Dokumen Cetak Biru Project Internet of Things

Optimalisasi Jalur Sepeda Listrik dan Skuter Listrik

KELOMPOK "ORA UMUM!"

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Daftar Isi

A. Pendahuluan

1. Latar Belakang

The main problem addressed in the IoT project for optimizing e-bike/scooter lanes is that e-bikes and scooters can use the correct lane without disturbing other road users, thus creating comfort for electric bike users and safety and smoothness for other road users. Disturbances happen when e-bike users enter lanes intended for pedestrians or other vehicles, causing conflict and potential accidents.

Potential opportunities include the development of sensor-based IoT systems, GPS, and dynamic lane management that can guide e-bike users through dedicated lanes and provide warnings if they enter the wrong way or potentially disrupt other users. This also includes regulating the speed and operating area of e-bikes to comply with road safety regulations and public convenience. For example, separating bike lanes with physical barriers and real-time monitoring systems can reduce user conflicts.

Given the evolving driving trends in recent years, the increasing use of e-bike/scooter in several cities has created new needs related to safety, comfort, traffic management, and more effective monitoring. It motivated us to work on and develop this project, hopefully it will give a benefit for several stakeholders.

2. Visi:

The big picture of this project is to develop an IoT system that optimizes lanes for electric bicycles and scooters so that their use remains comfortable and safe without disturbing other road users. This system aims to manage lanes dynamically and provide appropriate guidance for electric bicycle users to stay in designated lanes, reducing potential disturbances and accidents and improving harmony between various road users in urban areas.

This project will have a positive impact by improving the safety and comfort of riding electric bicycles/scooters and reducing traffic congestion. By optimizing routes, congestion and potential accidents can be reduced, improving the accessibility of environmentally friendly and efficient transportation. In addition, this management encourages the use of energy-efficient, environmentally friendly electric bicycles/scooters, thereby improving the mobility of the community in general. Related research shows that IoT-based monitoring and control systems can improve the safety and efficiency of electric bicycle/scooter use, while supporting the development of sustainable transportation infrastructure and reducing carbon emissions and pollution from motor vehicles.

3. Tujuan:

Based on the background and vision described above, the specific short-term and long-term objectives of this study are as follows:

1. Short Term (0-6 Months)

   The short-term goal focuses on the development, initial implementation, and validation of sensor-based lane security solutions.

   - Developing and integrating N lane sensor prototypes and warning systems on electric scooters/bicycles (e.g., $N=10$) that function accurately within the first 3 months.
   - Achieving a minimum Lane Detection Accuracy of 95% in different lighting conditions (day/night) within the first 6 months.
   - Reduce Lane Departure Violations by users equipped with prototypes by 40% within the first 3-month trial period after the sensors are activated.
   - Implement and test the functionality of safe automatic power disconnection (without causing sudden danger) on scooters when lane warnings are ignored within 6 months.

2. Long Term (6-24 Months)

   Long-term goals focus on scalability, additional security effectiveness (GPS), and broad impact on public safety.

   - Improving Road User Safety (pedestrians and riders) by reducing accidents involving electric scooters/bicycles by 25% in key implementation areas within 1 year.
   - Integrating a real-time GPS tracking system on 100% of the electric scooter/bike fleet in operation and activating a monitoring center for tracking and security (e.g., loss/theft detection) within 9 months.
   - Achieve a 70% level of road user satisfaction (pedestrians, cyclists, drivers) with the orderliness of micro-vehicle lanes (electric scooters/bicycles) through a survey after 1 year of full implementation.
   - Make the Color Lane and GPS-Based Security System a Mandatory Standard (Standard Operating Procedure) for all electric scooter/bike rental or operational services in certain areas within 2 years.

B. Gambaran Umum Proyek

1. Deskripsi Proyek:

This project will build an IoT system to optimize lanes specifically for e-bikes and scooters, marked with specific colors as boundaries. E-bikes/scooters will be equipped with GPS modules for real-time location tracking and color sensors or small cameras that can detect the color markings of the lane. Data from the sensors and GPS will be sent periodically to a gateway, which will then forward it to a cloud platform for processing. The system will monitor whether e-bikes are on the correct lane or crossing non-e-bikes lanes that could cause interference. If a user deviates into another lane, the system will provide a warning via the app or the e-bike's voice system so that the user can return to their dedicated lane, thus ensuring the comfort and safety of all road users.

