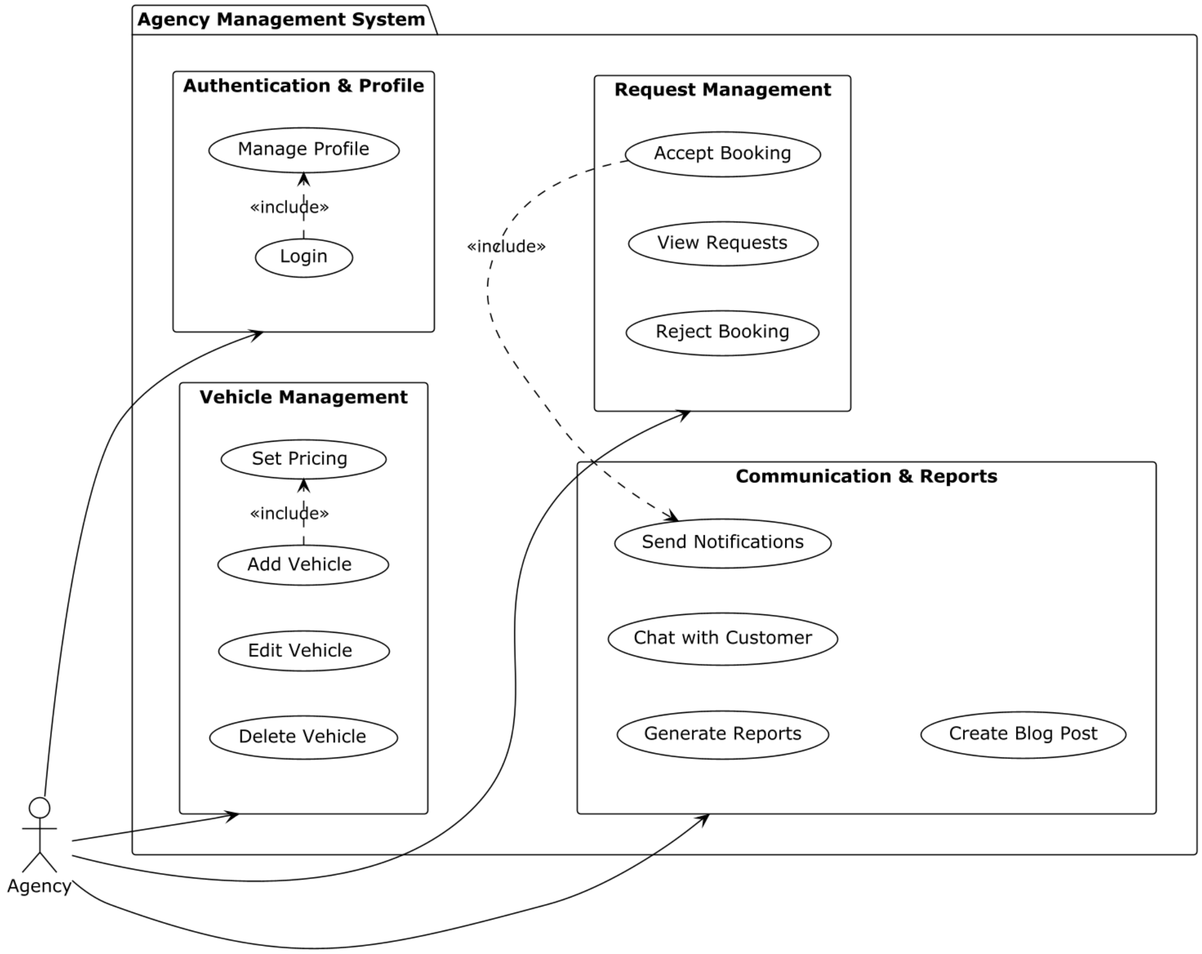


Figure 2.3 : Use Case Diagram for Agency - Fleet and Booking Management

Primary Use Cases for Agency :

— **UC-A01 : Manage Profile** - Agency updates their business information and settings.

— **UC-A02 : Add Car** - Agency adds a new vehicle to their fleet with details and photos.

— **UC-A03 : Edit Car** - Agency modifies existing car information.

— **UC-A04 : Delete Car** - Agency removes a car from the platform.

— **UC-A05 : Upload Photos** - Agency uploads multiple images for each car.

— **UC-A06 : View Requests** - Agency sees all rental requests for their cars.

— **UC-A07 : Approve Request** - Agency accepts a customer's booking request.

— **UC-A08 : Reject Request** - Agency declines a customer's booking request.

— **UC-A09 : Chat with Admin** - Agency communicates with administrators in real-time.

- **UC-A10 : Receive Notifications** - Agency receives alerts for new requests.

2.4.1.4 Administrator Use Case Diagram

The administrator use case diagram showcases the comprehensive system management capabilities available to platform administrators, including user management, content moderation, financial oversight, and system maintenance operations.

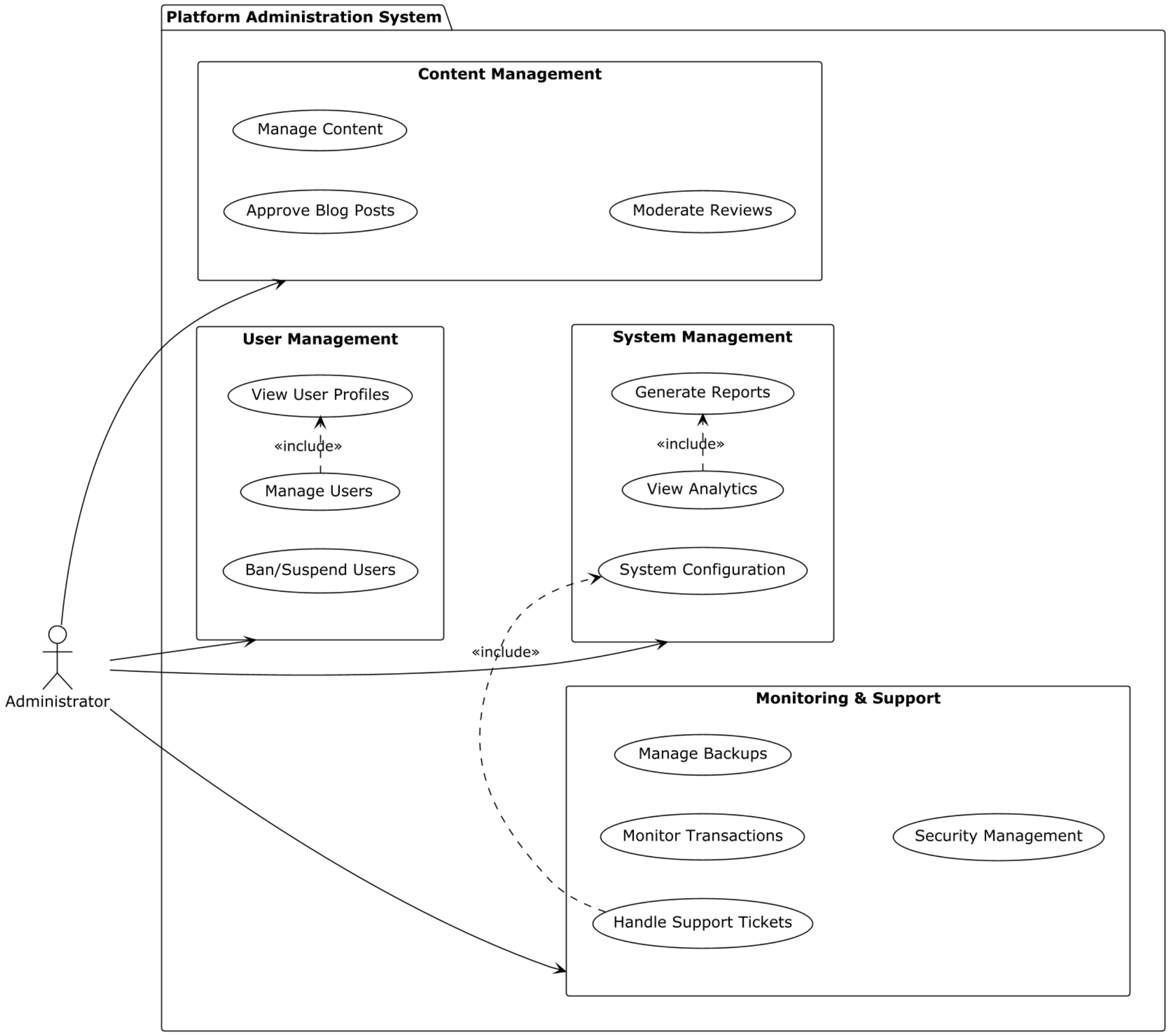


FIGURE 2.4 : Use Case Diagram for Administrator - System Management

Primary Use Cases for Administrator :

- **UC-AD01 : Manage Agencies** - Admin performs CRUD operations on agency accounts.
- **UC-AD02 : Manage Customers** - Admin manages customer accounts and issues.
- **UC-AD03 : Create Blog** - Admin publishes new blog content.
- **UC-AD04 : Edit Blog** - Admin updates existing blog posts.
- **UC-AD05 : Delete Blog** - Admin removes inappropriate content.
- **UC-AD06 : Chat with Agencies** - Admin communicates with agencies in real-time.

- **UC-AD07 : View Statistics** - Admin monitors platform metrics and performance.
- **UC-AD08 : Manage Settings** - Admin configures system preferences.
- **UC-AD09 : Respond to Contacts** - Admin replies to customer inquiries.
- **UC-AD10 : Monitor Security** - Admin oversees authentication and access control.

2.4.1.5 Visitor and Follower Use Cases

Visitor Use Cases :

- **UC-V01 : Browse Public Content** - View car listings and blog posts.
- **UC-V02 : Use Chatbot** - Interact with AI assistant.
- **UC-V03 : Register Account** - Create a new customer account.
- **UC-V04 : Subscribe as Follower** - Enter email for notifications.

Follower Use Cases :

- **UC-F01 : Subscribe** - Enter email in footer form.
- **UC-F02 : Receive Alerts** - Get email when new cars are added.
- **UC-F03 : Unsubscribe** - Opt out of notifications via email link.

2.4.2 Class Diagram

The class diagram represents the static structure of the system, showing the classes, their attributes, methods, and the relationships between them. It serves as the foundation for the database schema and backend models.

Core Entity Classes :

- **User** : Base class for all user types with common attributes (id, email, password, role).
- **Customer** : Extends User with customer-specific attributes (name, phone, address).
- **Agency** : Extends User with agency details (company name, logo, description).
- **Admin** : Extends User with administrative privileges.
- **Follower** : Simple entity with email for newsletter subscriptions.
- **Car** : Represents vehicles with attributes (name, model, type, price, images, availability).
- **RentalRequest** : Links Customer to Car with dates, status, and timestamps.
- **Blog** : Content entity with title, body, images, and author reference.
- **Comment** : User feedback linked to Car or Blog.
- **Message** : Chat messages between Admin and Agency.
- **Notification** : Alerts for users with type, content, and read status.

Key Relationships :

- Agency → Car : One-to-Many (Agency owns multiple cars).

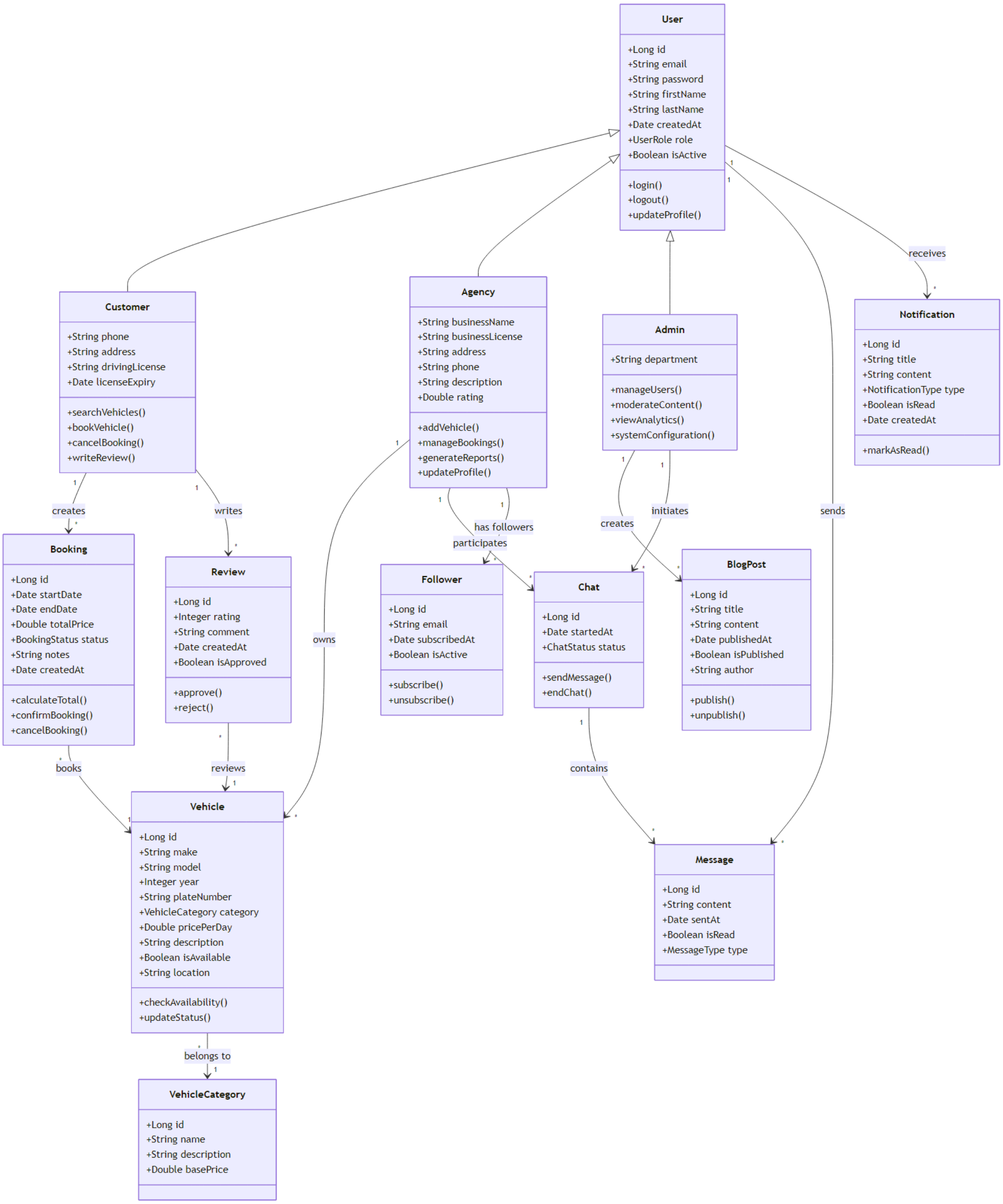


Figure 2.5 : Global Class Diagram Representing Car Rental Platform Architecture

- Customer → RentalRequest : One-to-Many (Customer makes multiple requests).
- Car → RentalRequest : One-to-Many (Car can have multiple requests).
- User → Comment : One-to-Many (User posts multiple comments).
- Admin → Blog : One-to-Many (Admin creates multiple blogs).
- Admin ↔ Agency (via Message) : Many-to-Many communication.

