SUP'COM

المدرسة العليا للمواصلات بتونس
Ecole Supérieure des Communications de Tunis
Higher School of Communications of Tunis

Veloway
Smart Bicycle Rental System

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1. Concept

1.1. Context

Tunisia is experiencing a remarkable tourism boom in 2025, having already welcomed 5.2 million visitors halfway through the year—surpassing pre-pandemic levels. This growth, driven by strategic sector development and active promotion of local destinations, has placed the country on a record growth trajectory.

However, this success has put unprecedented pressure on mobility infrastructures in tourist areas. Overcrowded streets suffer from chronic congestion, increased transportation demand, and rising environmental and noise pollution. The current transport offer—mainly based on private cars and limited public transport—shows clear limitations.

This situation creates a vicious cycle: congestion increases travel times, deteriorates the visitor experience, and discourages the use of alternative modes of transport. Studies have confirmed that urban travel accounts for nearly 70% of daily movements in major Tunisian cities, with critical peaks occurring in coastal and heritage areas.

For tourists, this results in difficulties moving autonomously, efficiently, and ecologically, potentially harming the quality of their stay and Tunisia's image as a destination.

1.2. Problematic

How can we design and deploy a sustainable, intelligent, and integrated mobility solution in Tunisian tourist zones to:

- Facilitate short and medium-distance trips for tourists and citizens.
- Significantly reduce car congestion, pollution, and road crowding.
- Improve the tourist experience by offering a flexible, enjoyable, and connected transportation mode.
- Ensure optimized and sustainable management of the bike fleet through a centralized technological platform.

1.3. Project objectives

Develop and implement a smart, connected bike-sharing service (VLS) powered by IoT technologies and a mobile application to address mobility challenges in tourist zones. By integrating sensors, GPS, and real-time monitoring systems, this solution enables:

- Optimized bike availability across stations.
- Monitoring of bike condition and failure prevention.
- User route planning and easy identification of free stations.
- Flexible, transparent, and secure payment systems.

1.4. Target Audience

The application is mainly intended for:

- **Local citizens:**
  - Residents of urban or tourist areas seeking fast and eco-friendly transport.
  - Users looking for a practical and affordable alternative to traditional transport.
- **Tourists and visitors:**
  - Travelers wishing to explore the city in a simple and enjoyable way.
  - Occasional users preferring a commitment-free solution.
- **Students and young professionals:**
  - Individuals searching for a flexible, low-cost transport option accessible via smartphone.
- **Local authorities and tourism boards:**
  - Municipalities aiming to promote sustainable mobility and reduce car traffic in urban centers.

2. Needs Description

2.1. Functional Requirements

Functional requirements represent the main features the application must provide to users (clients and administrators). These include user management, rental operations, IoT data handling, computer vision verification, and administrative functionalities.

2.1.1. User Management

- Account creation, authentication, and profile management.
- Linking of an electronic payment method (bank card or digital wallet).

2.1.2. Bike Rental

- Start of rental via QR code scan.
- Capture of an initial photo of the bike's condition.
- Real-time trip tracking and GPS location.
- End of rental with automatic detection of nearby stations and available docks.
- Capture of a final photo to compare condition before/after use.

2.1.3. Payment and Billing

- Automatic price calculation (by time or distance).
- Secure in-app payment.

2.1.4. IoT Data Management

- Real-time data transfer from stations via Raspberry Pi.
- Availability monitoring of bicycles and parking slots.

2.1.5. Mobile Application

- QR code scanning for unlocking bikes.
- GPS tracking of trips.
- Payment processing (based on time or distance).
- Photo upload for AI analysis before trip end.

2.1.6. Computer Vision Verification

- AI model detects damage on uploaded images.
- Results stored in the database for maintenance reports.

2.1.7. Backoffice Dashboard

- Admins can monitor station status, active trips, and maintenance reports.
- Visual analytics on usage, performance, and system health.

2.2. Non-Functional Requirements

These define the quality, performance, and technical constraints of the app:

- **Performance:**
  - Fast response for QR scanning, map updates, and GPS tracking.
  - Real-time updates of bike and station availability.
- **Security:**
  - Encryption of user data and financial transactions.
  - Secure authentication (strong passwords, possible OTP).
- **Reliability:**
  - Fault tolerance ensuring service continuity.
  - Regular data backups.
- **Compatibility:**
  - Available on both Android and iOS.

- Integration with multiple electronic payment systems.

- **Usability and Accessibility:**
  - Simple, intuitive, and multilingual interface (e.g., English, French).
  - Suitable for both tourists and local residents.

- **Scalability:**
  - Future addition of features like subscriptions or loyalty programs.
  - Expansion to other cities or tourist areas.

