UNIVERSITY OF PLYMOUTH

PUSL3190 Computing Individual Project

Project Proposal

<Real-Time Traffic Data Collection and Prediction System >

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Acknowledgment

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Chapter 01

1.1. Problem statement

Fast urban growth, more people, and more vehicles on the streets have caused big traffic jams in Colombo, the business center of Sri Lanka. The large amount of vehicles is hard for the city's roads to manage, especially at business and school times. Delays in travel, increased fuel use, more pollution, and lower work efficiency are some negative impacts this traffic has on the economy and environment. Colombo's traffic management systems struggle to provide accurate traffic predictions and travelers to make informed decisions.

It is challenging for traffic authorities to efficiently monitor road conditions and react quickly to events when there is a lack of integrated technology. Furthermore, commuters frequently do not have access to trustworthy information that would empower them to make well-informed travel choices. Because of this, traffic management initiatives are more reactive than proactive, which makes the congestion issue worse.

Following some current issues in this traffic field.

Traffic James in Peak Hours: Traffic is slow, and there are many jams at key intersections, which makes roads in Colombo quite crowded during the morning and evening. This affects everyday commuters and causes delays in logistics.

Lack of Real-Time Data: The existing systems for monitoring traffic do not provide detailed, real-time information on road conditions across the city. They use human reports, fixed cameras, and separate data sources.

Lack of Expected Capabilities: Colombo's traffic systems mainly observe the facts and do not offer forecasted insights. To assist commuters in planning and steering clear of traffic, there is a need for predictive models that can anticipate traffic trends.

Poor Traffic Management: Data from different sources, such as GPS units and Internet of Things sensors not combined well. This prevents using the best traffic control methods and leads to a disjoined view of the traffic overall.

Need for a solution: A cutting-edge traffic data collection system powered by GPS, IoT sensors, and weather data, would be necessary in Colombo city, enabling the real-time management of traffic issues through the use of AI-based machine learning models to predict the major causes and directions of traffic to commuters.

Chapter 02

2.1. Project description

This work is focused on constructing a Unified System for the collection and prediction of Real-Time Traffic Data for Colombo, Sri Lanka. (Hasan1, Wanigasekara2 and Hasan, 2024)
This defines a set of objectives related to a specific system, geared towards predicting the traffic conditions of certain roads that users intend to use during their travels or journeys. The schema is also beneficial to the ambulances whose traffic activities are on public roads on a scheduled basis. They will be able to have unrestricted access to the precise state of the roads. This application with other analysis parts will make sure that users are able to use their time wisely and avoid being late by going to the site sometime in advance owing to being able to know about the traffic condition much before time.
The main component of the system is a smartphone application that gives users (Sathyanjalee, no date) The app's real-time data analysis helps users avoid crowded places, make smart travel decisions, and get alerts on safety advisories and road conditions. A complex prediction model that can predict traffic trends based on patterns and environmental factors is powered by data gathered from multiple sources, including partnerships with the University of Moratuwa and the Colombo Traffic Police.
Because of its scalable nature, the predictive model can accommodate more users and adjust to changes in the traffic patterns of the city. The project supports Colombo's smart city objectives by emphasizing performance, scalability, and user ease, opening the door to a more effective, secure, and sustainable urban transportation system.

2.1.1. Project Objectives and Explanations

1. To study the current processes, there is a deep study on background research on various traffic jams in Sri Lanka. And also collect some relevant datasets from relevant authorities to develop the system environment.

Explanation: An extensive background study phase is necessary to properly create a Real-Time Traffic Data Collection and Prediction System for Colombo, with an emphasis on comprehending the city's distinct traffic patterns and congestion causes. This includes examining commuter behavior, infrastructure constraints, peak travel periods, and environmental factors that affect traffic flow. The Colombo Traffic Police and the Department of Transport Management at the University of Moratuwa are two important data sources that

offer crucial statistics on traffic patterns, vehicle density, and traffic incidents. These datasets allow the system to make precise forecasts. With the use of this data, the predictive models of the system can be improved to offer insights in real-time, assisting in the reduction of traffic and enhancement of urban mobility. Ongoing system enhancements will be supported by constant cooperation with these authorities, resulting in more efficient and data-driven traffic management in Colombo.

2. To interact with the users, develop a mobile application to forecast the traffic predictions and traffic patterns related to each user.