2.5 Project Management Methodology

2.5.1 Traditional vs Agile Methods

Before selecting a methodology for this project, it is essential to understand the fundamental differences between traditional (classical) and agile approaches to project management. The following table presents a comprehensive comparison :

Criteria	Traditional Methods
Process	Linear, sequential (V-Model, Waterfall)
Requirements	Detailed specs fixed at project start
Flexibility	Low, hard to integrate changes
Delivery	Single delivery at project end
Client Interaction	Limited after requirements phase
Risk Management	Upfront identification, few adjustments
Planning	Complete upfront, rigid
Ideal Project	Simple, well-defined, stable
Examples	V-Model, Waterfall, PERT

Tableau 2.1 : Comparison between Traditional and Agile Methods

2.5.2 Methodology Selection

The choice of the Scrum methodology for our project is based on several fundamental considerations. Before detailing the advantages of Scrum, it is relevant to compare this methodology with other recognized agile approaches, such as **Kanban** and **Extreme Programming (XP)**.

The following comparative table presents the three agile methods and justifies the choice of Scrum :

Criteria	Scrum
Structure	Fixed sprints (10-15 days), defined roles & ceremonies
Flexibility	Adaptation at sprint end
Collaboration	Strong via ceremonies & retrospectives
Tracking	Burndown charts, Daily Scrum
Ideal For	Frequent deliveries
Adaptability	High at sprint boundaries

Tableau 2.2 : Comparison between Agile Methods : Scrum, Kanban, and XP

Justification for Choosing Scrum :

— **Scrum** is chosen for its clear structure, which combines flexibility and rigor, while promoting close collaboration and continuous adaptation at each sprint.

- This methodology is particularly suited to our project, which requires regular deliveries and strong interaction with stakeholders.
- **Kanban** is flexible but lacks structure for projects requiring well-defined iterations.
- **XP** is very effective for code quality but demands rigorous discipline and is more oriented towards pure software development.

2.5.3 Scrum Methodology Overview

Scrum is an agile project management method designed to improve team productivity, even remotely, while allowing continuous product optimization through regular user feedback. Inspired by rugby, where teams gather in a scrum, Scrum encourages a dynamic and participative approach to project management.

This ensures a fair balance between initial investment and the final delivered product, offering flexibility to redirect the project along the way. Scrum is widely adopted by development teams because it promotes :

- Collaboration with the client
- Acceptance of change
- Interaction between team members
- Delivery of operational software

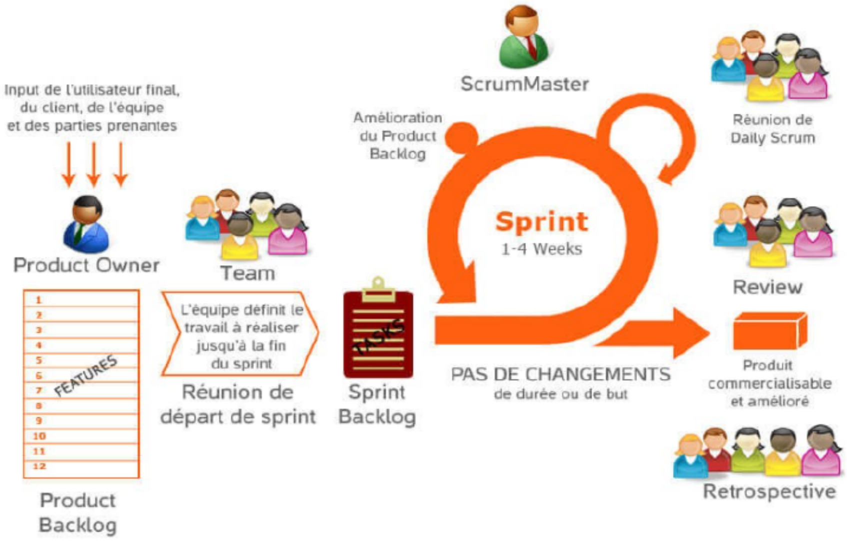


Figure 2.6 : Scrum Methodology Overview

2.5.3.1 Scrum Key Concepts

Sprint

Scrum breaks down the project into different iterations called sprints. Each sprint lasts no more than four weeks, during which the team develops the features specified in the product backlog.

Daily Scrum (Daily Stand-up)

This is a 15-minute daily meeting that tracks project progress. During this meeting, team members present :

- Tasks completed yesterday
- Tasks planned for today
- Identified obstacles preventing them from reaching their goal

Sprint Planning Meeting

A sprint planning meeting lasting no more than 4 hours, during which the team selects the priority features to develop for the upcoming sprint.

Sprint Review

The sprint review is a meeting at the end of the sprint where the team presents the developed features to the client and collects corresponding feedback.

Sprint Retrospective

A meeting where the team reflects on the sprint to identify what went well, what could be improved, and action items for the next sprint.

2.5.3.2 Scrum Team Composition

The Scrum team consists of the Scrum Master, the Product Owner, and the Development Team. The team's objective is to have business value to display at the end of each sprint and to make the most profitable increments at each sprint.

Role
Product Owner (PO)
Scrum Master (SM)
Development Team

Tableau 2.3 : Scrum Team Roles and Responsibilities

The Scrum team for this project is presented in the following table :

Product Owner	Scrum Master	Development Team
Amine Ben Chaabane	Mme. Sawsen Jalel	Bayrem Boussaidi

Tableau 2.4 : Project Scrum Team

2.6 Scrum Implementation and Artifacts

This section presents the detailed Scrum artifacts used throughout the project, including the product backlog, sprint planning, burndown charts, and velocity tracking—similar to tools like Jira.

Figure 2.7 : Scrum Team Structure - Myloc Agency Project

2.7 Introduction to Scrum Artifacts

Scrum artifacts provide key information that the Scrum Team and stakeholders need to understand the work being done, the value being created, and the progress being made. These artifacts are designed to maximize transparency and provide opportunities for inspection and adaptation.

In the context of the MyLoc car rental platform, Scrum artifacts played a crucial role in organizing development work, tracking progress, and ensuring all stakeholders had visibility into the project status.

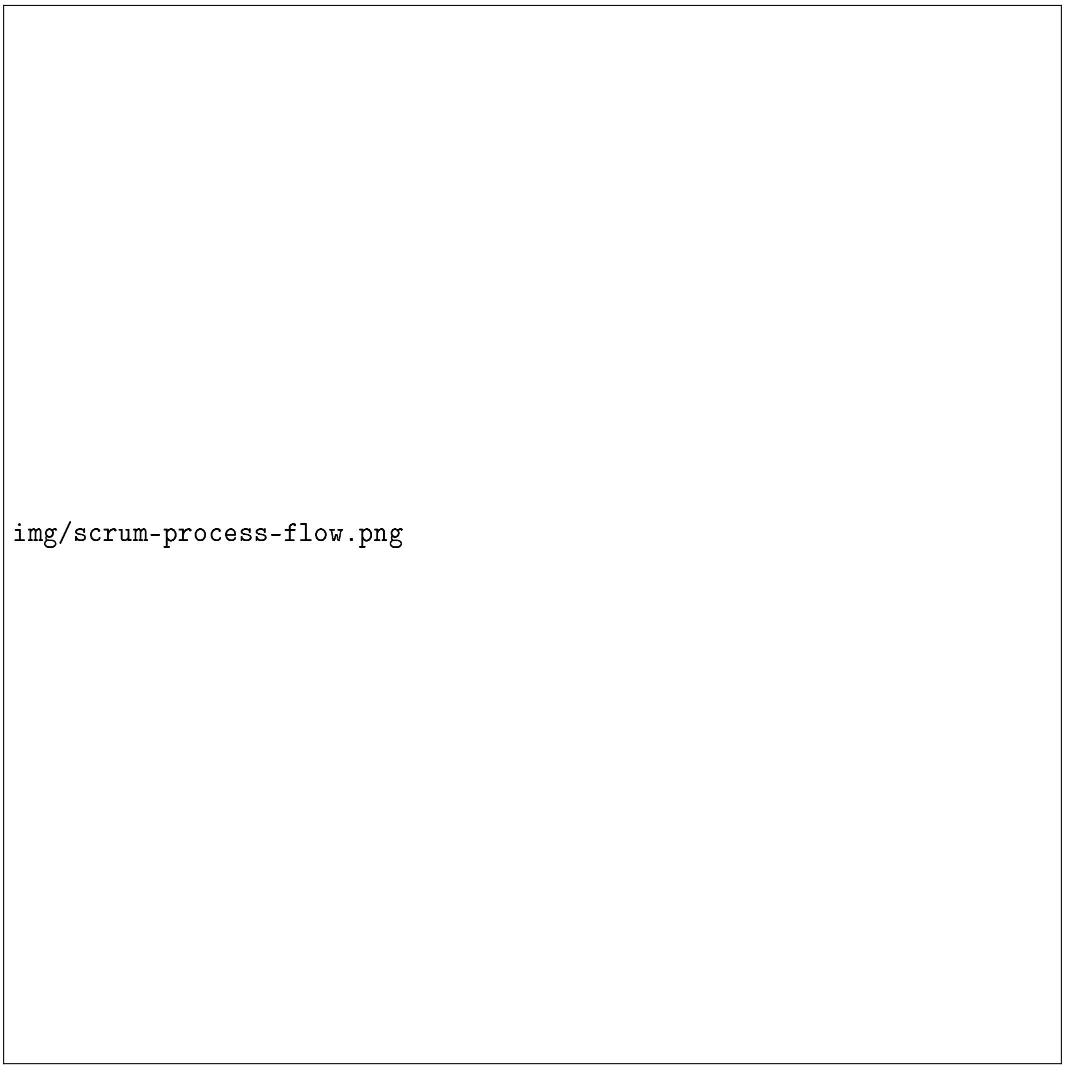


Figure 2.8 : Scrum Process Flow

2.7.1 Purpose of Scrum Artifacts

Product Backlog : Serves as the single source of truth for all work to be done on the product. It contains all features, requirements, enhancements, and bug fixes needed for the MyLoc platform.

Sprint Backlog : Provides a real-time picture of the work planned for the current sprint, helping the Development Team stay focused on the Sprint Goal.

Increment : Represents the cumulative value delivered at the end of each sprint—a potentially releasable version of the product.

Burndown Charts : Visual tools that helped our team track progress, identify potential delays early, and make data-driven decisions.

Velocity Charts : Helped forecast future capacity and establish realistic sprint commitments based on historical performance.

2.7.2 How We Used Artifacts

Throughout the MyLoc project, these artifacts were :

- **Maintained Continuously** : The Product Backlog was refined weekly, with new items added and priorities adjusted based on stakeholder feedback.
- **Reviewed During Ceremonies** : Sprint Backlogs were created during Sprint Planning and reviewed daily during Stand-ups.
- **Shared Transparently** : All artifacts were accessible to stakeholders, promoting trust and collaboration.
- **Used for Decision Making** : Burndown and velocity data informed sprint planning and release forecasting.

2.8 Product Backlog

The Product Backlog is the master list of all features, requirements, enhancements, and fixes that constitute the changes to be made to the product. Each item is described as a User Story with acceptance criteria, priority, and story point estimation.

2.8.1 User Stories and Prioritization

User stories follow the format : *"As a [role], I want [feature] so that [benefit]"*. Priority levels are defined using MoSCoW method (Must have, Should have, Could have, Won't have).

2.8.1.1 Authentication, Car Management & Booking (Sprints 1-3)

2.8.1.2 Communication, Blog, Contracts & DevOps (Sprints 4-8)

2.8.2 Backlog Summary

2.9 Sprint Planning

The project was executed over 8 sprints, each lasting 10-15 days. The team velocity stabilized at approximately 26 story points per sprint after the initial sprints.

2.9.1 Sprint Overview

2.9.2 Sprint 1 : Authentication & Platform Setup

Sprint Goal : Set up development environment and implement secure multi-role authentication using Keycloak.

ID	User Story Description	Priority	Sprint
US-01	Visitor registers an account	Must	1
US-02	User logs in securely	Must	1
US-03	Admin manages user roles	Must	1
US-04	User resets password	Should	1
US-05	User updates profile	Should	2
US-06	Agency adds new cars	Must	2
US-07	Agency edits car details	Must	2
US-08	Agency deletes cars	Must	2
US-09	Agency uploads car photos	Must	2
US-10	Customer browses cars	Must	2
US-11	Customer filters cars by criteria	Should	2
US-12	Customer views car details	Must	2
US-13	Customer checks car availability	Must	3
US-14	Customer submits rental request	Must	3
US-15	Agency views rental requests	Must	3
US-16	Agency approves/rejects requests	Must	3
US-17	Customer receives email notifications	Must	3

Tableau 2.5 : Product Backlog - Part 1 : Core Features (Sprints 1-3)

Duration : 12 days

Sprint 1 Retrospective :

- *What went well :* Keycloak integration was smoother than expected.
- *What could improve :* Initial environment setup took longer due to Docker configuration on Windows.
- *Action items :* Document Docker setup steps for future reference.

2.9.3 Sprint 2 : Car Management Module

Sprint Goal : Implement complete CRUD operations for car listings with image upload functionality.