3. Equipment

Table 3.1: List of required equipment for the Smart Bicycle Rental System

Equipment	**Description**
Raspberry Pi	Acts as a gateway between IoT devices and the backend system.
Sensors	Detects whether a bike is docked or rented.
GPS Module	Tracks user and bike locations during trips.
Camera	Captures images of the bike for damage verification using AI.
Smartphone	Allows users to interact with the mobile app, scan QR codes, and pay.
Server	Hosts Jakarta EE backend, APIs, and MongoDB database.

4. Technologies Choice

Table 4.1: Technology stack

Layer	Technologies
Backend	Jakarta EE, REST API, MongoDB
Frontend	React Native, ReactJS (Backoffice)
IoT Layer	Raspberry Pi,sensors, GPS module
AI Layer	PyTorch for image-based damage detection
Middleware	Apache Kafka for data streaming and monitoring

5. Architecture and limitations

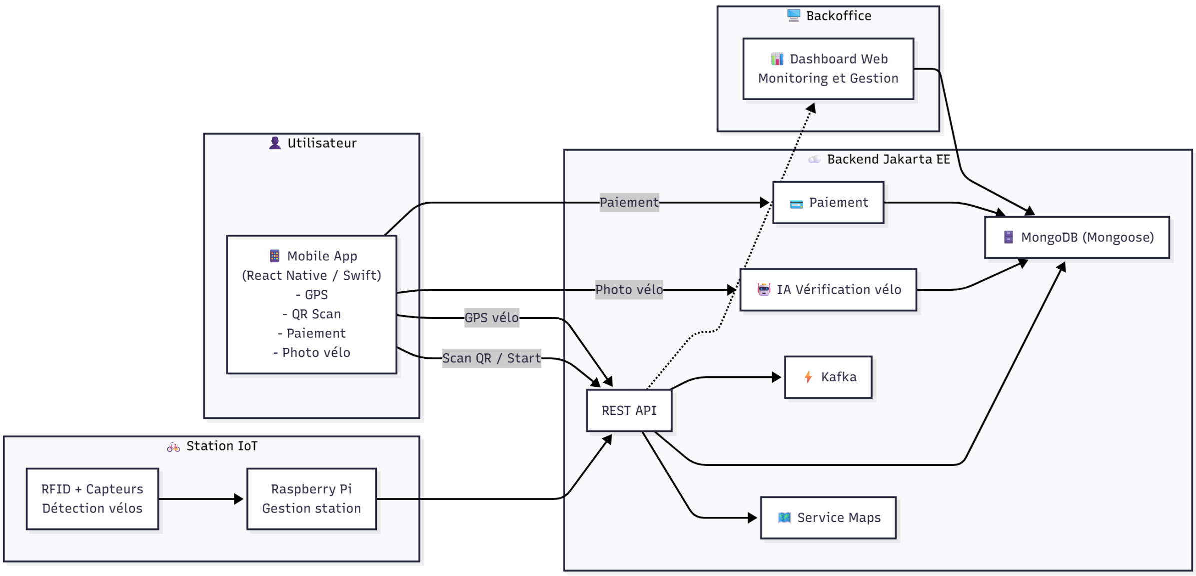

Figure 5.1: System Architecture

5.1. Limitations

The main limitations and constraints of the project include:

- **Data overload:** Continuous GPS data transmission may cause high battery and data consumption.
- **Image quality:** Captured photos may suffer from low resolution or poor lighting.
- **IoT sensor reliability:** Accuracy may vary depending on environment or sensor aging.
- **Internet dependency:** A stable network connection is required for real-time access. Offline functionality may be limited.
- **Scalability:** The system must remain capable of handling large-scale deployments.

6. Market Study and Marketing Mix

6.1. Market Study

6.1.1. Market Analysis

Global Market:
The eco-mobility and bike rental market is growing rapidly, driven by environmental awareness and demand for sustainable transport. Technological advances such as connected bikes and IoT systems are increasing market attractiveness.
Local Market:
In the Tunisian context, the market shows strong potential due to tourist areas, universities, and business districts where fast transport alternatives are needed. Although competitors exist, integrating IoT, GPS, and real-time monitoring provides **Veloway** with a strong competitive advantage—offering a safer, more flexible, and innovative experience.

6.1.2. Competitor Analysis

Understanding existing competitors helps identify market opportunities and differentiation strategies.

Direct Competitors:
Traditional bike-sharing services offering manual or electric bikes accessible via fixed stations. These often lack real-time monitoring and advanced connectivity, limiting user flexibility and safety.
Indirect Competitors:
Other mobility solutions such as e-scooters, taxis, ride-hailing apps, and public transport. While they meet fast mobility needs, they are not always ecological or ideal for short-distance travel.
Competitive Advantages of Veloway:

- **Connected bikes with GPS and IoT sensors:** Enable real-time tracking and optimized fleet management.
- **MLOps-based damage detection system:** Automatically checks bike condition upon return using photo analysis.
- **Flexible pricing models:** Choose between time-based or distance-based billing for wider adoption.
- **Intuitive mobile app:** Offers real-time navigation, station search, booking, and payments—all integrated.