Explanation: To give users individualized traffic pattern insights and real-time traffic forecasts based on their usual routes and commuting habits, a mobile application will be created. In order to assist users in making well-informed travel decisions, this app will make use of data from the real-time traffic prediction system to provide precise, location-based updates on congestion, incidents, and the best routes. The software may personalize its forecasts by incorporating user-specific information and preferences, giving users personalized alerts, projected trip times, and recommending other routes. Commuters will be able to handle Colombo's traffic more effectively because of an interactive, user-friendly interface, which will improve user happiness and overall urban mobility.

3. Users can get traffic alerts and notifications on road safety and current road status through this system.

Explanation: Through this system, users will receive timely alerts and notifications about traffic conditions, road safety, and current road statuses directly on their mobile devices. Leveraging real-time data collection and analysis, the system can instantly detect congestion, accidents, and other disruptions, notifying users of potential delays and offering alternative routes to avoid high-traffic areas. Safety alerts, such as accident-prone zones or adverse weather conditions affecting road visibility, will enhance user awareness, helping them travel more safely and efficiently. This proactive approach empowers users to make well-informed travel decisions, ultimately reducing congestion and improving overall road safety in Colombo.

2.1.2. Project keywords

1. Traffic Flow Optimization
2. Predictive Traffic Analytics
3. IoT for Traffic Monitoring
4. Machine Learning in Traffic Management
5. Traffic Pattern Recognition
6. Traffic Forecasting Models
7. Cloud-Based Traffic Data Storage
8. Crowd-sourced Traffic Data
9. Traffic Density Algorithms
10. Traffic Sensor Calibration

Chapter 03

3.1. Research Gap

The lack of necessary research can however be observed even with the increasing availability of traffic data and machine learning models for traffic management, which ultimately limits the full deployment of an effective traffic management system in Colombo. This challenge exists for both localized and global solutions but is still insufficient in solving the concrete challenges posed by the unique traffic patterns, urban environment, and socio-economic conditions of Colombo.

1. Poor contextualization for the local traffic situation in Colombo:

Most of the existing traffic management and prognosis systems were either developed for the needs of developed countries or large metropolises that include advanced road infrastructures, traffic regulations, and services. (Bellavista *et al.,* 2018) It is clear that there are no systems specifically designed for these contexts in Sri Lanka, where the concentration of tuk-tuks and pedestrian traffic, along with poorly timed traffic light systems, adds levels of complexity that are beyond what the universal technologies for traffic management offer.

Gap: No mechanisms exist for collecting and predicting localized traffic features that would take into account the specific characteristics of Colombo's Road system and traffic trends.

2. Insufficient Merging of Various Data Sources:

There are no effective systems for integrating multiple, various types of data sources in real-time, despite the fact that most of today's traffic systems are based either on (Hasan1, Wanigasekara2, and Hasan, no date). At the moment, there is no research devoted to the problem of real-time incorporation of such diverse data sources into the traffic management system of Colombo.

Gap: Lack of appropriate systems by which many traffic-related data including telemetry from GPS and its dependencies such, as IoT sensors, weather data, and public transport schedules are integrated, analyzed in real-time, and displayed within a single traffic management system.

3. Absence of Predictive Analytics and Machine Learning Models for Sri Lankan Traffic:

Much of the global effort on the development of machine learning predictive models for traffic has been focused on; however, relatively little focus has been made on algorithm development which can effectively cope with the Sri Lankan traffic conditions. (Sathyanjalee, no date) Models meant for such structured and controlled environments are also likely to fail in these environments.

Gap: Erratic driving patterns of local commuters and pedestrians, disregard for existing traffic regulations, and other factors that complicate and characterize the traffic in Colombo, are yet to be integrated into the predictive models and machine learning techniques.

4. Laggard focuses on user feedback loops in real-time:

This section examines the tools and capabilities built into the system for achieving this aim. (Nallaperuma *et al.,* 2019) Some apps even provide users a predictive insight only on certain factors like travel time which certain routes or roads will take in comparison during peak hours, which currently none of the local applications. Predicting the traffic patterns also allows one to offer commute prediction systems a user's getting commute prediction systems learning based on a user's commute habits.

Gap: The third gap concerns the lack of real-time user feedback loop technologies that suit the commuters' habits while providing pertinent information relevant to the traffic situation in the city of Colombo.