Duration : 14 days

2.9.4 Sprint 3 : Booking System Core

Sprint Goal : Implement the complete rental request workflow with availability checking and email notifications.

Duration : 15 days

2.9.5 Sprint 4 : Communication Features

Sprint Goal : Implement real-time chat system and notification infrastructure.

ID	User Story Description	Priority	Sprint
US-18	Customer views booking history	Should	4
US-19	Customer cancels pending requests	Should	4
US-20	Admin chats with agencies	Must	4
US-21	Agency receives real-time messages	Must	4
US-22	User receives in-app notifications	Should	4
US-23	Customer contacts admin via email	Should	4
US-24	Admin creates blog posts	Should	5
US-25	Admin edits/deletes blogs	Should	5
US-26	Visitor reads blogs	Should	5
US-27	Customer comments on blogs	Could	5
US-28	Visitor becomes Follower (email subscription for new car alerts)	Could	5
US-29	Customer receives PDF contract	Must	6
US-30	Contract includes QR code	Should	6
US-31	Customer pays online	Must	6
US-32	Agency tracks payments	Should	6
US-33	Visitor uses chatbot	Should	7
US-34	Customer uses multilingual chatbot	Could	7
US-35	Admin manages agencies	Must	7
US-36	Admin views statistics	Should	7
US-37	Admin manages customers	Should	7
US-38	Developer creates Docker containers	Must	8
US-39	Developer sets up CI/CD pipelines	Must	8
US-40	Developer deploys on Kubernetes	Should	8

Tableau 2.6 : Product Backlog - Part 2 : Advanced Features (Sprints 4-8)

Priority Level	Number of Stories	Total Story Points
Must Have	22	132
Should Have	14	63
Could Have	4	14
Total	**40**	**209**

Tableau 2.7 : Product Backlog Summary by Priority

Duration : 12 days

2.9.6 Sprint 5 : Blog & Subscription System

Sprint Goal : Implement blog management and email subscription for visitors.

Duration : 10 days

2.9.7 Sprint 6 : Contracts & Payments

Sprint Goal : Implement PDF contract generation with QR codes and online payment integration.

Duration : 15 days

Sprint	Goal	Duration	Planned SP	Completed SP
1	Authentication & Setup	12 days	24	24
2	Car Management Module	14 days	28	28
3	Booking System Core	15 days	31	31
4	Communication Features	12 days	24	24
5	Blog & Subscription	10 days	17	17
6	Contracts & Payments	15 days	31	31
7	Chatbot & Admin Panel	12 days	21	21
8	DevOps & Deployment	15 days	34	34
		Total (105 days)	**210**	**210**

Tableau 2.8 : Sprint Overview - Planned vs Completed Story Points

Task	Description	Assignee	Hours	Status
T1.1	Initialize Angular 16 project	Dev	4h	Done
T1.2	Set up Spring Boot 3.x backend	Dev	4h	Done
T1.3	Configure MySQL database	Dev	6h	Done
T1.4	Deploy Keycloak container	Dev	4h	Done
T1.5	Implement registration API	Dev	8h	Done
T1.6	Implement JWT login	Dev	10h	Done
T1.7	Create AuthGuard	Dev	8h	Done
T1.8	Password reset feature	Dev	6h	Done
T1.9	Login/register UI	Dev	8h	Done
T1.10	Unit testing	Dev	6h	Done

Tableau 2.9 : Sprint 1 Backlog - Authentication & Setup

Task	Description	Assignee	Hours	Status
T2.1	Design Voiture entity	Dev	4h	Done
T2.2	Create car CRUD endpoints	Dev	8h	Done
T2.3	Image upload service	Dev	6h	Done
T2.4	Car listing component	Dev	6h	Done
T2.5	Car detail page	Dev	4h	Done
T2.6	Search & filter functionality	Dev	8h	Done
T2.7	Agency dashboard	Dev	10h	Done
T2.8	Profile update feature	Dev	6h	Done
T2.9	Form validation	Dev	4h	Done
T2.10	Integration testing	Dev	6h	Done

Tableau 2.10 : Sprint 2 Backlog - Car Management

2.9.8 Sprint 7 : Chatbot & Admin Panel

Sprint Goal : Integrate AI chatbot and complete admin dashboard functionalities.

Duration : 12 days

Task	Description	Assignee	Hours	Status
T3.1	Design Booking entity	Dev	4h	Done
T3.2	Availability checking algorithm	Dev	10h	Done
T3.3	Booking request API	Dev	8h	Done
T3.4	Booking form with date picker	Dev	6h	Done
T3.5	Agency request management	Dev	8h	Done
T3.6	Approve/reject workflow	Dev	6h	Done
T3.7	Configure SMTP email	Dev	4h	Done
T3.8	Email notification templates	Dev	6h	Done
T3.9	Booking history page	Dev	6h	Done
T3.10	End-to-end testing	Dev	8h	Done

Tableau 2.11 : Sprint 3 Backlog - Booking System

Task	Description	Assignee	Hours	Status
T4.1	Design ChatMessage entity	Dev	3h	Done
T4.2	HTTP Polling configuration	Dev	8h	Done
T4.3	Chat service & endpoints	Dev	6h	Done
T4.4	Chat UI component	Dev	8h	Done
T4.5	Notification entity & service	Dev	6h	Done
T4.6	Notification dropdown	Dev	4h	Done
T4.7	Contact admin feature	Dev	4h	Done
T4.8	Booking cancel functionality	Dev	4h	Done
T4.9	Polish chat interface	Dev	4h	Done
T4.10	Real-time testing	Dev	6h	Done

Tableau 2.12 : Sprint 4 Backlog - Communication Features

Task	Description	Assignee	Hours	Status
T5.1	Design Blog entity	Dev	3h	Done
T5.2	Blog CRUD API endpoints	Dev	6h	Done
T5.3	Admin blog management	Dev	6h	Done
T5.4	Public blog listing	Dev	4h	Done
T5.5	Blog detail with comments	Dev	6h	Done
T5.6	Comment functionality	Dev	4h	Done
T5.7	Follower entity	Dev	2h	Done
T5.8	Subscription API	Dev	4h	Done
T5.9	Subscription form	Dev	3h	Done
T5.10	Feature testing	Dev	4h	Done

Tableau 2.13 : Sprint 5 Backlog - Blog & Subscription

2.9.9 Sprint 8 : DevOps & Deployment

Sprint Goal : Containerize all services and establish CI/CD pipeline with Kubernetes deployment.

Duration : 15 days

Task	Description	Assignee	Hours	Status
T6.1	Research PDF libraries (iText)	Dev	4h	Done
T6.2	Contract PDF template	Dev	6h	Done
T6.3	PDF generation service	Dev	10h	Done
T6.4	QR code integration (ZXing)	Dev	6h	Done
T6.5	Payment microservice	Dev	6h	Done
T6.6	Payment API endpoints	Dev	10h	Done
T6.7	Payment email template	Dev	4h	Done
T6.8	Payment webhook	Dev	6h	Done
T6.9	Auto-send PDF on payment	Dev	4h	Done
T6.10	Payment-to-contract testing	Dev	8h	Done

Tableau 2.14 : Sprint 6 Backlog - Contracts & Payments

Task	Description	Assignee	Hours	Status
T7.1	Flask chatbot project setup	Dev	4h	Done
T7.2	OpenAI ChatGPT integration	Dev	6h	Done
T7.3	Chatbot REST endpoints	Dev	4h	Done
T7.4	Chatbot UI widget	Dev	6h	Done
T7.5	Multilingual support (FR/EN)	Dev	4h	Done
T7.6	Agency management (Admin)	Dev	6h	Done
T7.7	Customer management (Admin)	Dev	4h	Done
T7.8	Statistics dashboard	Dev	6h	Done
T7.9	Data visualization charts	Dev	4h	Done
T7.10	Integration testing	Dev	4h	Done

Tableau 2.15 : Sprint 7 Backlog - Chatbot & Admin Panel

Task	Description	Assignee	Hours	Status
T8.1	Dockerfile for Angular	Dev	4h	Done
T8.2	Dockerfile for Spring Boot	Dev	4h	Done
T8.3	Dockerfile for Flask Chatbot	Dev	3h	Done
T8.4	docker-compose.yml	Dev	6h	Done
T8.5	GitLab CI/CD pipeline	Dev	10h	Done
T8.6	GitLab Container Registry	Dev	4h	Done
T8.7	K8s deployment YAMLs	Dev	10h	Done
T8.8	K8s services & ingress	Dev	6h	Done
T8.9	Minikube deployment	Dev	8h	Done
T8.10	Documentation	Dev	4h	Done

Tableau 2.16 : Sprint 8 Backlog - DevOps & Deployment

2.10 Sprint Burndown Analysis

The burndown chart tracks the remaining work (in story points) over the course of each sprint. Figure 2.9 illustrates the project-level burndown across all sprints.

img/project-burndown-chart.png

Figure 2.9 : Project Burndown Chart - Story Points Remaining Over Sprints

2.10.1 Project Burndown Data

Sprint	Start SP	Completed SP	Remaining
Project Start	210	–	210
Sprint 1 (12 days)	210	24	186
Sprint 2 (14 days)	186	28	158
Sprint 3 (15 days)	158	31	127
Sprint 4 (12 days)	127	24	103
Sprint 5 (10 days)	103	17	86
Sprint 6 (15 days)	86	31	55
Sprint 7 (12 days)	55	21	34
Sprint 8 (15 days)	34	34	0
Total (105 days)	**210**	**210**	**0**

Tableau 2.17 : Project Burndown - Story Points per Sprint

2.10.2 Sprint 3 Detailed Burndown (Example)

The following table shows the daily burndown for Sprint 3 (Booking System), demonstrating how work was completed throughout the 15-day period.

Day	Ideal	Actual	Done
Day 1	28.9	31	0
Day 2	26.8	29	2
Day 3	24.8	26	3
Day 4	22.7	24	2
Day 5	20.7	21	3
Day 6	18.6	18	3
Day 7	16.5	15	3
Day 8	14.5	12	3
Day 9	12.4	9	3
Day 10	10.3	7	2
Day 11	8.3	5	2
Day 12	6.2	3	2
Day 13	4.1	2	1
Day 14	2.1	1	1
Day 15	0	0	1

Tableau 2.18 : Sprint 3 Daily Burndown Chart Data

2.11 Team Velocity

Team velocity measures the amount of work completed per sprint, expressed in story points. This metric helps in future sprint planning and capacity estimation. Figure 2.10 visualizes the velocity trend across all sprints.

Sprint	Duration	Velocity (SP)	Cumulative SP
Sprint 1	12 days	24	24
Sprint 2	14 days	28	52
Sprint 3	15 days	31	83
Sprint 4	12 days	24	107
Sprint 5	10 days	17	124
Sprint 6	15 days	31	155
Sprint 7	12 days	21	176
Sprint 8	15 days	34	210
Average Velocity		**26.25 SP**	**210 SP Total**

Tableau 2.19 : Team Velocity per Sprint

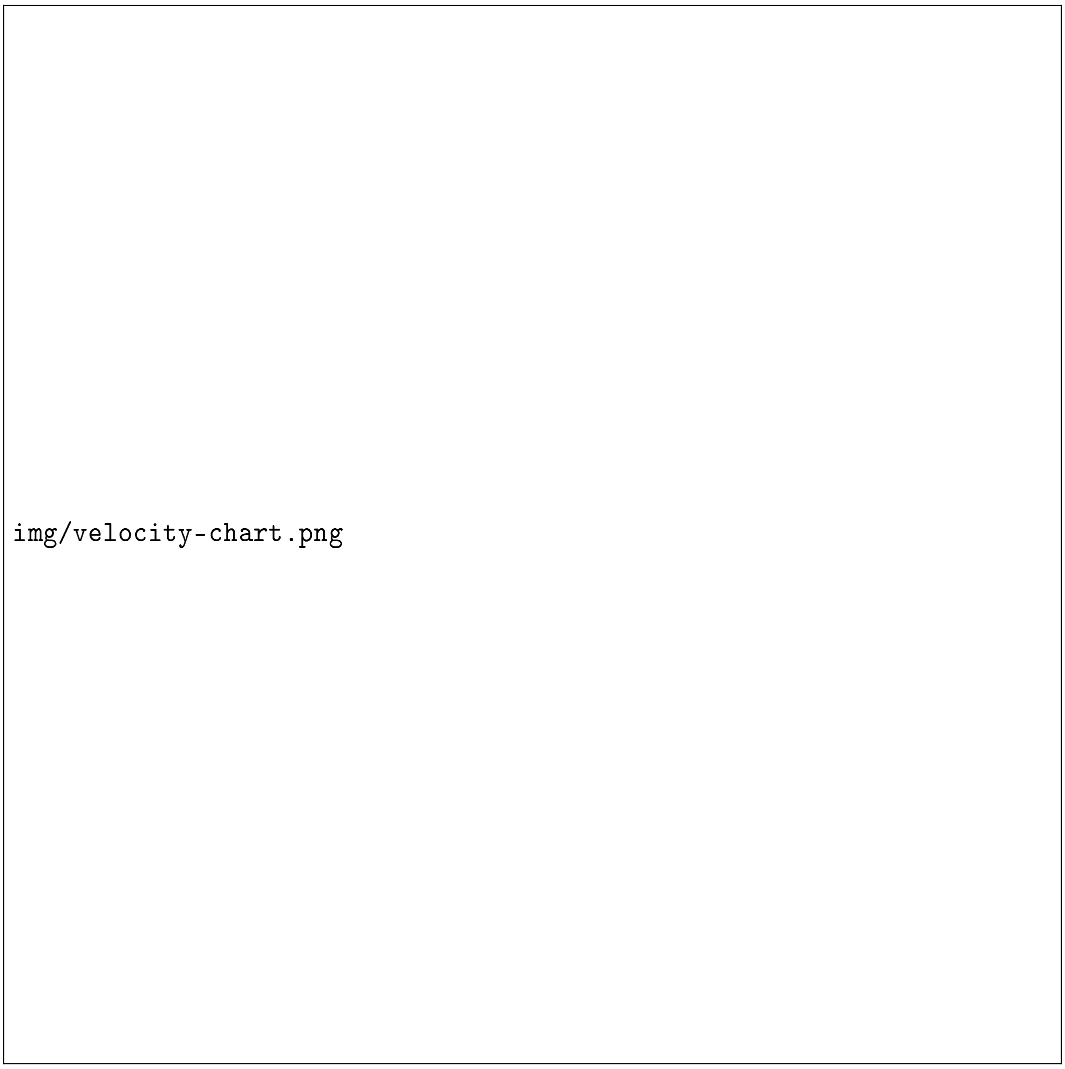


Figure 2.10 : Team Velocity Chart - Story Points Completed per Sprint

Velocity Analysis :

- The team maintained an average velocity of **26.25 story points per sprint**.
- Sprint 5 had lower velocity due to the complexity of blog features being lower than estimated.
- Sprint 8 had higher velocity due to familiarity with DevOps tasks and parallel work streams.
- Velocity remained consistent, indicating stable team performance and accurate estimation.