By combining these features, **Veloway** delivers a superior user experience while addressing modern demands for sustainable and smart mobility.

6.2. Marketing Mix (4P)

The Marketing Mix—or the 4Ps (*Product, Price, Place, Promotion*)—defines the core marketing strategy of the project. It aims to:

- Describe the proposed offer and features.
- Define appropriate pricing policies.
- Identify effective distribution channels.
- Establish communication strategies to boost visibility and adoption.

6.2.1. Product

Veloway provides bike rentals through a smart mobile app integrating GPS and IoT-enabled stations.
Key Features:

- Integrated booking and payment.
- Real-time bike tracking.
- Smart stations for pickup and drop-off.
- MLOps-based damage detection system.

Bike Variety:
City bikes for daily use, mountain bikes for sports routes, and electric bikes for longer distances—meeting diverse user needs and enhancing market appeal.

6.2.2. Price

Flexible pricing models:

- Time-based pricing (pay per minute/hour).
- Distance-based pricing (pay per kilometer).

This flexibility allows users to choose the model that best fits their habits, encouraging adoption and customer satisfaction.

6.2.3. Place

Access to bikes is available both digitally and physically:

- **Mobile App:** Main channel for booking, payment, and ride management.
- **Physical Stations:** Strategically located in high-traffic areas—tourist zones, parks, and leisure spots—to maximize accessibility and promote green mobility.

6.2.4. Promotion

To increase visibility and adoption, **Veloway** employs a multichannel communication strategy combining online and offline actions.
Advertising:
Digital campaigns on social media, Google Ads, and collaborations with local influencers to build engagement. Physical posters in stations and public areas for maximum local exposure.
Strategic Partnerships:
Collaborations with tourism boards, hotels, universities, and companies to promote offers tailored to specific audiences.

Content Marketing:
A dedicated blog and videos highlighting sustainable mobility, cycling tourism, and eco-benefits. Travel guides featuring recommended routes and maintenance tips for users.
Launch Offers:
First rides offered free or at discounted rates. Special deals for early subscribers and promotional events (e.g., test days, online challenges) to build excitement.

7. Timeline and Tasks

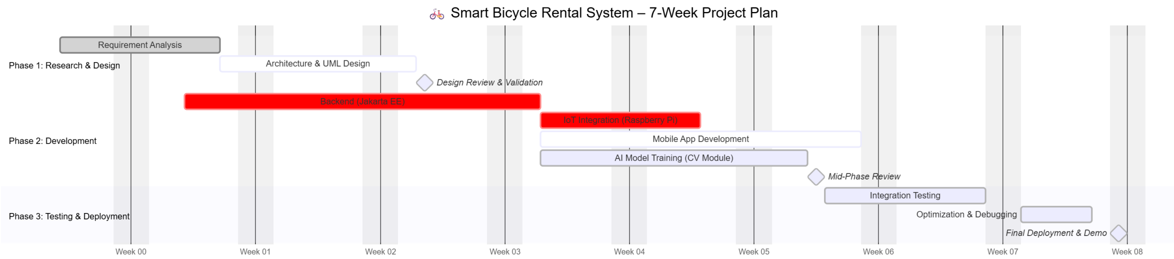

Figure 7.1: Project Gantt Timeline

8. Business Study

8.1. Business Model Canvas (BMC)

Business Model Canvas – Smart Bicycle Rental System

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value Proposition</th><th>Customer Relationships</th><th>Customer Segments</th></tr>
<tr><td>IoT hardware and sensor providers.

Cloud hosting and data analytics providers.

Municipal authorities, transport agencies.</td><td>Backend, mobile app, and IoT gateway development.

AI model training for damage detection.

Integration of payment gateways.</td><td>Eco-friendly and affordable smart mobility solution.

Real-time bicycle and station tracking.

AI-powered damage detection before trip closure.</td><td>Continuous technical support and maintenance feedback.

Reward system for frequent users.

Community feedback integration for improvements.</td><td>Urban commuters, students, and tourists.

City councils and private operators.

Green mobility enthusiasts.</td></tr>
<tr><td colspan="2">Key Resources
Hardware: Raspberry Pi, cameras, sensors.
Software: Jakarta EE backend, mobile app.
Human: IoT and AI engineers, UX developers.
Data: usage analytics and GPS tracking.</td><td colspan="2">Channels
Mobile app and QR codes at stations.
Digital marketing and social media.
Partnerships with universities and municipalities.</td><td>Cost Structure
IoT hardware and maintenance.
Cloud hosting and development.
Marketing and staff salaries.</td></tr>
<tr><td colspan="5">Revenue Streams
Rental fees (time/distance-based).
Subscription plans for frequent users.
Advertisements and partnership sponsorships.
Maintenance and upgrade services.</td></tr>
</table>

8.2. SWOT Analysis

Figure 8.1: Swot Analysis

9. Constraints

- The project must be completed before June 2025.
- Limited access to physical IoT components for testing.
- Cloud deployment must comply with data privacy regulations.