Chapter 04

4.1. Requirements Analysis

1. Functional Requirements

The system persistently gathers vehicle traffic data such as GPS from automobiles, which in turn instantiates IoT-based traffic sensors. Such sensors include bumper counting for the number and categories of passing vehicles. Technologies such as RFID, infrared sensors, and magnetic sensors can be used.

The system looks for historical trends and builds enhancement models not only for long-range forecasts but also for real-time predictions. This is important for understanding traffic in Colombo, as anticipations can be improved by using more recurrent patterns and trends for a certain period.

The system shall use those techniques in order to forecast real-time traffic conditions and for a series of upcoming hours. Over time prediction accuracy should be improved focusing on the use of historical data especially for weekends and peak hours.

Developed under this project traffic prediction and updates should be availed for the users to access through the mobile application. Based upon user preferences the system should offer different routes to be taken. The system must offer notifications in real-time.

2. Non-functional requirements

The performance and scalability of the system in a busy city such as Colombo must be well-designed from the start for long-term sustainability. The system has to provide high reliability, especially during the peak busy times in the morning and evening, with an uptime of 99.9 percent.

For scheduled service options, downtimes have to be avoided through the implementation of backup servers and failover procedures. The model needs to triangulate around 85-90% of traffic predictions on a traffic system for app users, and this will improve with the model as it learns through data. Measures should be followed to encrypt and authenticate in order to protect user information of location as well as trip history in the system.

Users of the system should be able to operate the user interface of the system with ease without too many frustrations. Comply with all applicable local data protection laws and Colombo's data privacy policies, including Sri Lanka's Right to Information Act.

Establish and put into effect a data retention policy that outlines the amount of time that certain kinds of data will be kept on file before being archived or deleted. Arrange yearly security and compliance audits to confirm compliance with legal requirements and pinpoint areas in need of enhancement.

Reduce inaccurate or corrupt data by implementing validation tests at the data entry points to guarantee data accuracy and consistency. To confirm and cross-reference the accuracy of data, set up redundancy in key data collection points. To ensure accuracy in traffic measures, schedule routine calibrations for IoT sensors and other data-gathering devices.

3. Stakeholder specific requirements

Traffic and Route Management: Drivers and Commuters: Users need to have immediate access to real-time traffic information, such as accident notifications, anticipated travel times, and congestion levels. They anticipate that this data will be up-to-date and accurate. Commuters require alerts that are specific to their typical travels, including recommendations for alternate routes in the event of crises, heavy traffic, or road construction. To accommodate daily travel needs, users need an intuitive mobile application interface with dynamic maps, easily accessible notifications, and clear route recommendations. Users expect a high level of privacy and data security, with guarantees that their travel and location information will be safely stored and not disclosed without permission.

Colombo Traffic Police: Incident Reporting and Monitoring: In order to effectively respond to accidents or road interruptions, the Traffic Police need systems for tracking current traffic conditions and incident notifications. Having access to daily and weekly traffic statistics enables authorities to spot high-risk regions, comprehend trends, and deploy resources for safer and more efficient traffic flow. In order to plan and carry out proactive traffic control measures, authorities must forecast data for traffic shifts during holidays, events, and peak hours.

Chapter 05

5.1. Finance

The focus of the financial need presented for the project Real-Time Traffic Data Collection and Prediction System is only on the acquisition of hardware components. This includes connectivity modules, Internet of Things sensors, and any other necessary hardware components.

The following table shows the estimated budget plan for this project.

Hardware component	Unit cost	Quantity	Estimated cost
Ultrasonic Sensor	240.00-250.00	6	1500.00
Node MCU	1250.00-1300.00	1	1300.00
Jumper wires	160.00-200.00	50	1000.00
Arduino Uno board	1400.00-2850.00	1	2850.00
Estimated Total			**6650.00**

Let me clarify that payments for the usage of software tools within the framework of the Real-Time Traffic Data Collection and Prediction System project are not necessary. This is also consistent with the cost constraints of the project as open-source software, free development tools, and cloud-based services under freemium models were utilized.

Chapter 06

6.1. External organizations

1. Colombo City Traffic Police

Role: The Traffic Police are in charge of overseeing traffic flow, monitoring road conditions, and responding to events as the main traffic law enforcement agency in Colombo.

