UNIVERSIDAD DE GUADALAJARA

Centro Universitario de los Valles

Master of Software Engineering

Intelligent Traffic Management System

Baseline 1.1

Presents: Ing. Tomás Alejandro Lugo Limón

Assesor: Omar Ali Zatarain Durán

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Baseline

This is the final version with implemented changes. [1] contains the initial values; this document evolved to become [2]. We will be able to see the presentation of the project we worked on, its definitions, architecture and design of the project, modules, resources, risk management and schedule.

Presentation

Abstract

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.

Objective

The Intelligent Traffic Management System project aims to revolutionize traffic efficiency and safety in urban environments through the implementation of advanced technological solutions. This system aims to optimize traffic flow, improve road safety, and reduce travel times by integrating innovative technologies.

Project Scope

The Intelligent Traffic Management System will encompass a wide range of interconnected modules covering traffic monitoring, signal management, incident detection, and route optimization. This project will be divided into modular segments to facilitate development, implementation, and maintenance.

Key Technologies

The system will employ technologies such as IoT sensors, real-time data analytics, machine learning algorithms, and mobile applications to create an intelligent and adaptable ecosystem capable of dynamically responding to traffic conditions and user needs.

Expected Benefits

The successful implementation of the Intelligent Traffic Management System promises significant benefits, including congestion reduction, decreased accidents, improved public transportation efficiency, and optimized user experience.

Summary

The Intelligent Traffic Management System is an ambitious initiative designed to transform the way traffic is managed in urban environments. By incorporating advanced technologies, this project aims to address current challenges in urban traffic, enhancing road safety, optimizing mobility, and reducing travel times.

The modular approach of the project will enable the implementation of specific solutions in areas such as signal control, incident management, and route optimization. The use of IoT sensors, real-time data analytics, and machine learning algorithms will ensure the adaptability and effectiveness of the system, resulting in smoother, safer, and more efficient traffic flow.

The successful implementation of this project will bring about a significant change in urban traffic management, benefiting both individual drivers and overall road infrastructure.

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.

Architecture and Design of the Project

The Intelligent Traffic Management System will consist of several interconnected modules to perform specific functions. The architecture will be divided into the following components.

Traffic Monitoring
Traffic sensors at key points in the city.
Interface for data collection and processing.

Data Analysis and Management
Data warehouse to store collected information.
Analysis and visualization tools to interpret traffic data.

User Information
Mobile application and web platform to provide real-time traffic information.
Notification systems and route recommendations based on real-time data.

Traffic Lights and Signals Control

Adaptive traffic light control based on traffic flow.
Variable signaling systems based on traffic events.

Modules

These modules changed after the acceptance of two change requests. If you wish to review the initial modules, please refer to [1].
To display the description changes in a more intuitive manner, they were enclosed in [brackets].
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.
[Record user experience on the phone before uploading it to the database.]
[Capture and store additional information about user system usage.]
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.
[Process user experience data after it has been uploaded to the database.]
[Process and analyze user usage data for report generation.]
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.
[Allow the recording of user experience before uploading it.]
[Allow users to view their own usage reports and may need new functionality to display this data.]
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. [include functionalities for the generation and distribution of monthly reports.]
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.
[Involves user experience data.]
[Involves user usage data.]
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.

Risk Management

Technical Risks
Failures in integrating system modules.
Interoperability issues between different technologies used.
Performance and scalability problems of the system.

Time Risks
Delays in developing critical system modules.
Frequent changes in client requirements or specifications.
Unforeseen issues during testing consuming more time than planned.

Resource Risks
Shortage of qualified personnel in certain technical areas.
Budget limitations that might impact the acquisition of necessary equipment or tools.
Problems with external vendors affecting the delivery or quality of key components.

Security and Privacy Risks
Security breaches in collecting or storing sensitive data.
Non-compliance with privacy regulations resulting in legal penalties.

Environmental Risks
Extreme weather conditions affecting detection devices or system operation.
Power outages disrupting the system's function in specific areas.

To manage these risks, it's essential to:

Identify and assess their likelihood of occurrence and potential impact.

Develop mitigation strategies and contingency plans for the most critical risks.
Continuously monitor risks throughout the project and adjust strategies as needed.

The risk management plan should be a dynamic document, subject to regular updates as new risks are discovered or project circumstances change.

Schedule

Phase of Planning (August 30 - September 15)

Definition of project objectives and scope.
Analysis of requirements and specifications.
Creation of project structure and team designation.

Development Phase (September 16 - April 30 of the following year)

Development of system modules: traffic light control, traffic monitoring, etc.
Implementation of detection technologies and data collection.
System integration and user interface development.

Testing Phase (May 1 - June 15)

Functionality and system performance testing.
Identification and resolution of issues.
Optimization and final adjustments.

Implementation Phase (June 16 - July 15)

System implementation in pilot areas.
Staff and user training.
Initial monitoring of system effectiveness.

Evaluation and Adjustment Phase (July 16 - July 30)

Data collection on system performance in pilot areas.
Evaluation of results and necessary adjustments.

Full Deployment Phase (August 1 - August 15)

Complete deployment of the system in all planned areas.
Final evaluation and approval for general use.