King Fahd University of Petroleum and Minerals

College of Computer Sciences and Engineering (CCSE)
COE 485
Senior Design Project

Intelligent Transportation System

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Abstract

This is the midterm report for the Intelligent Transportation System project. It first introduces the problem, the selected approach, and the potential impacts. After that it lists the project's requirements, specifications, and constraints. Then discusses the tasks as a work plan. After that it describes the system design by showing the Use-Cases, Activity diagrams, listing the system's specification, standards and describing the system's architecture. Finally, it concludes the team's future vision.

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1 Introduction

This section discuss the problem of traffic congestion and mention one of the current solution for the problem and why we selected another approach. Then it discusses our project approach in details. Finally, it mentions some of the potential impacts in general, whether it is a positive or negative impact.

1.1 Traffic Congestion

Intelligent Transportation System (ITS) is an application of data collection and manipulation that is used to improve and advance the traffic network. It is a very wide topic and has many derivations, and one of them is smart traffic lights system. The problem is that every traffic light in the network is independent of each other, and there is no communication between any of them resulting in a huge increase in the average trip time. As an example, in Riyadh 2019, extra 11 minutes were wasted for every 30 minutes trip during morning rush hours, and extra 13 minutes during evening rush hours [1]. The average time lost in traffic in the year of 2019 is 94 hours, that is over 3 days wasted in just the traffic [1]. With this huge time lost in traffic; it is difficult for emergency vehicles to get to their destination as fast as possible. Another problem is the impact over the economy as people who get stuck in the traffic congestion would rather use their time in traffic could be benefited and use this time in other areas. Our goal for this project is to help emergency vehicles while also minimizing the average trip time for users.

1.2 Selected Approach

The current smart traffic solution is added sensors to the traffic light, once a side of the intersection is empty it automatically skips this side and doesn't change the light to green. While this approach solves a part of the problem, it shortens the trip time but does not have any priority to sides that are more congested and has no priority to emergency vehicle. Our approach is a traffic light network system that will use cameras distributed among the sides of each intersection, and it would detect the type and congestion of cars to calculate the priority of each side. The priority will decide the time and traffic light sequence. Another added feature is when an emergency vehicle is detected, it will give the highest priority to the emergency vehicle side, then notify other traffic lights within the emergency vehicle path to reduce the trip time of the emergency vehicle. Since most traffic lights has built in CCTV cameras, we could add a simple controller that communicates with other traffic lights and an outer cloud to monitor all the controllers within the system. Our system would be cost efficient as the cost a simple controller is $40 and the cameras are already there.

1.3 Potential Impacts

One potential benefit is that emergency vehicles would reach their destination faster since they will be given the highest priority. Another benefit is reduced trip for most cars based on their priority, so they could utilize their time in ways that would benefit the economy. On the other hand, reducing trip time would induce people to drive their cars more often, and they would not hesitate to go out because of the traffic. This leads to more CO_2 emissions and impact the environment. Another downside of the approach is that the system will be under one cloud server, and this server would be a single point of failure.

2 Requirements, Specifications, and Constraints

Before we start any development, we needed a clear idea of the project requirements, specification, and constrains. First, application requirements are as follows:

2.1 Requirements

1. The system shall ensure high availability of five nines (99.999%) which mean high availability of services, when the downtime is less than 5.26 minutes per year
2. The traffic light shall not be green on an empty side while there is a car on one of the other sides within the intersection.
3. The traffic lights controller shall not coast more than 40$(given that the traffic lights already have cameras).
4. The system shall be easy to expand to any traffic light with regular traffic monitoring cameras.
5. The system shall have different types of vehicles with different priorities such as private cars, trucks, police, ambulance etc.
6. The system shall be able to handle 300 traffic lights.
7. The system shall include a website for the admin to control the traffic lights.

2.2 Specifications and Constraints

1. The system shall analyze and recognize cars clearly.
2. The system's parts shall be able to communicate with reliable and acceptable data transfer rate.
3. The communication protocol shall be able to handle more than 300 client at a time.

3 Work Plan

This is the work plan we have been following till now, and we have made a plan that we think is feasible to follow for the rest of the semester. The durations of each task is are not 100% accurate.