Interest: In order to properly deploy resources, react to collisions promptly, and control traffic, the Traffic Police need access to real-time traffic data. They can take proactive steps to increase road safety and get ready for periods of high traffic with the use of predictive analytics.

Contribution: They may help set up traffic sensors, give access to on-ground traffic data, and aid in creating protocols for utilizing the system in daily operations.

2. Department of Transport Management and Logistics Engineering, University of Moratuwa

Role: This department can provide technical advice, research, and insights into the project's data modeling and prediction algorithms because it is an academic institution with experience in transport engineering.

Interest: Working together on creative traffic management solutions is probably something the department is interested in, offering a great chance for case studies, testing, and research. Their contribution to community-centered technical achievements may be strengthened by this collaboration.

Contribution: By working together on data analytics, machine learning models, and performance assessments, faculty and students could offer research insights and technical assistance for the system's advancement.

3. Colombo Municipal Council (CMC)

Role: CMC is in charge of Colombo's infrastructure development, urban policy execution, and city planning.

Interest: To aid with Colombo's development, CMC is investing in enhancing urban mobility and city infrastructure. Data insights would help them manage their infrastructure more effectively, ease traffic, and lessen their negative effects on the environment.

Contribution: CMC might help with the coordination required for system implementation across several city zones, provide finance or logistical support, and make it easier to integrate IoT sensors into city infrastructure.

4. Sri Lanka Road Development Authority (RDA)

Function: RDA is in charge of preserving and growing Sri Lanka's road system, which includes the city roads of Colombo.

Interest: RDA is eager to address issues of traffic congestion and enhance the effectiveness of the road infrastructure. Making better decisions about upcoming infrastructure expenditures can be facilitated by having access to real-time traffic and congestion data.

Contribution: RDA could help with sensor placement and system implementation, as well as supply information on road usage, construction dates, and other infrastructure elements necessary for predictive modeling.

