UNIVERSIDAD DE GUADALAJARA

Centro Universitario de los Valles

Master of Software Engineering

Intelligent Traffic Management System

Baseline

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Client request:

Project Summary

The project aims to develop an intelligent traffic management system for metropolitan areas with the goal of optimizing traffic flow, reducing congestion, and enhancing urban mobility. The system will collect and analyze real-time traffic data from traffic sensors to provide up-to-date information on traffic conditions, suggest alternative routes, and efficiently coordinate traffic lights.

Project Justification

Metropolitan areas face traffic congestion issues that lead to delays, stress, and unnecessary emissions. An intelligent traffic management system can address these issues by providing real-time information to drivers, optimizing traffic light coordination, and predicting traffic patterns. This can improve traffic flow, reduce travel time, and contribute to environmental sustainability.

Project Modules

In the development of large-scale technological projects, efficient resource management and scalability are fundamental to success. To address these challenges and ensure agile and controlled development, we have adopted a core strategy: dividing the project's baseline into clearly defined modules. Each of these modules represents a functional and cohesive piece of the complete system, with specific objectives and requirements.

This modular structure enables us to develop, test, and maintain each component independently, streamlining the development process and facilitating resource and team management. Each module focuses on a particular set of functionalities and seamlessly integrates into the overall system.

Data Acquisition Module

Description: This module is responsible for collecting real-time data from traffic sensors located on roads and urban streets.
Key Functionalities: Sensor communication, raw data processing, filtering irrelevant data.

Requirements Analysis:

Requirement: The system must be capable of collecting real-time traffic sensor data.

Description: A data acquisition service will be implemented to connect to sensors through compatible hardware interfaces.

Requirement: It must be compatible with different types of traffic sensors, such as cameras, speed sensors, and flow sensors.
Description: A modular architecture will be developed to allow easy integration of new sensor types through specific adapters.

Requirement: It must provide mechanisms for sensor calibration and maintenance.
Description: Calibration and diagnostic functionality will be included, allowing operators to make adjustments and perform sensor maintenance remotely.

Requirement: The module must perform quality tests on acquired data and detect possible sensor errors or failures.
Description: A continuous monitoring system will be implemented to verify data quality and generate alerts in case of issues.

Real-Time Data Processing Module:

Description: This module processes real-time data to obtain information about the current traffic status.
Key Functionalities: Real-time data processing, congestion detection, average speed calculation.

Requirements Analysis:

Requirement: The module must process real-time data to identify the current traffic status.
Description: Real-time processing algorithms will be developed to analyze incoming data and calculate traffic metrics.

Requirement: It must calculate average speeds, traffic densities, and estimated travel times.
Description: Real-time functions for speed, density, and travel time calculation will be implemented using sensor data.

Requirement: It must detect traffic congestions and notify other modules.
Description: A congestion detection system will be developed based on predefined thresholds, and notifications will be sent via an internal communication interface.

Requirement: The module must provide an interface to access real-time processed data.
Description: An API will be implemented to allow other modules to access processed traffic data.

Traffic Pattern Prediction Module:

Description: This module uses machine learning algorithms to predict traffic patterns based on historical data and recurrent events.
Key Functionalities: Prediction model training, future congestion prediction.

Requirements Analysis:

Requirement: The module must train traffic prediction models based on historical data and recurrent events.
Description: A model training system will be implemented using historical data and machine learning algorithms to create prediction models.

Requirement: It must make predictions about traffic congestion within a specific time horizon.
Description: A prediction component will be developed, taking into account historical and real-time information to generate congestion forecasts.

Requirement: It must provide information about optimal alternative routes based on predictions.
Description: A route recommendation system will be implemented using congestion predictions to suggest alternative routes.

Requirement: It must be able to continuously adjust models as new data arrives.
Description: A continuous training process will be established to update models with recent data to maintain accuracy.

Traffic Signal Coordination Module:

Description: This module coordinates traffic signals at intersections to improve traffic flow based on real-time information and predictions.
Key Functionalities: Coordination of traffic signal cycles, adaptive adjustment based on current traffic.

Requirements Analysis:

Requirement: The module must coordinate traffic signals at intersections to optimize traffic flow in real-time.
Description: A traffic signal coordination system will be developed that receives real-time traffic data and adjusts signal cycles and phases adaptively.

Requirement: It must receive information about the current traffic status and predictions of congestion.
Description: A communication interface with the real-time data processing module will be established to receive updated data about traffic.