The main components (hardware/software) of this system include:

- A GPS sensor that can monitor the position of an e-bike/scooter in real time for navigation and lane mapping.
- A color sensor or small camera that can detect the color of the dedicated lane so the system knows whether the bicycle is on the correct lane.
- A communication module (gateway) that connects data from the sensor to the cloud using technologies such as LTE, 5G, or Wi-Fi.
- A cloud platform that can store, process, and analyze position and lane data to determine interventions such as warnings or dynamic lane setting.
- An audio/visual actuator on the e-bike that provides audible or light warnings if the user strays from the dedicated lane.
- A user app that displays the rider's location, lane status, and safety warnings in real time.

To operate the IoT system on an e-bike/scooter, these are how it works:

1. The e-bike/scooter is turned on, and the GPS and color sensors are activated.
2. The color sensors scan the lane color ahead to ensure it is in the correct lane.
3. Lane position and color data are continuously sent to a cloud-connected gateway.

4. The cloud platform analyzes the lane position and color data, comparing it to a dedicated lane map.
5. When the sensors detect an inappropriate lane color or a position in a non-e-bike lane, the system sends an alert to the bike's audio/visual actuators and the user's app.
6. The user knows to return to the designated lane to avoid disrupting other users.
7. This data can also be used by city managers for lane improvements and better traffic management.

C. Manfaat

1. Technical Benefits
    - Improved Route Efficiency

      With the reorganization of routes and the restructuring of the existing system, route usage will be optimized, reducing congestion and conflicts between road users.
    - Improved user safety

      Technologies such as sensors can help prevent accidents and guide fellow users in their lanes.
    - Reduced infrastructure burden

      With a more even distribution of users, roads will not deteriorate as quickly, reducing maintenance costs.
2. Business Benefits
    - Increased revenue for electric scooter/bike operators

      By improving user comfort, more people will be interested in the service.
    - Operational cost efficiency

      With real-time data, operators can optimize unit distribution, minimize damage, and reduce maintenance costs.
    - Increased urban economic value

      Cities that are friendly to micro-mobility are more attractive to tourists, businesses, and investors.
3. The beneficiaries of this project
    - Electric bicycle and scooter users will enjoy a comfortable ride thanks to well-managed dedicated lanes, reducing the risk of conflict with other road users. The IoT system can also provide navigation guidance and alerts to ensure safety and optimize travel routes, thereby increasing time and energy efficiency.
    - Other road users such as pedestrians and non-electric vehicle drivers will be spared from disruption and potential danger caused by electric bicycles entering their lanes. With neatly arranged and monitored lanes, traffic becomes more orderly and safer, reducing accidents and inconvenience.

- The government and city administrators benefit from better and more sustainable urban transportation planning. This project helps support environmentally friendly transportation programs while reducing traffic congestion and pollution.
- The general public will feel the positive impact of improved public spaces that are safer, more comfortable, and more efficient. Reduced carbon emissions from the optimal use of electric bicycles also support environmental health and social welfare.

D. Analisis Proyek IoT

1. Analisis Kebutuhan Fungsional

No	Aktor	Deskripsi	Prioritas
1	Rider	The system can detect whether electric bicycles/scooters are in the dedicated lane through color sensors.	High
		The system can provide audio/visual warnings if the user deviates from the designated lane.	High
		The system can display the position and route of electric bicycles on the user application in real time.	High
		The system can provide recommendations for the fastest and safest routes through the application.	Middle
		The system can adjust the warning level according to the zone/traffic density.	Low
2	Admin	The system can collect lane violation data for analysis and monitoring in the cloud.	Middle
		The system can generate statistical reports on the use of dedicated lanes for urban development.	Middle

2. Analisis Kebutuhan Non-Fungsional

This section details the necessary quality properties, constraints, and system characteristics for the Dynamic Color-Coded Lane Compliance (DCLC) system (e-scooters/e-bikes).

a. Kebutuhan Non-Fungsional Software

It defines the expected qualities of the software and firmware running on the scooters and the central server.

1. Performance:
   - Response Time: Lane violation detection and automatic warning must be triggered in less than 1 second for effective safety intervention.
   - Data Latency: Real-time GPS location data must be updated on the central server dashboard every 5 to 10 seconds maximum.
2. Reliability:
   - Controlled Safety Stop: The automatic vehicle shutdown sequence must be a controlled, gradual reduction of power to prevent the rider from being thrown off.
   - Uptime: The central server and database must maintain an availability of 99.9% (less than 9 hours of downtime per year).
3. Usability:
   - Intuitive Monitoring Dashboard: The operator interface must display EMD locations, status (compliant/warning/shutdown), and lane boundaries using clear visual cues and simple color coding.
   - User Feedback Clarity: On-device warnings (haptic or audio) must be clearly distinguishable from regular operation.
4. Maintainability:
   - Remote Updates (OTA): All EMD firmware must be able to receive Over-The-Air (OTA) updates for bug fixes and feature improvements.
   - Modularity: The software codebase must be highly modular to allow new features (e.g., integrating a pollution sensor) to be added easily.

b. Kebutuhan Non-Fungsional Dependency Software

These are external software, platforms, or services that the DCLC system relies upon.