Task Details	Working Team Member	Duration	State
Research the literature to choose and evaluate the project's idea	All	1 Week	Done
Research about the any logic possible features and learn how to use it and do some experiments on it and compare it with other simulation tools	All	1 Week	Done
Project Concept, Architecture, and Deployment Diagram	All	1 Week	Done

Design the road and the traffic light. And Integrate the design of the road and traffic infrastructure in the simulation software.	Adnan and Abdullah	2 weeks	Done
Mid-semester Progress report & Presentation &	All	2 weeks	Done
Implement a cloud server and link it with the emulation software	Saleh	1 Week	In Process
Figuring out how to control the traffic light signal. And how to set priority to different types of vehicles.	All	2-4 Days	In Process
Start configuring the traffic light with the integration of the priority system.	All	1 Week	In Process
Design a computer vision system that identifies emergency vehicles and measures the level of congestion in each side in the intersection	All	3 Weeks	In Process
Integrate the computer vision with the simulation tool	All	1 Week	In Process

4 System Design

One of the most important steps in an engineering project design is to have a clear idea of the project, this includes specific use-case diagrams, activity diagrams, detailed system specifications, and a complete system architecture. And as part of the engineering design is to follow standards, we added a detailed subsection to discuss the compliance with standards.

4.1 Use-Cases Diagram

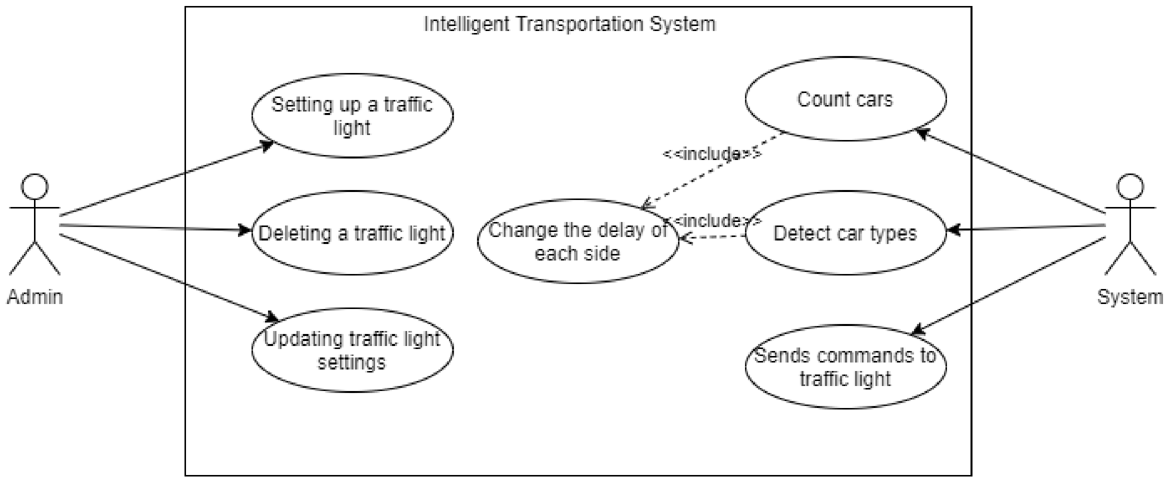

Figure 1: Use-Case Diagram

4.2 Activity Diagrams

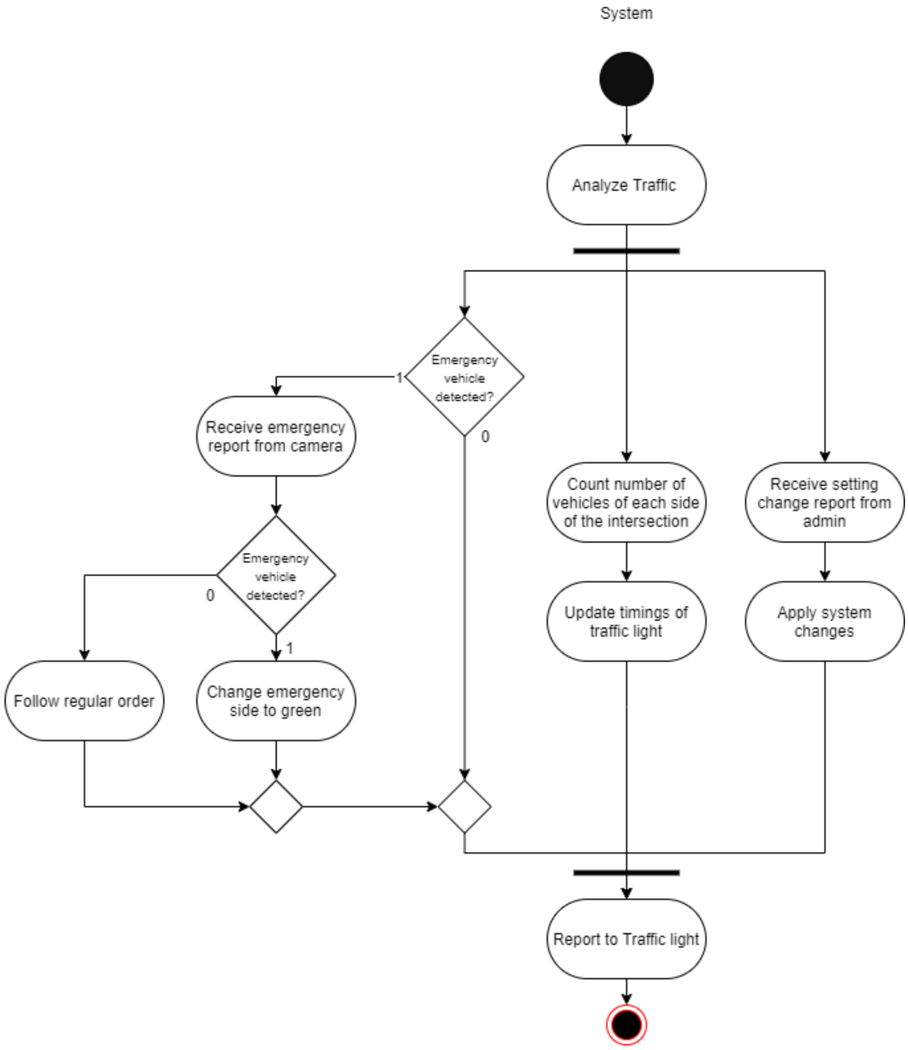

Figure 2: System Activity Diagram

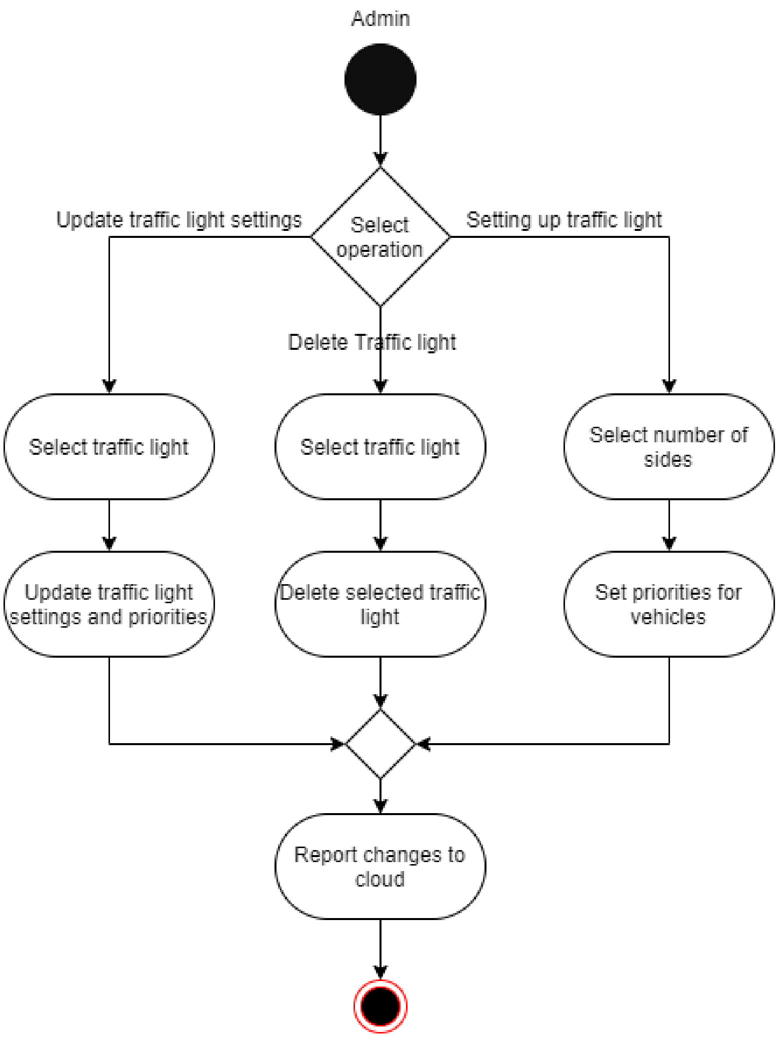

Figure 3: Admin Activity Diagram

4.3 System Specifications

1. The clients shall have at least 50kbps connection.
2. The vehicle recognizing process shall has at most 5% deflection rate.
3. The controllers shall be connected to the traffic lights' power source.
4. The system shall utilize HD cameras used in current traffic lights.
5. The system shall use computer vision to recognize types and number of cars.
6. The cloud shall be able to handle at least 300 clients.