2.12 Definition of Done (DoD)

A user story is considered "Done" when all the following criteria are met :

- Code is written and follows project coding standards.
- Unit tests are written and pass successfully.
- Code is reviewed by at least one team member.
- Feature is integrated with the main branch.
- Feature is tested in the staging environment.

- Documentation is updated (API docs, README if needed).
- No critical or high-severity bugs remain.
- Product Owner accepts the feature during Sprint Review.

2.13 Scrum Ceremonies

The following Scrum ceremonies were conducted throughout the project :

Ceremony	Frequency
Sprint Planning	Start of sprint
Daily Stand-up	Daily (15 min)
Sprint Review	End of sprint
Retrospective	End of sprint
Backlog Refinement	Weekly

Tableau 2.20 : Scrum Ceremonies Overview

2.13.1 Chapter Conclusion

In this chapter, we explored the functional and non-functional requirements for the car rental platform. We identified the different user roles (Admin, Agency, Customer, Visitor), their needs, and outlined the system features accordingly.

We also established the development methodology using Scrum, assigned team roles (Product Owner, Scrum Master, Development Team), and laid out the complete sprint plan with a detailed product backlog containing 40 user stories totaling 210 story points. The project was organized into 8 sprints with an average team velocity of 26.25 story points per sprint.

This structured specification ensures the platform is developed efficiently, securely, and in alignment with user needs through iterative development and continuous feedback.

2.14 Conclusion

The analysis and specification phase has established a solid foundation for the project. With clearly defined requirements, comprehensive use case diagrams, and a detailed Scrum planning with product backlog, the development team is well-prepared to begin implementation.

In the following chapters, we will detail the realization of each sprint, starting with Sprint 1 focused on platform setup and secure authentication using Keycloak.

Chapitre 3

Réalisation : Core Platform et Système de Réservation

Plan

3.1 Introduction

Ce chapitre détaille la réalisation complète de la plateforme MyLoc, couvrant à la fois les fondations techniques et les fonctionnalités métier essentielles. Conformément à la méthodologie Scrum, cette phase correspond aux **Sprints 1-5**, délivrant l'infrastructure de base ainsi que le système de réservation complet.

Les objectifs de cette phase incluent :

- Configuration de l'environnement de développement et de la stack technologique.
- Conception et implémentation du schéma de base de données.
- Implémentation de l'authentification sécurisée via Keycloak.
- Construction du module de gestion des voitures pour les agences.
- Création des fonctionnalités de gestion des agences et des clients.
- Implémentation du workflow complet de réservation.
- Développement du système de notifications par email.
- Génération de contrats PDF avec QR codes.
- Mise en place du système de chat en temps réel.

3.2 Sprint 1 : Development Environment and Authentication

3.2.1 Development Environment Setup

The development environment was carefully configured to support a modern microservices architecture with multiple technologies working together seamlessly.

3.2.1.1 Frontend Environment

- **Angular 16** : Chosen for its robust component-based architecture and TypeScript support.
- **Node.js 20 LTS** : Runtime environment for Angular CLI and build tools.
- **npm** : Package manager for frontend dependencies.
- **Angular CLI** : For project scaffolding, component generation, and build automation.

Key Angular Packages :

- `@angular/router` : For single-page application navigation.
- `@angular/forms` : For reactive form handling and validation.
- `@angular/common/http` : For REST API communication.
- `angular-oauth2-oidc` : For Keycloak OAuth2 integration.
- `ngx-toastr` : For user-friendly notifications.

3.2.1.2 Backend Environment

- **Java 17 LTS** : The programming language for backend development.
- **Spring Boot 3.x** : Framework providing auto-configuration and rapid development.
- **Maven** : Build tool and dependency management.
- **MySQL 8** : Relational database for data persistence.

Key Spring Dependencies :

- `spring-boot-starter-web` : For REST API development.
- `spring-boot-starter-data-jpa` : For database operations with Hibernate.
- `spring-boot-starter-security` : For security configuration.
- `spring-boot-starter-mail` : For email notification sending.
- `mysql-connector-java` : MySQL database driver.

3.2.1.3 Development Tools

Tool	**Version**		**Purpose**
Visual Studio Code	Latest		Primary IDE for frontend and configuration
IntelliJ IDEA	Community		Backend Java development
XAMPP	8.x		Local MySQL database server
Postman	Latest		API testing and documentation
Git	Latest		Version control
Docker Desktop	Latest		Container management

Tableau 3.1 : Development Tools and Their Purposes

3.2.2 Authentication System with Keycloak

Security is paramount for the MyLoc platform. We implemented a robust authentication system using Keycloak, an open-source identity and access management solution.

3.2.2.1 Why Keycloak ?

- **Industry Standard** : Implements OAuth2 and OpenID Connect protocols.
- **Centralized Identity Management** : Single source of truth for all user identities.
- **Role-Based Access Control (RBAC)** : Easy management of user roles and permissions.
- **Built-in Features** : Login, registration, password reset, session management.
- **Docker Support** : Easy deployment in containerized environments.

3.2.2.2 Keycloak Configuration

The Keycloak server was configured with :

- **Realm** : `myloc-realm` - The security domain for our application.
- **Clients** :
  - `angular-frontend` : For frontend authentication.
  - `spring-backend` : For backend API protection.
- **Roles** :
  - `ADMIN` : Full platform access.
  - `AGENCY` : Agency dashboard and car management.
  - `CUSTOMER` : Booking and profile management.

3.2.2.3 Angular AuthGuard Implementation

Route protection in Angular ensures that only authorized users access protected pages.

Figure 3.1 : Authentication Flow with Keycloak

Protected Routes :

- `/admin/*` : Requires ADMIN role.
- `/agency/*` : Requires AGENCY role.
- `/customer/*` : Requires CUSTOMER role.
- `/` : Public access for visitors.

3.3 Sprint 2 : Database Design and Implementation

3.3.1 Database Architecture

The system uses MySQL as its relational database. The schema was designed following normalization principles to ensure data integrity and minimize redundancy.

3.3.1.1 Entity-Relationship Model

The database consists of the following main entities :

3.3.1.2 Core Tables

Agency Table Stores information about car rental agencies registered on the platform.

```
CREATE TABLE agence (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    agency_name VARCHAR(100) NOT NULL,
    email VARCHAR(255) NOT NULL UNIQUE,
    password VARCHAR(64) NOT NULL,
    photo LONGTEXT,
    phone_number VARCHAR(20) NOT NULL,
    city VARCHAR(100),
    description TEXT,
    created_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    updated_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP
);
```

Field Descriptions :

- `id` : Unique identifier (auto-incremented).
- `agency_name` : Business name of the agency.
- `email` : Login email (unique constraint).

img/database-er-diagram.png

Figure 3.2 : Entity-Relationship Diagram for MyLoc Database

- `password` : Hashed password (bcrypt).
- `photo` : Base64 encoded agency logo.
- `phone_number` : Contact phone number.
- `city` : Agency location.

Car (Voiture) Table Stores vehicle information listed by agencies.

```
CREATE TABLE voiture (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    name VARCHAR(100) NOT NULL,
    model VARCHAR(100),
    type VARCHAR(50),
    price DOUBLE NOT NULL,
    description TEXT,
    features TEXT,
    main_image LONGTEXT,
    additional_images LONGTEXT,
    agency_id BIGINT NOT NULL,
    available BOOLEAN DEFAULT TRUE,
    created_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    FOREIGN KEY (agency_id) REFERENCES agence(id) ON DELETE CASCADE
);
```

Field Descriptions :

— `name` : Car name/brand.

— `model` : Specific model.

— `type` : Category (SUV, Sedan, Compact, etc.).

— `price` : Daily rental price.

— `features` : JSON or comma-separated features list.

— `agency_id` : Foreign key to owning agency.

Booking Table Stores rental requests and their status.

```
CREATE TABLE booking (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    username VARCHAR(255) NOT NULL,
    user_email VARCHAR(255) NOT NULL,
    phone VARCHAR(255),
    description VARCHAR(255),
    start_date DATE NOT NULL,
    end_date DATE NOT NULL,
    price DOUBLE,
    voiture_id BIGINT NOT NULL,
    nbr_jrs INT,
    booking_status VARCHAR(50) DEFAULT 'PENDING',
    pickup_location VARCHAR(255),
    dropoff_location VARCHAR(255),
    car_name VARCHAR(255),
    agence TEXT,
    created_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    FOREIGN KEY (voiture_id) REFERENCES voiture(id)
);
```

Booking Status Values :

- `PENDING` : Request submitted, awaiting agency response.
- `APPROVED` : Agency accepted the request.
- `REJECTED` : Agency declined the request.
- `COMPLETED` : Rental period finished.
- `CANCELLED` : Customer cancelled the request.

Customer Table Stores registered customer information.

```
CREATE TABLE customers (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    username VARCHAR(100) NOT NULL,
    email VARCHAR(255) NOT NULL UNIQUE,
    password VARCHAR(64) NOT NULL,
    phone VARCHAR(20),
    address TEXT,
    created_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP
);
```

Blog Table Stores blog posts created by administrators.

```
CREATE TABLE blog (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    title VARCHAR(255) NOT NULL,
    img_url VARCHAR(255),
    author VARCHAR(255),
    date VARCHAR(255),
    time VARCHAR(255),
    description VARCHAR(1024),
    quote VARCHAR(255),
    created_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP
);
```

Follower Table Stores email subscriptions for new car notifications.

```
CREATE TABLE followers (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    email VARCHAR(255) NOT NULL UNIQUE,
    subscribed_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    active BOOLEAN DEFAULT TRUE
);
```

Chat Message Table Stores real-time chat messages between admin and agencies.

```
CREATE TABLE chat_messages (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    sender_id BIGINT NOT NULL,
    sender_type VARCHAR(20) NOT NULL,
    receiver_id BIGINT NOT NULL,
    receiver_type VARCHAR(20) NOT NULL,
    message TEXT NOT NULL,
    sent_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    read_status BOOLEAN DEFAULT FALSE
);
```

Notification Table Stores user notifications.

```
CREATE TABLE notifications (
    id BIGINT AUTO_INCREMENT PRIMARY KEY,
    user_id BIGINT NOT NULL,
    user_type VARCHAR(20) NOT NULL,
    title VARCHAR(255) NOT NULL,
    message TEXT,
    type VARCHAR(50),
    read_status BOOLEAN DEFAULT FALSE,
    created_at TIMESTAMP DEFAULT CURRENT_TIMESTAMP
);
```

3.3.2 Database Relationships Summary

Relationship	Type	Description
Agency → Car	One-to-Many	Agency owns multiple cars
Car → Booking	One-to-Many	Car can have multiple bookings
Customer → Booking	One-to-Many	Customer can make multiple bookings
Admin → Blog	One-to-Many	Admin creates multiple blogs
User → Comment	One-to-Many	Users can post multiple comments

Tableau 3.2 : Database Relationship Summary

3.4 Sprint 3 : Core CRUD Operations

3.4.1 Backend REST API Structure

The Spring Boot backend follows a layered architecture for maintainability and testability.

3.4.1.1 Architecture Layers

- **Controller Layer** : Handles HTTP requests and responses.
- **Service Layer** : Contains business logic.
- **Repository Layer** : Interfaces with the database using JPA.
- **Entity Layer** : Defines data models mapped to database tables.
- **DTO Layer** : Data Transfer Objects for API communication.

3.4.1.2 REST API Endpoints

The API follows RESTful conventions with consistent URL patterns.

Method	Endpoint		Description
GET	/api/cars		Get all cars
GET	/api/cars/{id}		Get car by ID
GET	/api/cars/agency/{agencyId}		Get cars by agency
POST	/api/cars		Create new car
PUT	/api/cars/{id}		Update car
DELETE	/api/cars/{id}		Delete car
GET	/api/cars/unavailable-dates/{id}		Get unavailable dates

Tableau 3.3 : Car Management API Endpoints

Car Management Endpoints

Agency Management Endpoints

img/spring-architecture.png

Figure 3.3 : Spring Boot Layered Architecture

Method	Endpoint		Description
GET	/api/agencies		Get all agencies
GET	/api/agencies/{id}		Get agency by ID
POST	/api/agencies		Register new agency
PUT	/api/agencies/{id}		Update agency
DELETE	/api/agencies/{id}		Delete agency
POST	/api/agencies/login		Agency login

Tableau 3.4 : Agency Management API Endpoints

3.4.2 Frontend Angular Components

The Angular frontend is organized into feature modules for maintainability.

3.4.2.1 Module Structure

- **CoreModule** : Services, interceptors, guards.
- **SharedModule** : Reusable components, pipes, directives.
- **AuthModule** : Login, register, password reset.
- **AdminModule** : Admin dashboard and management.
- **AgencyModule** : Agency dashboard and car management.

— **CustomerModule** : Customer profile and bookings.

— **PublicModule** : Home, car listings, blogs.

3.4.2.2 Key Components

Component		**Description**
CarListComponent		Displays all available cars with filtering
CarDetailComponent		Shows detailed car information and booking form
AgencyDashboardComponent		Agency management interface
CarFormComponent		Add/Edit car form with image upload
AdminDashboardComponent		Platform administration interface
LoginComponent		User authentication form

Tableau 3.5 : Key Angular Components

3.4.3 Intelligent Car Filtering Service

One of the key business features of the MyLoc platform is the intelligent filtering service that prioritizes MyLoc agency cars in search results, providing a competitive advantage.