1. Mapping Services:
    - The monitoring application must integrate with a high-resolution geospatial API (e.g., Google Maps Platform or similar) capable of accurately displaying sub-meter lane boundaries.
2. Database Management System (DBMS):
    - The chosen DBMS must handle high velocity and high volume data ingestion (thousands of GPS points per minute) reliably.
3. Cloud Infrastructure:
    - The central application must be hosted on a redundant and scalable cloud platform (e.g., AWS, Azure, GCP) to manage sudden peaks in usage and ensure 24/7 reliability.
4. Embedded Operating System (OS):
    - The scooter's embedded computer must use a lightweight and real-time operating system to guarantee immediate processing of sensor data.

c. Kebutuhan Non-Fungsional Hardware

The necessary properties of the physical hardware components for the Dynamic Color-Coded Lane Compliance (DCLC) system. The expected hardware properties are:

Property	Description	Source Reference
Durability	The on-vehicle hardware (GPS, color sensor/camera, actuator, communication module) must be resistant to external environmental conditions (weather, vibration, shock) and should have an IP67 rating or equivalent for protection against dust and water.	The hardware needs to support the e-bike components.
Sensor Accuracy	The GPS Sensor must have a minimum positional accuracy of	The accuracy is crucial for safety intervention.

	sub-meter to clearly differentiate between dedicated and non-dedicated lanes. The Color Sensor/Camera must maintain a color detection accuracy of 95% across various lighting conditions (day/night) and road surfaces (dry/wet).	
Power Consumption	All hardware modules must be highly power-efficient (Low Power Consumption) to avoid significantly reducing the e-bike/scooter's battery range.	The system must encourage the use of energy-efficient electric bicycles/scooters.
Processing Speed	The Embedded Computer (microcontroller or SoC) on the e-bike must be fast enough to process real-time sensor data and trigger warnings in less than 1 second, as required for effective safety intervention.	Quick response time is a performance requirement.
Communication Capability	The Gateway Module must support low-latency cellular network connectivity (such as LTE/5G) to ensure GPS position data is updated on the central server every 5 to 10 seconds maximum.	Data latency and connectivity are essential for real-time monitoring.

d. Kebutuhan Non-Fungsional Brainware

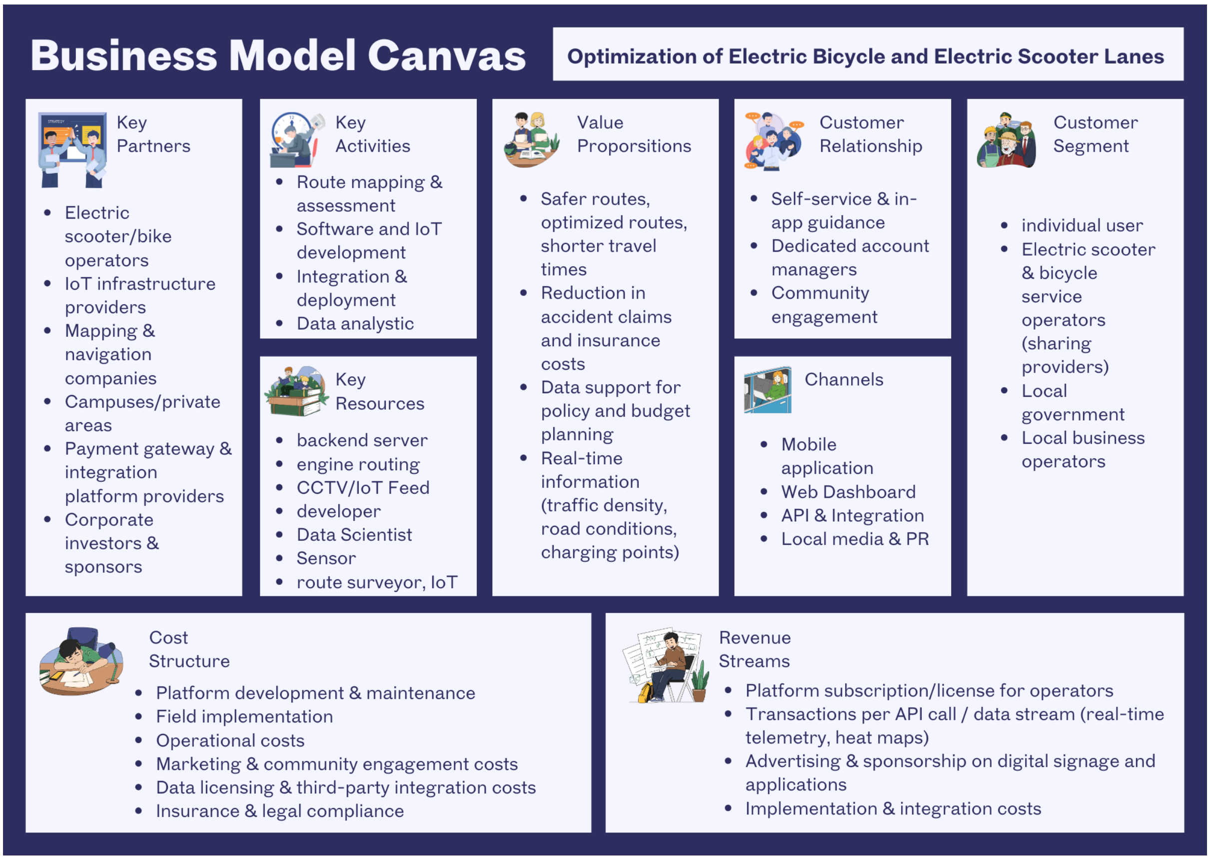
Outline the expected properties and skills required for the users (*riders* and *operators*) to effectively utilize the DCLC system.

