

**School Of Computer Science and Engineering**

**VIT-AP UNIVERSITY, AMARAVATI**

Capstone Project

Improving Vehicular and Pedestrian Traffic Management using Cloud & Edge Computing and High-Performance Computing

Mentor

Prof. Hemant Kumar Reddy

Author

Tathagata Guha Ray

Software Requirements Specification

for Capstone Project

1. **Introduction:**

**1.1 Purpose:**

The purpose of this document is to outline the requirements for a vehicular and pedestrian traffic management system leveraging Cloud and Edge Computing. This project aims to optimize traffic flow, enhance safety, and reduce congestion by analysing real-time data from edge devices deployed across an urban setting.

it.

* 1. **Intended Audience:**

This document is intended for:

* **Project Team Members** responsible for design, development, and deployment.
* **Stakeholders** including city planners, traffic management authorities, and municipal agencies.
* **System Administrators** for deployment, maintenance, and support.
* **Developers and Integrators** handling interface integrations, data analysis, and future upgrades.

**1.3 Intended Use:**

This document will guide the project’s development lifecycle by providing a clear outline of system requirements. It serves as a reference for developers, testers, and project managers to ensure all project objectives align with user needs and system functionality.

**1.4 Scope:**

This project will develop a scalable system to detect, track, and count vehicles and pedestrians in real time using edge devices. The system will integrate with existing traffic and Vehicle-to-Everything (V2X) infrastructures and perform cloud-based data analysis to optimize traffic flow and resource allocation.

**1.5 Definitions & Acronyms:**

* **YOLOv8:** You Only Look Once, a real-time object detection model.
* **V2X:** Vehicle-to-Everything communication for inter-device data exchange.
* **HPC:** High-Performance Computing.
* **CloudSim:** Simulation tool for modelling cloud infrastructure and services.
* **Edge Computing:** Processing data near its source (edge devices) to reduce latency.

**2. Overall Description:**

**2.1 Product Perspective:**

The system is designed as an advanced, multi-tier solution integrating Cloud and Edge Computing for urban traffic management. Edge devices deployed at intersections will process real-time video feeds to detect and track vehicles and pedestrians, while cloud servers will aggregate this data for citywide analysis.

**2.2 Product Functions:**

Key functions include:

* **Object Detection and Tracking**: YOLOv8 and ByteTrack algorithms for identifying and tracking objects in video feeds.
* **Counting and Analysis**: Counting vehicles and pedestrians and analysing traffic patterns.
* **Integration with Traffic and V2X Infrastructure**: Adjusting traffic lights based on data and facilitating inter-vehicle communication.
* **Cloud Aggregation and Analysis**: Centralized data aggregation and analysis to detect traffic patterns.
* **Performance Reporting**: Generating traffic performance and optimization reports.

**2.3 User Needs:**

Users require a responsive, reliable system for:

* Real-time monitoring of traffic data.
* Accurate reporting on vehicle/pedestrian counts.
* Data-driven decision-making for traffic flow adjustments.
* Integration with existing city infrastructure.

**2.4 Principal Actors:**

* **Traffic Authorities**: Monitor real-time traffic, manage signals, and optimize flow.
* **City Planners**: Analyse traffic patterns for urban development.
* **System Administrators**: Deploy, maintain, and monitor system performance.
* **General Public**: Benefits from reduced traffic congestion and improved safety.

**2.5 General Constraints:**

* **Regulatory Compliance**: Adherence to data protection laws (e.g., GDPR).
* **Network Bandwidth**: Sufficient bandwidth must be available for real-time video data transmission.
* **Processing Requirements**: Edge devices should meet performance standards for real-time detection.

**3. System Features and Requirements:**

**3.1 Functional Requirements:**

**Vehicle and Pedestrian Detection**

* The system shall detect vehicles and pedestrians with a confidence threshold of 95%.

**Tracking and Counting**

* The system shall track and count each detected object with unique IDs per object to prevent ID-switching.

**Traffic Flow Optimization**

* Based on detected traffic density, the system shall adjust traffic signals for smoother flow.

**Data Aggregation and Analysis**

* Edge devices shall send aggregated data to the cloud at configurable intervals for citywide analysis.

**Performance Reporting**

* The system shall generate daily, weekly, and monthly reports summarizing traffic density and peak hours.

**3.2 Non-Functional Requirements:**

**Reliability**

* System uptime of 99.9% required for real-time applications.

**Scalability**

* The system should support up to 5,000 edge devices and process data for over 200,000 vehicles daily.

**Security**

* All transmitted data must be encrypted, and access control mechanisms must be in place for all system components.

**Maintainability**

* The system should allow seamless updates and modular expansion of components.

**Usability**

* The system should provide an intuitive user interface with real-time data visualization.

**3.3 Performance Requirements:**

**Detection and Tracking Latency**

* Edge devices should process frames at a rate of 30 frames per second with a maximum latency of 200 milliseconds.

**Data Throughput**

* Each edge device should handle 5 Mbps data throughput for video streaming.

**Accuracy**

* Object detection and classification should achieve an accuracy level of 95%.

**System Response Time**

* The user interface should respond to user actions within one second, and updates on traffic data should refresh in near real-time.