3.4.3.1 Filtering Algorithm Logic

The car listing service implements a custom sorting algorithm that ensures MyLoc agency vehicles always appear first in search results, regardless of other filtering criteria applied by the user.

Business Logic :

1. Retrieve all cars matching the user's filter criteria (type, price range, city, availability).
2. Identify cars belonging to "MyLoc" agency (primary agency).
3. Sort results : MyLoc cars first, then other agencies alphabetically.
4. Within each group, sort by relevance score (rating, price, availability).
5. Return paginated results to the frontend.

3.4.3.2 Backend Implementation

```
@Service
public class CarFilterService {


    private static final String PRIORITY_AGENCY = "MyLoc";
    @Autowired
    private VoitureRepository voitureRepository;

    public List<Voiture> getFilteredCars(CarFilterDTO filters) {
        // Get all cars matching basic criteria
        List<Voiture> allCars = voitureRepository.findByFilters(
            filters.getType(),
            filters.getMinPrice(),
            filters.getMaxPrice(),
            filters.getCity(),
            filters.getStartDate(),
            filters.getEndDate()
        );

        // Separate MyLoc cars from others
        List<Voiture> mylocCars = allCars.stream()
            .filter(car -> PRIORITY_AGENCY.equalsIgnoreCase(
                car.getAgence().getAgencyName()))
            .sorted(Comparator.comparing(Voiture::getPrice))
            .collect(Collectors.toList());

        List<Voiture> otherCars = allCars.stream()
            .filter(car -> !PRIORITY_AGENCY.equalsIgnoreCase(
                car.getAgence().getAgencyName()))
            .sorted(Comparator.comparing(
                v -> v.getAgence().getAgencyName()))
            .collect(Collectors.toList());

        // Combine: MyLoc first, then others
        List<Voiture> result = new ArrayList<>();
        result.addAll(mylocCars);
        result.addAll(otherCars);
        return result;
    }

    public Page<Voiture> getFilteredCarsPaginated(
            CarFilterDTO filters, Pageable pageable) {
        List<Voiture> allFiltered = getFilteredCars(filters);

        int start = (int) pageable.getOffset();
        int end = Math.min(start + pageable.getPageSize(),
                          allFiltered.size());

        List<Voiture> pageContent = allFiltered.subList(start, end);
        return new PageImpl<>(pageContent, pageable,
                             allFiltered.size());
    }
}
```

3.4.3.3 Filter DTO Structure

```
public class CarFilterDTO {
    private String type;        // SUV, Sedan, Compact, etc.
    private Double minPrice;
    private Double maxPrice;
    private String city;
    private LocalDate startDate;
    private LocalDate endDate;
    private String sortBy;      // price, rating, name
    private String sortOrder;   // ASC, DESC

    // Getters and Setters
}
```

3.4.3.4 Frontend Filter Component

```
// car-filter.component.ts
@Component({
  selector: 'app-car-filter',
  templateUrl: './car-filter.component.html'
})
export class CarFilterComponent implements OnInit {
  filters: CarFilter = {
    type: '',
    minPrice: 0,
    maxPrice: 1000,
    city: '',
    startDate: null,
    endDate: null
  };

  carTypes = ['SUV', 'Sedan', 'Compact', 'Luxury', 'Van'];
  cities = ['Tunis', 'Sousse', 'Sfax', 'Monastir', 'Hammamet'];

  constructor(private carService: CarService) {}

  applyFilters() {
    this.carService.getFilteredCars(this.filters)
      .subscribe(cars => {
        // Cars are already sorted with MyLoc first
        this.filteredCars = cars;
      });
  }

  resetFilters() {
    this.filters = { type: '', minPrice: 0, maxPrice: 1000,
                     city: '', startDate: null, endDate: null };
    this.applyFilters();
  }
}
```

Method	Endpoint		Description
GET	/api/cars/filter		Get filtered cars (MyLoc priority)
GET	/api/cars/filter ?type=SUV		Filter by car type
GET	/api/cars/filter ?city=Tunis		Filter by city
GET	/api/cars/filter ?minPrice=50&maxPrice=200		Filter by price range

Tableau 3.6 : Car Filtering API Endpoints

3.4.3.5 API Endpoint for Filtering

Key Benefits of Priority Filtering :

- **Business Advantage** : MyLoc agency cars get maximum visibility.
- **User Experience** : Customers see premium options first.
- **Flexibility** : Other agencies still appear in results.
- **Transparency** : Users can still apply their own sorting preferences.

La première partie de cette réalisation a établi les fondations de la plateforme MyLoc. L'environnement de développement a été configuré avec des outils modernes, un schéma de base de données robuste a été implémenté, l'authentification sécurisée a été intégrée via Keycloak, et les opérations CRUD de base pour les voitures et les agences ont été complétées.

La méthodologie Scrum a assuré une livraison itérative avec des retours réguliers, permettant une amélioration continue. Toutes les 12 user stories planifiées pour les Sprints 1-3 ont été complétées, atteignant 100% des objectifs de cette phase.

3.5 Système de Réservation

3.5.1 Aperçu du Workflow de Réservation

Le système de réservation est le processus métier central de la plateforme MyLoc. Il gère l'ensemble du cycle de vie d'une demande de location, de la soumission à la finalisation.

3.5.1.1 États de Réservation

Une demande de réservation traverse plusieurs états durant son cycle de vie :

img/booking-workflow-diagram.png

Figure 3.4 : Diagramme Complet du Workflow de Réservation

État		**Description**
PENDING		Demande soumise, en attente de revue par l'agence
APPROVED		L'agence a accepté la demande, en attente de paiement
REJECTED		L'agence a refusé la demande
CONFIRMED		Paiement reçu, contrat généré
IN_PROGRESS		La période de location a commencé
COMPLETED		Véhicule retourné, location terminée
CANCELLED		Le client a annulé avant approbation

Tableau 3.7 : États de Réservation et leurs Descriptions

3.5.1.2 Algorithme de Vérification de Disponibilité

Avant qu'un client puisse soumettre une demande de réservation, le système vérifie si la voiture est disponible pour les dates sélectionnées.

Logique de l'Algorithme :

1. Le client sélectionne une date de début et une date de fin.
2. Le système interroge toutes les réservations existantes pour la voiture sélectionnée.
3. Pour chaque réservation existante, vérification du chevauchement de dates :
   - Si (nouveau_début $\leq$ existant_fin) ET (nouveau_fin $\geq$ existant_début) → Chevauchement détecté.
4. Si chevauchement avec réservations APPROVED, CONFIRMED ou IN_PROGRESS → Voiture indisponible.
5. Si aucun chevauchement → Voiture disponible, procéder à la réservation.

Implémentation Backend (Spring Boot) :

```
@GetMapping("/unavailable-dates/{carId}")
public ResponseEntity<List<DateRange>> getUnavailableDates(
        @PathVariable Long carId) {
    List<Booking> bookings = bookingRepository
        .findByVoitureIdAndStatusIn(carId,
            Arrays.asList("APPROVED", "CONFIRMED", "IN_PROGRESS"));

    List<DateRange> unavailableDates = bookings.stream()
        .map(b -> new DateRange(b.getStartDate(), b.getEndDate()))
        .collect(Collectors.toList());

    return ResponseEntity.ok(unavailableDates);
}
```

3.5.1.3 Soumission de Demande de Réservation

Lorsqu'un client soumet une demande de réservation, les données suivantes sont capturées :

3.5.2 Gestion des Demandes par l'Agence

Les agences reçoivent des notifications lorsque de nouvelles demandes de réservation arrivent pour leurs voitures.

Champ	Type	Description
username	String	Nom complet du client
user_email	String	Adresse email du client
phone	String	Numéro de téléphone
start_date	Date	Date de début de location
end_date	Date	Date de fin de location
pickup_location	String	Lieu de prise en charge
dropoff_location	String	Lieu de retour
voiture_id	Long	ID de la voiture sélectionnée
description	String	Notes/demandes additionnelles

Tableau 3.8 : Champs de Données de Demande de Réservation

3.5.2.1 Tableau de Bord Agence - Vue des Demandes

Le tableau de bord de l'agence affiche toutes les demandes en attente avec les informations suivantes :

- Nom et coordonnées du client
- Détails de la voiture demandée
- Dates et durée de location
- Prix total calculé
- Horodatage de soumission de la demande
- Boutons d'action : Approuver / Rejeter

3.5.2.2 Processus d'Approbation/Rejet

Lorsqu'une agence clique sur "Approuver" ou "Rejeter" :

Flux d'Approbation :

1. Le statut de réservation passe à "APPROVED"
2. Le système génère un contrat PDF avec QR code
3. Email de confirmation envoyé au client avec pièce jointe PDF
4. Notification in-app créée pour le client
5. Disponibilité de la voiture mise à jour pour les dates sélectionnées

Flux de Rejet :

1. Le statut de réservation passe à "REJECTED"
2. Email de notification simple envoyé au client
3. Notification in-app créée pour le client

img/agency-requests-dashboard.png

Figure 3.5 : Tableau de Bord Agence - Vue des Demandes en Attente

4. La voiture reste disponible pour d'autres réservations

3.6 Système d'Email et de Notifications

3.6.1 Architecture du Service d'Email

Le système d'email est construit en utilisant le starter mail de Spring Boot avec configuration SMTP.

3.6.1.1 Configuration Email

```
# application.properties
spring.mail.host=smtp.gmail.com
spring.mail.port=587
spring.mail.username=${EMAIL_USERNAME}
spring.mail.password=${EMAIL_PASSWORD}
spring.mail.properties.mail.smtp.auth=true
spring.mail.properties.mail.smtp.starttls.enable=true
```

3.6.1.2 Implémentation du Service Email

La classe EmailService gère toutes les opérations d'email :

```
@Service
public class EmailService {

    @Autowired
    private JavaMailSender mailSender;

    public void sendConfirmationEmail(Booking booking, byte[] pdfBytes) {
        MimeMessage message = mailSender.createMimeMessage();
        MimeMessageHelper helper = new MimeMessageHelper(message, true);

        helper.setTo(booking.getUserEmail());
        helper.setSubject("Confirmation de Réservation - MyLoc");
        helper.setText(buildConfirmationBody(booking));

        // Attacher le contrat PDF
        helper.addAttachment("contrat.pdf",
            new ByteArrayResource(pdfBytes));

        mailSender.send(message);
    }

    public void sendRejectionEmail(Booking booking) {
        SimpleMailMessage message = new SimpleMailMessage();
        message.setTo(booking.getUserEmail());
        message.setSubject("Notification de Réservation - MyLoc");
        message.setText("Votre réservation pour " +
            booking.getCarName() + " a été refusée.");
        mailSender.send(message);
    }
}
```

3.6.2 Génération de Contrat PDF

Lorsqu'une réservation est approuvée, le système génère un contrat PDF professionnel utilisant la bibliothèque iText.

3.6.2.1 Structure du Contenu PDF

Le PDF généré inclut :

- **En-tête** : Logo MyLoc Agency et coordonnées
- **Titre du Contrat** : "Contrat de Location de Véhicule"
- **Informations Client** : Nom, email, téléphone
- **Détails du Véhicule** : Nom, modèle, type, agence
- **Période de Location** : Date début, date fin, durée
- **Tarification** : Tarif journalier, prix total, taxes le cas échéant
- **Conditions Générales** : Termes standards de location
- **QR Code** : Code unique de vérification de réservation
- **Pied de page** : Lignes de signature et date

3.6.2.2 Génération du QR Code

Le QR code est généré en utilisant la bibliothèque ZXing et contient :

- ID de réservation
- Email du client
- ID de la voiture
- Dates de location
- Hash de vérification

```
public byte[] generateQRCode(String content, int width, int height) {
    QRCodeWriter qrCodeWriter = new QRCodeWriter();
    BitMatrix bitMatrix = qrCodeWriter.encode(
        content, BarcodeFormat.QR_CODE, width, height);

    ByteArrayOutputStream outputStream = new ByteArrayOutputStream();
    MatrixToImageWriter.writeToStream(bitMatrix, "PNG", outputStream);

    return outputStream.toByteArray();
}
```

3.6.3 Système de Notifications In-App

En plus des emails, les utilisateurs reçoivent des notifications in-app affichées dans la plateforme.

3.6.3.1 Entité Notification

```
@Entity
public class Notification {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    private Long userId;
    private String userType; // CUSTOMER, AGENCY, ADMIN
    private String title;
    private String message;
    private String type; // BOOKING, SYSTEM, ALERT
    private boolean readStatus;
    private LocalDateTime createdAt;
}
```

3.6.3.2 Types de Notifications

Type	**Destinataire**		**Déclencheur**
BOOKING_RECEIVED	Agence		Nouvelle demande de réservation soumise
BOOKING_APPROVED	Client		L'agence a approuvé la demande
BOOKING_REJECTED	Client		L'agence a rejeté la demande
NEW_CAR	Followers		Nouvelle voiture ajoutée à la plateforme
NEW_MESSAGE	Admin/Agence		Message chat reçu
SYSTEM	Tous		Annonces de la plateforme

Tableau 3.9 : Types de Notifications et Déclencheurs

3.7 Système de Chat en Temps Réel

3.7.1 Architecture du Chat

Le système de chat permet une communication quasi temps réel entre administrateurs et agences en utilisant un mécanisme de **HTTP Polling** avec un service de rafraîchissement automatique.