1. For E-bike/Scooter Users (Riders)
    a. Users are expected to have the basic ability to use a smartphone application to view routes, location, and receive warnings from the system.

b. The Users must have the fundamental awareness to heed and respond to audio/visual warnings from the system and return to the dedicated lane.
c. Users must understand and comply with the Standard Operating Procedures (SOP) for using the color-coded lanes, especially if the system becomes a mandatory standard for operational services.

2. For System Administrators and Operators (City Officials/Service Providers)
    a. Monitoring Expertise for Operators must possess the ability to interpret the intuitive monitoring dashboard, including understanding vehicle location, status (compliant/warning/shutdown), and lane boundaries using clear visual cues and simple color coding.
    b. Data Analysis Skills to responsible personnel are expected to be capable of analyzing statistical reports and violation data generated by the system for the purpose of lane improvement, urban development, and better traffic management.
    c. System Maintenance Skills that Technical staff must have the expertise to perform Over-The-Air (OTA) firmware updates , perform basic troubleshooting, and maintain the system modules to ensure 99.9% server uptime.

3. Analisis Bisnis



This Business Model Canvas explains how the system creates safer bike and electric scooter lanes with the help of apps and sensors. The main points covered are real-time route information and improved safety levels. This project is in collaboration with the government and scooter operators, with revenue coming from platform services and these partnerships. The main costs incurred include system development and sensor installation. Overall, this BMC shows how the project has successfully created a safer and more efficient micro-transportation system for users in the city.

4. Analisis Keamanan IoT

- Data Security

Data security is crucial considering that this system collects location data, user movements, and route violation history. To ensure data confidentiality and integrity:

- Encryption

All data sent from GPS sensors and gateways to the cloud platform is encrypted with the TLS/SSL protocol so that it cannot be accessed by unauthorized parties during transmission.

- Authentication & access

Only verified users and administrators have access to sensitive data. The use of multi-factor authentication (MFA) and access rights management in applications and the cloud prevents illegal access.

- Audit logs

The system records all access activities and data changes so that they can be traced in the event of a security incident.

- System Performance Security

Performance security keeps the system responsive, reliable, and free from disruptions that could reduce functionality.

- Network redundancy

Uses secondary communication channels (backup WiFi/5G) if the primary connection fails, so data can still be sent and processed without interruption.

- Real-time monitoring

The cloud monitoring system automatically detects anomalies and limits DDoS or malware attacks with cloud firewalls and anti-virus software.

- Regular data backup

All important data and system configurations are automatically backed up to avoid data loss from device damage or attacks.

- System Usage Security

Usage security ensures that physical devices, applications, and infrastructure are safe for public use.

- Device validation

Each GPS module and sensor can only operate if it is registered in the system, preventing device manipulation and illegal use.

- Safety warnings

The system provides automatic warnings in case of use in inappropriate areas, both for traffic safety and user privacy.

- Firmware updates

Always send software/firmware updates to close new security gaps and improve device protection from exploitation.

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