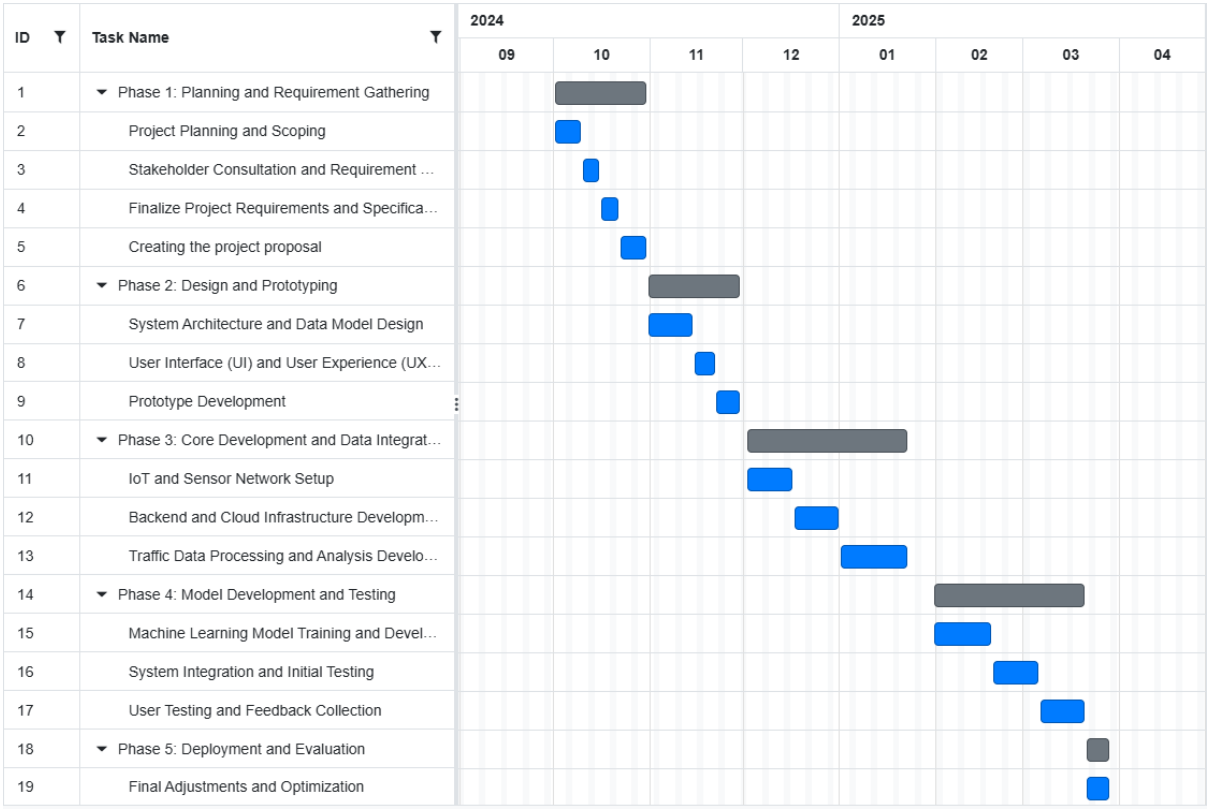
5. Colombo Commuters and Road Users

Role: People who are immediately impacted by Colombo's traffic conditions include everyday commuters, private automobile owners, and public transportation users.

Interest: Reliable information on alternate routes, prompt incident alerts, and shorter travel times are what commuters are looking for. Predictive traffic data might help them better organize their daily travel.

Contribution: The comments and usage habits of commuters would be very helpful in enhancing the accuracy, usability, and interface of the system. System features would be improved and user demands would be met with the support of the general public and regular feedback.

.6.2. Time Frame / Timeline



Phase 1: Planning and Requirement Gathering: 2024/10/01-2024/10/30

Project Planning and Scoping: 2024/10/01-2024/10/09

Stakeholder Consultation and Requirement Gathering: 2024/10/10 -2024/10/15

Finalize Project Requirements and Specifications: 2024/10/16-2024/10/21

Creating the project proposal: 2024/10/22-2024/10/30

Phase 2: Design and Prototyping: 2024/10/31-2024/11/29

System Architecture and Data Model Design: 2024/10/31-2024/11/14

User Interface (UI) and User Experience (UX) Design: 2024/11/15-2024/11/21

Prototype Development: 2024/11/22-2024/11/29

Phase 3: Core Development and Data Integration: 2024/12/02-2025/01/22

IoT and Sensor Network Setup: 2024/12/02-2024/12/16

Backend and Cloud Infrastructure Development: 2024/12/17-2024/12/31

Traffic Data Processing and Analysis Development: 2025/01/01-2025/01/22

Phase 4: Model Development and Testing: 2025/01/31-2025/03/20

Machine Learning Model Training and Development: 2025/01/31-2025/02/18

System Integration and Initial Testing: 2025/02/19-2025/03/05

User Testing and Feedback Collection: 2025/03/06-2025/03/20

Phase 5: Deployment and Evaluation: 2025/03/21-2025/03/25

Final Adjustments and Optimization: 2025/03/21-2025/03/25

As a summary,

October 2024 – November 2024: Gather requirements, finish background research, and form alliances with the University of Moratuwa and the Colombo Traffic Police to gain access to data. Start gathering data and doing preliminary analysis.

December 2024 – January 2025: Create the backend infrastructure, install IoT sensors, and develop the system architecture. Prepare datasets for predictive model training and begin incorporating real-time data sources.

February 2025 – March 2025: For precise traffic forecasts, concentrate on developing and testing the models and optimizing the predictive algorithms. Create the user interface for the mobile application at the same time to enable personalized notifications and user interaction.

Conclusion

In conclusion, the Real Time Traffic Data Collection and Prediction System for Colombo City employs cloud computing, machine intelligence, and IoT technology to provide substantial improvement in urban transport. In order to assist commuters, businesses, and city planners in decreasing travel times, maltreating road hazards, and fully utilizing local structure, this project set out to provide immediate and actionable insights based on the data collected.

Enhanced planning and decision-making processes will be possible due to the fusion of proprietary and indicator data from their IoT sensors, GPS devices, and even meteorological and mass transport inputs so as to provide more accurate traffic reports. Besides solving existing challenges of traffic congestion, this approach provides a robust foundation for future intelligent urban solutions. This project seeks to provide a cutting-edge, customer-centric solution to the growing urban transportation needs of the city of Colombo. It will do this through a stepwise approach to design, development, and deployment in addition to a mechanism to support operational and infrastructure costs.

Moreover, the modular design of the project provides the necessary conditions for future enhancement, such as the addition of advanced elements to meet the changing needs of the city. In the phased development approach, stakeholder feedback and usability testing are the key features that make it possible to develop the system in a user-centered and adaptable manner.

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