3.7.1.1 Stack Technologique

— **Backend** : Spring Boot REST API avec endpoints de messagerie

— **Frontend** : Angular avec service de polling natif (HttpClient + RxJS)

— **Mécanisme** : HTTP Polling toutes les 30 secondes

— **Persistance** : MySQL pour l'historique des messages

3.7.1.2 Service de Polling Angular

```
@Injectable({ providedIn: 'root' })
export class ChatPollingService {
    private readonly POLLING_INTERVAL = 30000; // 30 seconds
    private pollingSubscription: Subscription;

    constructor(private http: HttpClient) {}

    startPolling(conversationId: number): Observable<Message[]> {
        return interval(this.POLLING_INTERVAL).pipe(
            startWith(0),
            switchMap(() => this.fetchMessages(conversationId)),
            distinctUntilChanged((prev, curr) =>
                JSON.stringify(prev) === JSON.stringify(curr))
        );
    }

    private fetchMessages(conversationId: number): Observable<Message[]> {
        return this.http.get<Message[]>(
            `/api/messages/conversation/${conversationId}`
        );
    }
    stopPolling(): void {
        this.pollingSubscription?.unsubscribe();
    }
}
```

3.7.2 Fonctionnalités du Chat

- **Messagerie quasi temps réel** : Les messages sont récupérés toutes les 30 secondes via polling automatique
- **Historique des messages** : Toutes les conversations sont stockées et récupérables
- **Notifications visuelles** : Indicateur de nouveaux messages non lus
- **Rafraîchissement manuel** : Possibilité de rafraîchir manuellement les messages
- **Persistance** : Les messages sont sauvegardés en base de données MySQL

img/chat-interface.png

Figure 3.6 : Interface de Chat en Temps Réel entre Admin et Agence

3.7.3 Entité Message Chat

```
@Entity
public class ChatMessage {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    private Long senderId;
    private String senderType; // ADMIN or AGENCY
    private Long receiverId;
    private String receiverType;

    @Column(columnDefinition = "TEXT")
    private String content;

    private LocalDateTime sentAt;
    private boolean readStatus;
}
```

3.8 Système d'Abonnement Followers

3.8.1 Comment ça Fonctionne

Le système de followers permet aux visiteurs de s'abonner aux alertes de nouvelles voitures sans créer un compte complet.

3.8.1.1 Flux d'Abonnement

1. Le visiteur entre son email dans le formulaire d'abonnement du footer
2. Le système valide le format de l'email
3. L'email est stocké dans la table followers
4. Message de confirmation affiché à l'utilisateur
5. Quand une nouvelle voiture est ajoutée, tous les followers actifs reçoivent un email

3.8.1.2 Entité Follower

```
@Entity
```

```
public class Follower {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    @Column(unique = true)
    private String email;

    private LocalDateTime subscribedAt;
    private boolean active;
}
```

3.8.1.3 Déclencheur d'Alerte Nouvelle Voiture

Quand une agence ajoute une nouvelle voiture, le système notifie automatiquement tous les followers :

```
@PostMapping("/cars")
public ResponseEntity<Car> addCar(@RequestBody Car car) {
    Car savedCar = carRepository.save(car);

    // Notifier tous les followers actifs
    List<Follower> followers = followerRepository
        .findByActiveTrue();

    for (Follower follower : followers) {
        emailService.sendNewCarAlert(follower.getEmail(), savedCar);
    }

    return ResponseEntity.ok(savedCar);
}
```

ID	**User Story**	**Statut**
Sprint 1-3 : Core Platform		
US-01	Le visiteur crée un compte	Fait
US-02	L'utilisateur se connecte de manière sécurisée	Fait
US-03	L'admin gère les rôles utilisateurs	Fait
US-04	L'utilisateur réinitialise son mot de passe	Fait
US-05	L'utilisateur met à jour son profil	Fait
US-06	L'agence ajoute de nouvelles voitures	Fait
US-07	L'agence modifie les détails des voitures	Fait
US-08	L'agence supprime des voitures	Fait
US-09	L'agence télécharge des photos de voitures	Fait
US-10	Le client parcourt les voitures	Fait
US-11	Le client filtre les voitures par critères	Fait
US-12	Le client consulte les détails d'une voiture	Fait
Sprint 4-5 : Booking & Communication		
US-13	Le client vérifie la disponibilité d'une voiture	Fait
US-14	Le client soumet une demande de location	Fait
US-15	L'agence consulte les demandes de location	Fait
US-16	L'agence approuve/rejette les demandes	Fait
US-17	Le client reçoit des notifications par email	Fait
US-18	Le client consulte son historique de réservations	Fait
US-19	Le client annule les demandes en attente	Fait
US-20	L'admin discute avec les agences	Fait
US-21	L'agence reçoit des messages en temps réel	Fait
US-22	L'utilisateur reçoit des notifications in-app	Fait
US-28	Le visiteur devient Follower	Fait
US-29	Le client reçoit un contrat PDF	Fait
US-30	Le contrat inclut un QR code	Fait

Tableau 3.10 : User Stories Complétées - Sprints 1-5

3.9 Livrables de cette Phase

3.9.1 User Stories Complétées

3.9.2 Captures d'Écran

3.10 Conclusion

Ce chapitre a couvert la réalisation complète de la plateforme MyLoc, depuis les fondations techniques jusqu'aux fonctionnalités métier essentielles. L'environnement de développement a été configuré avec des outils modernes, un schéma de base de données robuste a été implémenté, l'authentification sécurisée via Keycloak a été intégrée, et toutes les opérations CRUD pour les voitures et les agences ont été complétées.

img/screenshot-login.png

Figure 3.7 : Page de Connexion avec Intégration Keycloak

Le système de réservation fournit un workflow complet de la soumission de demande à la génération de contrat. Le système de notifications par email tient les clients informés à chaque étape. Le système de chat en temps réel permet une communication efficace entre administrateurs et agences. Le système d'abonnement follower aide les agences à atteindre des clients potentiels avec de nouvelles offres.

Le prochain chapitre couvrira l'implémentation avancée, incluant l'intégration du chatbot IA, le système de blog, et les aspects DevOps de la plateforme.

img/screenshot-car-list.png

Figure 3.8 : Page de Liste des Voitures avec Options de Filtrage

img/screenshot-agency-dashboard.png

Figure 3.9 : Tableau de Bord Agence pour la Gestion de Flotte

Chapitre 4

Implémentation Avancée : Chatbot IA, Blog et DevOps

Plan

4.1 Introduction

Ce chapitre présente l'implémentation avancée de la plateforme MyLoc, couvrant le système d'emails avec exemples concrets, l'intégration du chatbot IA avec ChatGPT, le système de blog et commentaires, ainsi que les aspects DevOps avec Docker, Kubernetes et CI/CD. Cette phase correspond aux **Sprints 6-8** du planning Scrum.

Les objectifs de cette phase incluent :

- Finalisation du système d'emails avec contrats PDF et QR codes.
- Intégration du chatbot IA avec l'API ChatGPT.
- Développement du système de blog et commentaires.
- Containerisation avec Docker.
- Déploiement sur Kubernetes (Minikube).
- Configuration du pipeline CI/CD avec GitLab.

4.2 Récapitulatif des Modules Implémentés

L'application est organisée en composants modulaires correspondant à des fonctionnalités spécifiques, rôles utilisateurs et workflows. Chaque module est indépendamment testable, scalable et maintenu en alignement avec l'architecture microservices.

4.2.1 Module d'Authentification (Keycloak)

- Le contrôle d'accès basé sur les rôles est implémenté via Keycloak.
- Les utilisateurs sont authentifiés via OAuth2 et reçoivent des tokens JWT.
- L'Angular AuthGuard protège les tableaux de bord Admin, Agence et Client.
- Les routes du backend Spring Boot sont sécurisées avec des annotations basées sur les rôles (`@PreAuthorize`, `@RolesAllowed`).

4.2.2 Module Administrateur

- Ajouter, modifier et supprimer des agences.
- Gérer les clients et les blogs (opérations CRUD).
- Consulter et gérer toutes les réservations.
- Communiquer avec les agences via le chat en temps réel.

4.2.3 Module Agence

- Ajouter, modifier et supprimer des voitures.

- Télécharger des photos pour les voitures existantes.
- Gérer la disponibilité et les demandes de réservation.
- Accepter ou refuser les demandes de location, déclenchant emails et notifications.
- Communiquer avec l'admin via l'interface de chat en temps réel.

4.2.4 Module Client

- Parcourir les voitures disponibles et les blogs.
- S'inscrire et se connecter avec Keycloak (ou naviguer en tant que visiteur).
- Soumettre des demandes de location pour les voitures disponibles.
- Recevoir des notifications et emails lors des changements de statut.
- Consulter l'historique des locations et supprimer les demandes non confirmées.
- Commenter les annonces de voitures et les blogs.
- Recevoir un contrat PDF avec QR code après confirmation du paiement.

4.3 Sprint 6 : Intégration du Chatbot IA

4.3.1 Architecture du Chatbot

Le chatbot est implémenté comme un microservice séparé utilisant Flask et l'API GPT d'OpenAI.

4.3.1.1 Stack Technologique

- **Framework** : Flask (Python)
- **API IA** : OpenAI ChatGPT (GPT-3.5 ou GPT-4)
- **Communication** : REST API avec le frontend Angular
- **Langues** : Support multilingue (Français et Anglais)

4.3.1.2 Implémentation Flask du Chatbot

```
from flask import Flask, request, jsonify
from flask_cors import CORS
import openai

app = Flask(__name__)
CORS(app)

openai.api_key = os.environ.get('OPENAI_API_KEY')
```

```
# Contexte système pour le chatbot MyLoc
SYSTEM_CONTEXT = """
Tu es l'assistant virtuel de MyLoc, une plateforme de location de voitures.
Tu peux aider les utilisateurs à:
- Trouver des voitures disponibles
- Comprendre le processus de réservation
- Répondre aux questions sur les tarifs
- Expliquer les conditions de location
- Fournir des informations sur les agences
Réponds de manière professionnelle et utile.
"""

@app.route('/api/chat', methods=['POST'])
def chat():
    data = request.json
    user_message = data.get('message', '')

    try:
        response = openai.ChatCompletion.create(
            model="gpt-3.5-turbo",
            messages=[
                {"role": "system", "content": SYSTEM_CONTEXT},
                {"role": "user", "content": user_message}
            ],
            max_tokens=500,
            temperature=0.7
        )

        bot_response = response.choices[0].message.content
        return jsonify({"response": bot_response, "status": "success"})

    except Exception as e:
        return jsonify({"response": "Désolé, une erreur est survenue.",
                       "status": "error"}), 500


if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000)
```

4.3.1.3 Intégration Angular du Chatbot

Le composant Angular communique avec le service chatbot :

```
// chatbot.service.ts
@Injectable({ providedIn: 'root' })
export class ChatbotService {
  private apiUrl = environment.chatbotApiUrl;

  constructor(private http: HttpClient) {}

  sendMessage(message: string): Observable<ChatResponse> {
    return this.http.post<ChatResponse>(`${this.apiUrl}/api/chat`, {
      message: message
    });
  }
}

// chatbot.component.ts
@Component({
  selector: 'app-chatbot',
  templateUrl: './chatbot.component.html'
})
export class ChatbotComponent {
  messages: Message[] = [];
  userInput: string = '';
  isLoading: boolean = false;

  constructor(private chatbotService: ChatbotService) {}

  sendMessage() {
    if (!this.userInput.trim()) return;

    this.messages.push({ text: this.userInput, sender: 'user' });
    this.isLoading = true;

    this.chatbotService.sendMessage(this.userInput).subscribe({
      next: (response) => {
        this.messages.push({ text: response.response, sender: 'bot' });
        this.isLoading = false;
      },
      error: () => {
        this.messages.push({
          text: 'Erreur de connexion au chatbot',
          sender: 'bot'
        });
        this.isLoading = false;
      }
    });

    this.userInput = '';
  }
}
```

4.3.1.4 Exemples de Conversations

	Question Utilisateur
	"Comment puis-je réserver une voiture ?"
	"Quels sont les modes de paiement acceptés ?"
	"Y a-t-il des SUV disponibles ?"

Tableau 4.1 : Exemples de Conversations avec le Chatbot

4.4 Sprint 7 : Système de Blog et Commentaires

4.4.1 Module Blog

Le système de blog permet à l'administrateur de publier des articles pour engager les utilisateurs.

4.4.1.1 Entité Blog

```
@Entity
@Table(name = "blogs")
public class Blog {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    @Column(nullable = false)
    private String title;

    @Column(columnDefinition = "TEXT")
    private String content;

    private String author;
    private String imageUrl;
    private String category;

    @Column(name = "created_at")
    private LocalDateTime createdAt;

    @OneToMany(mappedBy = "blog", cascade = CascadeType.ALL)
    private List<Comment> comments;
}
```

4.4.1.2 API Endpoints Blog

Méthode	Endpoint	Description
GET	/api/blogs	Liste tous les articles
GET	/api/blogs/{id}	Récupère un article par ID
POST	/api/blogs	Crée un nouvel article (Admin)
PUT	/api/blogs/{id}	Met à jour un article
DELETE	/api/blogs/{id}	Supprime un article
GET	/api/blogs/{id}/comments	Liste les commentaires
POST	/api/blogs/{id}/comments	Ajoute un commentaire

Tableau 4.2 : API Endpoints du Système de Blog

4.4.2 Système de Commentaires

Les utilisateurs peuvent commenter les articles de blog et les annonces de voitures.

4.4.2.1 Entité Comment

```
@Entity
@Table(name = "comments")
public class Comment {
    @Id
    @GeneratedValue(strategy = GenerationType.IDENTITY)
    private Long id;

    @Column(columnDefinition = "TEXT", nullable = false)
    private String content;

    private String authorName;
    private String authorEmail;

    @ManyToOne
    @JoinColumn(name = "blog_id")
    private Blog blog;

    @ManyToOne
    @JoinColumn(name = "car_id")
    private Voiture car;

    @Column(name = "created_at")
    private LocalDateTime createdAt;

    private boolean approved;
}
```

4.4.3 Module de Paiement en Ligne

- Lors de l'acceptation d'une réservation, un lien de paiement est envoyé par email.
- Le paiement est traité et validé via le backend Spring Boot.

- Un PDF avec QR code est généré et envoyé après confirmation du paiement.
- Le statut de réservation passe à "confirmed".

4.5 Système d'Emails et Notifications

- Les clients reçoivent des emails pour les nouvelles voitures, décisions de réservation ou mises à jour.
- Les Followers reçoivent des notifications pour les nouvelles annonces.
- Les notifications sont stockées en base de données et affichées in-app.

4.5.0.1 Système de Confirmation par Email

Lorsqu'une agence approuve une demande de location, le système génère et envoie automatiquement un email de confirmation au client. Cet email contient tous les détails de la réservation et un contrat PDF avec un QR code unique pour vérification.