Requirement: It must adjust signal cycle times and phases based on received information.
Description: A control algorithm will be implemented to make decisions about signal coordination based on real-time information and predictions.

User Interface Module:

Description: This module provides user interfaces in mobile applications to display traffic information to users.
Key Functionalities: User interface design, real-time notifications, selection of alternative routes.

Requirements Analysis:

Requirement: The module must provide mobile applications for Android and iOS platforms that allow drivers to access real-time traffic information.
Description: Native mobile applications will be developed for Android and iOS using platform-specific languages and frameworks.

Requirement: It must display the current traffic status, including congestion and road conditions, clearly and legibly.
Description: An intuitive user interface will be designed to present real-time traffic information through interactive map applications and visual markers.

Requirement: It must provide real-time push notifications to drivers about congestion and available alternative routes.
Description: A push notification system will be implemented to alert drivers about relevant traffic events, such as congestion or accidents.

Requirement: Drivers must be able to select routes suggested by the system and receive step-by-step directions.
Description: Navigation functionality will be integrated to offer alternative routes and turn-by-turn directions using map and navigation services.

Administration Module:

Description: This module allows administrators to configure traffic management parameters and monitor the system.

Key Functionalities: Parameter configuration, administrator access, report generation.

Requirements Analysis:

Requirement: The module must allow administrators to configure traffic management parameters, such as signal cycle times and congestion thresholds.
Description: A secure administration interface will be developed to enable administrators to access and configure key system parameters.

Requirement: It must generate reports on system performance and collected traffic data.
Description: A report generation system will be implemented to collect relevant data and create periodic reports.

External Systems Integration Module:

Description: This module facilitates integration with external navigation systems and map applications.
Key Functionalities: Integration APIs, industry-standard compatibility.

Requirements Analysis:

Requirement: The module must offer integration APIs for external systems, such as navigation applications.
Description: Secure RESTful APIs will be developed to allow external systems to access processed traffic data and send control commands.

Requirement: It must efficiently provide processed traffic data to external systems.
Description: API performance will be optimized to ensure fast and efficient delivery of data to external systems.

Security and Privacy Module:

Description: This module ensures the security of traffic data and user privacy.
Key Functionalities: Data encryption, identity management, compliance with regulations.

Requirements Analysis:

Requirement: The module must encrypt traffic data and user data.
Description: End-to-end encryption will be implemented for both traffic and user data using secure algorithms and security protocols.

Requirement: It must manage user identity and ensure secure access to the system.
Description: A robust authentication system will be established, including measures like two-factor authentication (2FA) to ensure secure access.

Requirement: It must comply with road safety and data protection regulations, including LFPDPPP and local standards.
Description: Policies and procedures will be established to comply with local data protection and road safety regulations, and regular audits will be conducted to verify compliance.

Having each of these modules developed and tested independently facilitates project management and scalability. Furthermore, this modular structure allows you to assign specific tasks to teams or individual developers, which can expedite the development process.

Glossary:

Intelligent Traffic Management System (ITMS): The central project aiming to optimize traffic flow, reduce congestion, and enhance urban mobility through real-time data collection and analysis.

Module: A functional and cohesive unit within the overall system, focused on specific tasks such as data acquisition, information processing, or traffic pattern prediction.

Functional Requirements: Detailed specifications of the capabilities and functions that the system must fulfill, such as real-time data collection or traffic light coordination.

Non-Functional Requirements: Specifications that define constraints and characteristics of the system, such as information update latency or compatibility with specific operating systems.

Baseline: A set of functional and non-functional requirements that establish the scope and expectations of the project.

User Interface: The part of the system that interacts with end-users, such as mobile applications displaying real-time traffic information.

Traffic Pattern Prediction: The system's ability to forecast future traffic conditions based on historical data and recurring events.

Traffic Light Coordination: The functionality that allows adjusting traffic lights at intersections to improve real-time traffic flow.

Integration with External Systems: The capability to connect and collaborate with other systems, such as navigation apps or external maps.

Security and Privacy: Protection of traffic data and user information, including encryption, authentication, and regulatory compliance.

Traffic Management: Configuration and monitoring of the system by administrators to optimize traffic flow.

API (Application Programming Interface): A set of rules and protocols that enable different components of the system to communicate with each other.

LFPDPPP (Federal Law for the Protection of Personal Data Held by Private Parties): The Mexican regulation for the protection of personal data.

Bibliography:

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