Workflow Email :

1. L'agence clique sur "Approuver" sur une demande en attente.
2. Le backend génère un contrat PDF avec les détails de la réservation.
3. Un QR code unique est intégré au PDF pour vérification lors de la récupération.
4. Le service email envoie la confirmation avec la pièce jointe PDF.
5. Le client reçoit une notification instantanée (in-app + email).
6. Le statut de réservation passe de "PENDING" à "APPROVED".

Exemple : Email de Confirmation Envoyé au Client

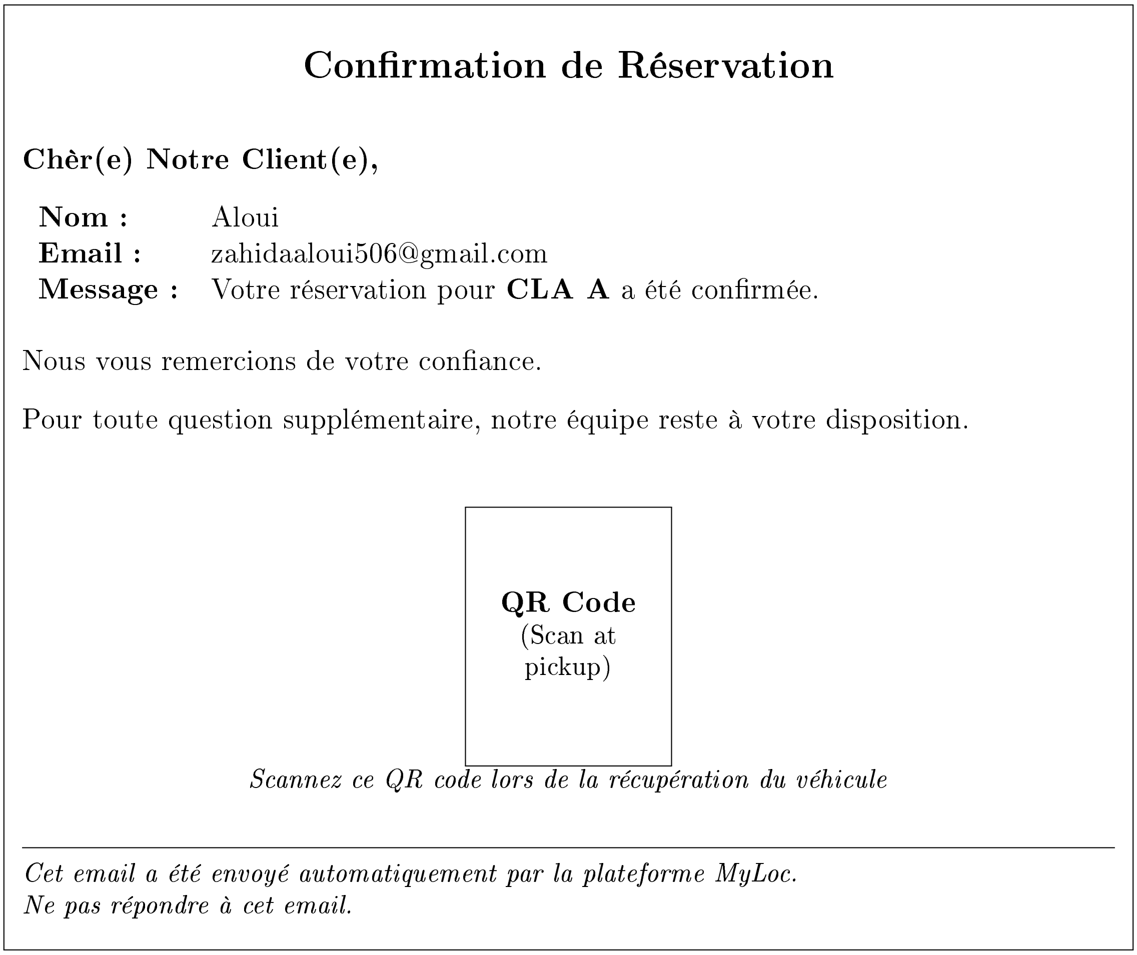
La Figure 4.1 montre un exemple réel d'email de confirmation envoyé à un client après l'approbation de sa réservation.

Email Content Details :

- **Subject Line** : "Confirmation de Réservation - MyLoc Agency"
- **Recipient** : Customer's registered email address.
- **Body** : Personalized message with customer name and car details.
- **Attachment** : PDF contract with complete booking information.
- **QR Code** : Unique identifier for the booking, scannable at vehicle pickup.

QR Code Verification Process :

1. Customer arrives at the agency to pick up the vehicle.
2. Agency staff scans the QR code from the email or PDF.



Confirmation de Réservation

Chèr(e) Notre Client(e),

Nom :	Aloui
Email :	zahidaaloui506@gmail.com
Message :	Votre réservation pour **CLA A** a été confirmée.

Nous vous remercions de votre confiance.

Pour toute question supplémentaire, notre équipe reste à votre disposition.

QR Code
(Scan at
pickup)

Scannez ce QR code lors de la récupération du véhicule

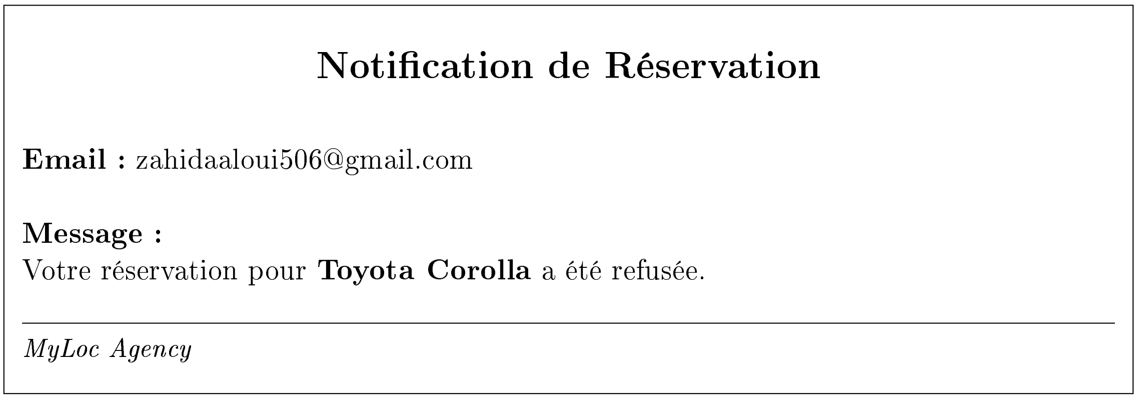
Cet email a été envoyé automatiquement par la plateforme MyLoc.
Ne pas répondre à cet email.

Figure 4.1 : Example of Booking Confirmation Email with QR Code

3. System verifies the booking details and validity.
4. If valid, the rental process proceeds.
5. Booking status updates to "IN_PROGRESS" or "COMPLETED".

4.5.0.2 Rejection Email Example

When an agency declines a rental request, a simple notification email is sent to inform the customer.



Notification de Réservation

Email : zahidaaloui506@gmail.com

Message :
Votre réservation pour **Toyota Corolla** a été refusée.

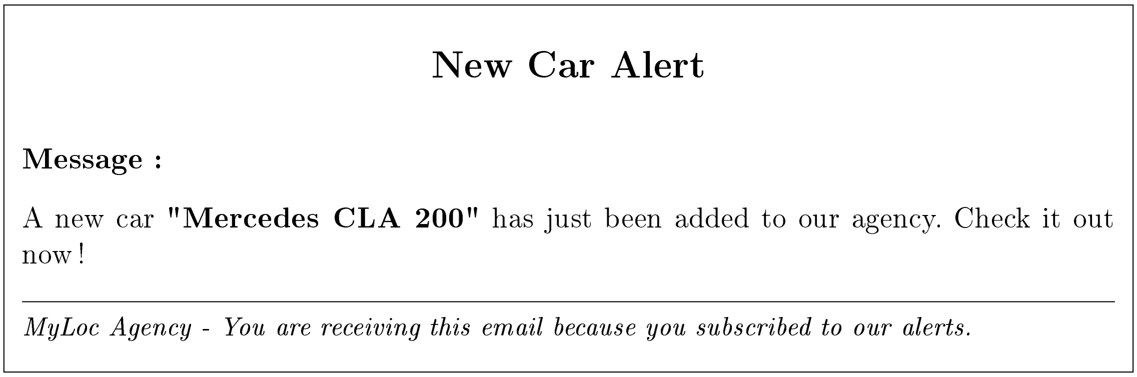
MyLoc Agency

Figure 4.2 : Example of Booking Rejection Email

Note : Contrairement à l'email de confirmation, l'email de rejet n'inclut pas de pièce jointe PDF ni de QR code. C'est une simple notification pour informer le client que sa demande n'a pas été acceptée.

4.5.0.3 Email d'Alerte Nouvelle Voiture (Pour les Followers)

Les Followers qui se sont abonnés via le footer du site reçoivent automatiquement des emails lorsque de nouvelles voitures sont ajoutées à la plateforme.



New Car Alert

Message :

A new car **"Mercedes CLA 200"** has just been added to our agency. Check it out now !

MyLoc Agency - You are receiving this email because you subscribed to our alerts.

Figure 4.3 : Example of New Car Alert Email for Followers

Récapitulatif des Types d'Emails :

Type d'Email	**PDF Attaché**	**QR Code**	**Destinataire**
Confirmation de Réservation	Oui	Oui	Client
Rejet de Réservation	Non	Non	Client
Alerte Nouvelle Voiture	Non	Non	Followers

Tableau 4.3 : Types d'Emails et leur Contenu

4.6 Sprint 8 : DevOps - Docker, Kubernetes et CI/CD

4.6.1 Containerisation avec Docker

Chaque composant de la plateforme est containerisé pour assurer la portabilité et la facilité de déploiement.

4.6.1.1 Dockerfile Backend (Spring Boot)

```
FROM openjdk:17-jdk-slim

WORKDIR /app

COPY target/myloc-backend.jar app.jar

EXPOSE 8080

ENTRYPOINT ["java", "-jar", "app.jar"]
```

4.6.1.2 Dockerfile Frontend (Angular)

```
# Stage 1: Build
FROM node:20-alpine AS build
WORKDIR /app
COPY package*.json ./
RUN npm ci
COPY . .
RUN npm run build --prod

# Stage 2: Serve
FROM nginx:alpine
COPY --from=build /app/dist/myloc-frontend /usr/share/nginx/html
COPY nginx.conf /etc/nginx/conf.d/default.conf
EXPOSE 80
CMD ["nginx", "-g", "daemon off;"]
```

4.6.1.3 Dockerfile Chatbot (Flask)

```
FROM python:3.11-slim
WORKDIR /app
COPY requirements.txt .
RUN pip install --no-cache-dir -r requirements.txt
COPY . .
EXPOSE 5000
CMD ["python", "app.py"]
```

4.6.1.4 Docker Compose

```
version: '3.8'
services:
  frontend:
    build: ./frontend
    ports:
      - "80:80"
    depends_on:
      - backend
    networks:
      - myloc-network

  backend:
    build: ./backend
    ports:
      - "8080:8080"
    environment:
      - SPRING_DATASOURCE_URL=jdbc:mysql://db:3306/myloc
      - SPRING_DATASOURCE_USERNAME=${DB_USER}
      - SPRING_DATASOURCE_PASSWORD=${DB_PASS}
    depends_on:
      - db
    networks:
      - myloc-network

  chatbot:
    build: ./chatbot
    ports:
      - "5000:5000"
    environment:
      - OPENAI_API_KEY=${OPENAI_KEY}
    networks:
      - myloc-network

  db:
    image: mysql:8
    environment:
      - MYSQL_ROOT_PASSWORD=${DB_ROOT_PASS}
      - MYSQL_DATABASE=myloc
    volumes:
      - mysql-data:/var/lib/mysql
    networks:
      - myloc-network
  keycloak:
    image: quay.io/keycloak/keycloak:latest
    ports:
      - "8180:8080"
    environment:
      - KEYCLOAK_ADMIN=admin
      - KEYCLOAK_ADMIN_PASSWORD=${KC_ADMIN_PASS}
    command: start-dev
    networks:
      - myloc-network

networks:
  myloc-network:
    driver: bridge

volumes:
  mysql-data:
```

4.6.2 Déploiement Kubernetes (Minikube)

Le déploiement sur Kubernetes permet une orchestration avancée des conteneurs.

4.6.2.1 Deployment Backend

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myloc-backend
  labels:
    app: myloc-backend
spec:
  replicas: 2
  selector:
    matchLabels:
      app: myloc-backend
  template:
    metadata:
      labels:
        app: myloc-backend
    spec:
      containers:
      - name: backend
        image: myloc/backend:latest
        ports:
        - containerPort: 8080
        env:
        - name: SPRING_DATASOURCE_URL
          valueFrom:
            secretKeyRef:
              name: myloc-secrets
              key: db-url
        resources:
          requests:
            memory: "512Mi"
            cpu: "250m"
          limits:
            memory: "1Gi"
            cpu: "500m"
---
apiVersion: v1
kind: Service
metadata:
  name: myloc-backend-service
spec:
  selector:
    app: myloc-backend
  ports:
  - port: 8080
    targetPort: 8080
  type: ClusterIP
```

4.6.2.2 Deployment Frontend

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myloc-frontend
spec:
  replicas: 2
  selector:
    matchLabels:
      app: myloc-frontend
  template:
    metadata:
      labels:
        app: myloc-frontend
    spec:
      containers:
      - name: frontend
        image: myloc/frontend:latest
        ports:
        - containerPort: 80
        resources:
          requests:
            memory: "128Mi"
            cpu: "100m"
---
apiVersion: v1
kind: Service
metadata:
  name: myloc-frontend-service
spec:
  selector:
    app: myloc-frontend
  ports:
  - port: 80
    targetPort: 80
  type: LoadBalancer
```

4.6.3 Pipeline CI/CD avec GitLab

Le pipeline CI/CD automatise le build, les tests et le déploiement.

4.6.3.1 Configuration .gitlab-ci.yml

```
stages:
  - build
  - test
  - docker
  - deploy

variables:
  DOCKER_REGISTRY: registry.gitlab.com
  IMAGE_TAG: $CI_COMMIT_SHORT_SHA

# Build Stage
build-backend:
  stage: build
  image: maven:3.9-openjdk-17
  script:
    - cd backend
    - mvn clean package -DskipTests
  artifacts:
    paths:
      - backend/target/*.jar
    expire_in: 1 hour

build-frontend:
  stage: build
  image: node:20-alpine
  script:
    - cd frontend
    - npm ci
    - npm run build --prod
  artifacts:
    paths:
      - frontend/dist/
    expire_in: 1 hour

# Test Stage
test-backend:
  stage: test
  image: maven:3.9-openjdk-17
  script:
    - cd backend
    - mvn test
  dependencies:
    - build-backend

test-frontend:
  stage: test
  image: node:20-alpine
  script:
    - cd frontend
    - npm ci
    - npm run test -- --watch=false --browsers=ChromeHeadless
  dependencies:
    - build-frontend

# Docker Stage
docker-build:
  stage: docker
  image: docker:latest
  services:
    - docker:dind
  script:
    - docker login -u $CI_REGISTRY_USER -p $CI_REGISTRY_PASSWORD $DOCKER_REGISTRY
    - docker build -t $DOCKER_REGISTRY/myloc/backend:$IMAGE_TAG ./backend
    - docker build -t $DOCKER_REGISTRY/myloc/frontend:$IMAGE_TAG ./frontend
    - docker push $DOCKER_REGISTRY/myloc/backend:$IMAGE_TAG
    - docker push $DOCKER_REGISTRY/myloc/frontend:$IMAGE_TAG
  dependencies:
    - build-backend
    - build-frontend

# Deploy Stage
deploy-staging:
  stage: deploy
  image: bitnami/kubectl:latest
  script:
    - kubectl config use-context staging
    - kubectl set image deployment/myloc-backend
        backend=$DOCKER_REGISTRY/myloc/backend:$IMAGE_TAG
    - kubectl set image deployment/myloc-frontend
        frontend=$DOCKER_REGISTRY/myloc/frontend:$IMAGE_TAG
    - kubectl rollout status deployment/myloc-backend
    - kubectl rollout status deployment/myloc-frontend
  environment:
    name: staging
  only:
    - develop

deploy-production:
  stage: deploy
  image: bitnami/kubectl:latest
  script:
    - kubectl config use-context production
    - kubectl set image deployment/myloc-backend
```

```
        backend=$DOCKER_REGISTRY/myloc/backend:$IMAGE_TAG
    - kubectl set image deployment/myloc-frontend
        frontend=$DOCKER_REGISTRY/myloc/frontend:$IMAGE_TAG
  environment:
    name: production
  only:
    - main
  when: manual
```

4.7 Implémentation Base de Données

La plateforme utilise une base de données relationnelle MySQL. Les entités sont mappées via annotations JPA.

- **Agence Table :** Stores agency profiles and login credentials.
- **Booking Table :** Stores rental requests, dates, customer info, price, and car details.
- **Blog Table :** Contains articles, authors, multimedia content.
- **Voiture Table :** Stores car details (name, type, price, photos).
- **User Table :** Stores customer information and login references.
- **Notification Table :** Stores in-app messages and alert statuses.

4.8 Screenshots of the Application

Screenshots illustrate the platform's functionalities for different user roles :

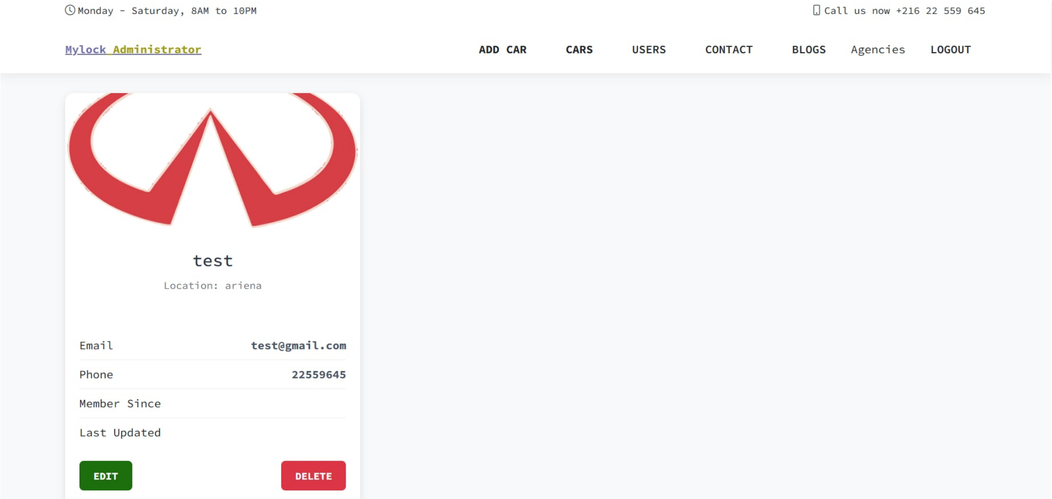
- Tableau de bord admin avec gestion des agences.
- Tableau de bord agence avec opérations CRUD voitures.
- Page de réservation client et vue historique.
- Interface de chat en temps réel admin-agences.
- Contrat PDF généré avec QR code.
- Interface chatbot intégrée sur la page d'accueil.

4.9 Tests et Validation

Le système a été validé à travers des tests manuels et automatisés.

4.9.1 Tests Unitaires

- Tests unitaires Spring Boot pour les services et contrôleurs.

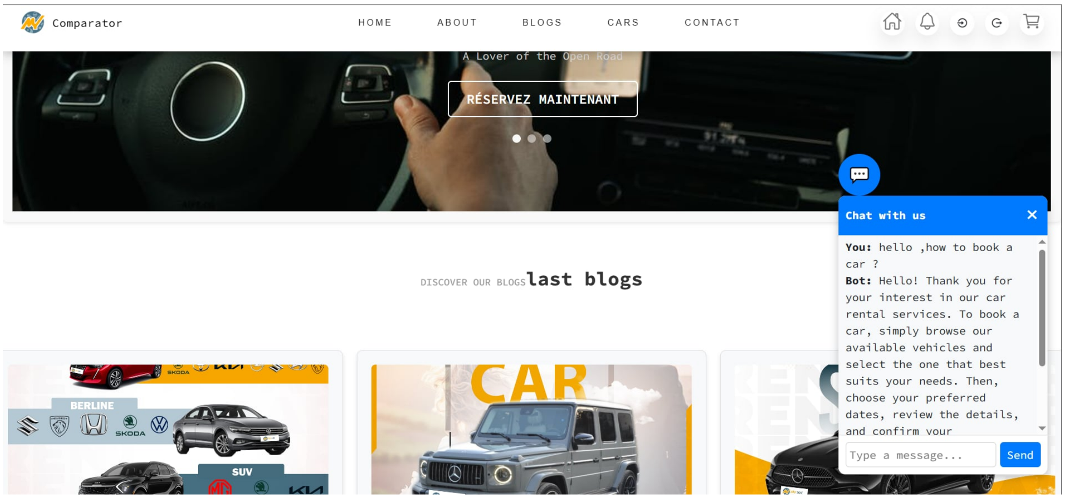


test

Location: ariena

Email	test@gmail.com
Phone	22559645
Member Since	
Last Updated	

Figure 4.4 : Tableau de Bord Admin pour la Gestion des Agences



You: hello ,how to book a car ?

Bot: Hello! Thank you for your interest in our car rental services. To book a car, simply browse our available vehicles and select the one that best suits your needs. Then, choose your preferred dates, review the details, and confirm your

Figure 4.5 : Intégration du Chatbot sur la Page d'Accueil

- Endpoints REST API testés avec Postman.
- Tests unitaires Angular utilisant Jasmine et Karma.

4.9.2 Tests d'Intégration

- Tests end-to-end du flux de réservation de la demande client à la validation agence.
- Traitement des paiements, génération PDF et envoi d'emails testés avec des gateways mock.
- Fonctionnalité de chat en temps réel testée entre admin et agences.

4.9.3 Validation Pipeline CI/CD

- Les pipelines GitLab CI testent les processus de build, exécutent les tests unitaires et déploient sur Kubernetes.
- Conteneurs Docker testés localement et en environnements de staging.
- Procédures de rollback et hotfix validées.

4.9.4 Témoignages Utilisateurs

Pour compléter les résultats de tests quantitatifs, nous avons collecté des retours d'utilisateurs réels ayant interagi avec la plateforme :

- **Bassem Ajengui (CEO & Fondateur) :** "Super application, très intuitive et facile à utiliser. Je recommande vivement !"
- **Assyl Kria (Designer) :** "Franchement, rien à dire ! Les voitures sont top et le service hyper pro."
- **Bayrem Boussaidi (Propriétaire de Magasin) :** "J'ai adoré la facilité de réservation et la qualité des véhicules proposés."
- **Aymen Arfaoui (Freelancer) :** "Une des meilleures agences de location de voitures, je reviendrai sans hésiter."
- **Mouhib Touati (Entrepreneur) :** "Je suis très satisfait du service, les prix sont abordables et les voitures impeccables."

Ces témoignages démontrent une réception positive de multiples rôles utilisateurs, confirmant l'utilisabilité, la clarté et la fiabilité de la plateforme.

4.10 Livrables de cette Phase

4.10.1 User Stories Complétées

ID	User Story	Statut
Sprint 6 : Chatbot IA		
US-23	Le visiteur interagit avec le chatbot	Fait
US-24	Le chatbot répond aux questions courantes	Fait
US-25	Le chatbot supporte le multilingue	Fait
Sprint 7 : Blog & Commentaires		
US-26	L'admin crée des articles de blog	Fait
US-27	Le client commente les blogs	Fait
US-31	Le client commente les voitures	Fait
Sprint 8 : DevOps		
US-32	L'équipe déploie via Docker	Fait
US-33	L'équipe configure Kubernetes	Fait
US-34	Le pipeline CI/CD est opérationnel	Fait
US-35	Les tests automatisés passent	Fait

Tableau 4.4 : User Stories Complétées - Sprints 6-8

4.11 Conclusion

La phase d'implémentation avancée a transformé avec succès la conception en une plateforme web robuste et fonctionnelle. Tous les modules planifiés — de l'authentification et des workflows de réservation à la messagerie en temps réel, notifications email automatisées, support chatbot IA et paiements en ligne — ont été développés, testés et déployés.

L'infrastructure DevOps avec Docker, Kubernetes et GitLab CI/CD assure une livraison continue et un déploiement fiable. Le système est stable, scalable et fournit une expérience digitale fluide pour tous les rôles utilisateurs.

General Conclusion

This project aimed to design, develop, and deploy a comprehensive car rental web platform, tailored to the needs of different users : administrators, agencies, customers, and visitors. Following an Agile Scrum methodology and leveraging modern DevOps tools, we successfully completed all phases, from requirements analysis to deployment on a Kubernetes cluster.

The platform successfully integrates several key features :

- Secure multi-role authentication and access control via Keycloak.
- Vehicle management by administrators and agencies, including photo management.
- Smooth booking process with real-time availability checking and agency validation.
- Automatic email notifications and PDF contract generation with integrated QR code.
- Real-time chat system facilitating communication between agencies and administrators.
- Intelligent chatbot offering 24/7 support via Flask and OpenAI integration.
- Intelligent car filtering service with MyLoc agency priority display.
- Robust CI/CD pipelines using GitLab, Docker containerization, and scalable Kubernetes deployment.

This project successfully combines RESTful architecture, microservices modularity, and artificial intelligence tools to deliver a complete, scalable, and maintainable solution.

Future Perspectives

The MyLoc platform opens the way to numerous future improvements, both technical and functional. The following enhancements are planned for upcoming releases :

Online Payment Integration

- **Payment Gateways** : Integration with Stripe, PayPal, and local payment providers (Flouci, Paymee for Tunisia).
- **Secure Transactions** : PCI-DSS compliant payment processing.
- **Multiple Payment Options** : Credit cards, bank transfers, mobile payments.
- **Automatic Invoicing** : PDF invoice generation upon successful payment.
- **Refund Management** : Automated refund processing for cancellations.

WhatsApp Integration

- **WhatsApp Business API** : Direct communication channel between customers and agencies.

- **Booking Notifications** : Instant WhatsApp messages for booking confirmations and reminders.
- **Click-to-Chat** : One-click WhatsApp contact buttons on car listings.
- **Customer Support** : WhatsApp-based customer service for quick inquiries.
- **Automated Messages** : Booking reminders, pickup instructions, and feedback requests.

Enhanced AI Capabilities

- **AI-Powered Recommendations** : Machine learning algorithms to suggest cars based on user preferences and booking history.
- **Price Prediction** : Dynamic pricing suggestions based on demand, season, and market trends.
- **Natural Language Search** : Voice-enabled car search using speech recognition.
- **Sentiment Analysis** : Automatic analysis of customer reviews and feedback.
- **Fraud Detection** : AI-based detection of suspicious booking patterns.
- **Predictive Maintenance** : AI alerts for vehicle maintenance scheduling.
- **Chatbot Enhancement** : Integration with GPT-4 for more sophisticated conversations and booking assistance.

Mobile Application

- **Native Mobile Apps** : iOS and Android applications using React Native or Flutter.
- **Push Notifications** : Real-time alerts for booking updates.
- **Offline Mode** : Access to booking history without internet connection.
- **GPS Integration** : Navigation to pickup locations.

Additional Features

- **Loyalty Program** : Points system and rewards for frequent customers.
- **Multi-language Support** : Arabic, German, and Italian language options.
- **Insurance Integration** : Partnership with insurance providers for rental coverage.
- **Fleet Analytics** : Advanced dashboards for agencies to analyze their fleet performance.
- **Carbon Footprint Tracking** : Environmental impact calculator for rentals.

In conclusion, this work perfectly illustrates how modern web technologies and cloud principles can transform a traditional rental process into an advanced digital experience, bringing added value to users and service managers. The MyLoc platform is positioned for continuous growth and innovation in the car rental industry.

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Résumé

FR

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Abstract

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