4.4 Compliance with Standards

1. Transmission protocol: One of the major tasks in this project is to communicate between the parts. For example, reporting that an ambulance vehicle is entering the cross-section in order to inform the next traffic light. To send that information the system needs to have a way to communicate between the different parts. However, in order to have a suitable performance the transmission protocol shall meet two requirements. The first requirement is the ability to transmit the message with an error rate less than or equal

to 5%. Another constraint is the ability to serve a lot of clients (traffic light controllers). For example, in Los Angeles there are 4,500 traffic lights.[2] To meet those requirements, the team has chosen to use RabbitMQ since it has less error rate while serving larger number of clients than the REST api. [3]

4.5 System's Architecture

Our architecture consist of four layers, namely, cameras, traffic light controller, a cloud server, and the traffic light. It starts by detecting the number of cars in each side using the camera, then send a the info to the traffic light controller. The traffic light controller then sends the data to the cloud to compute the new timings of the traffic light. Finally, the cloud server sends the feedback to the controller and update the traffic light timings.

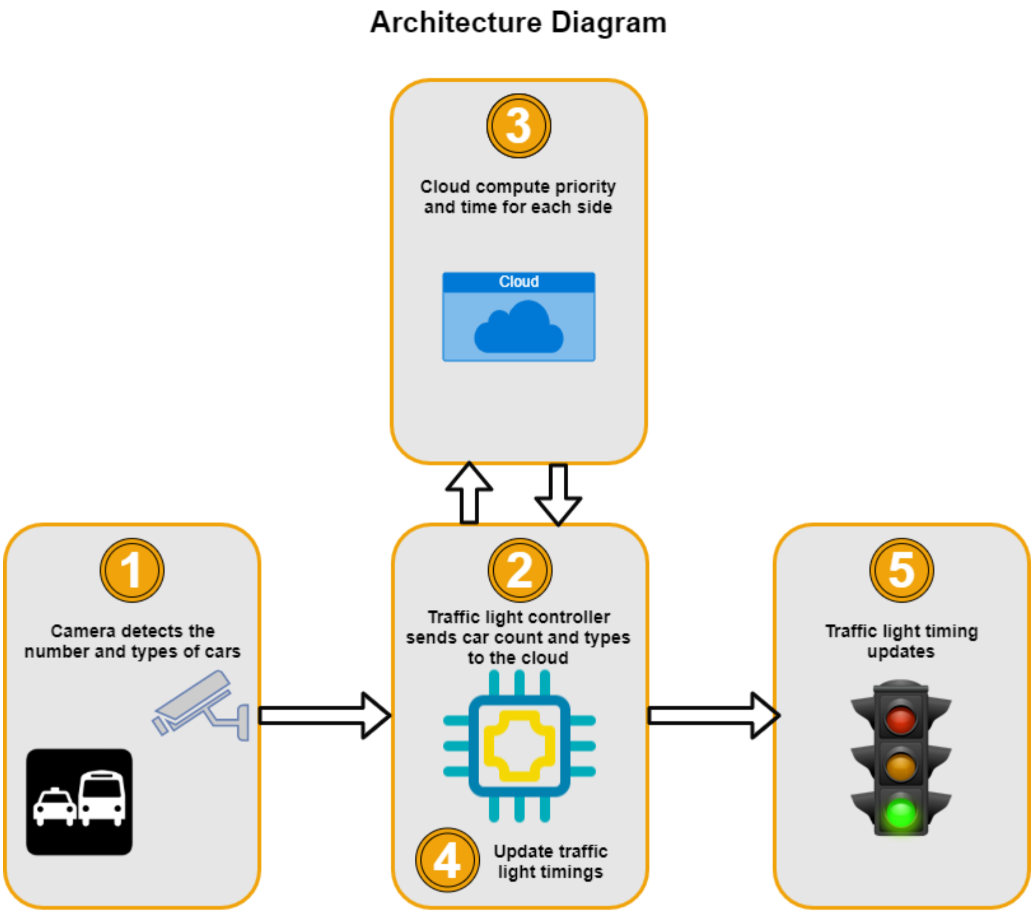

Figure 4: Architecture Diagram

For the deployment diagram (figure 5), we have two main devices, the server and traffic light controller. The server has an interface to allow the admin to control it and it is running a python code to compute all the required data. The traffic light controller is running a client python code that detects the number and type of cars in each side using the camera, and also controls the traffic light. they all communicate using RabbitMQ protocol.

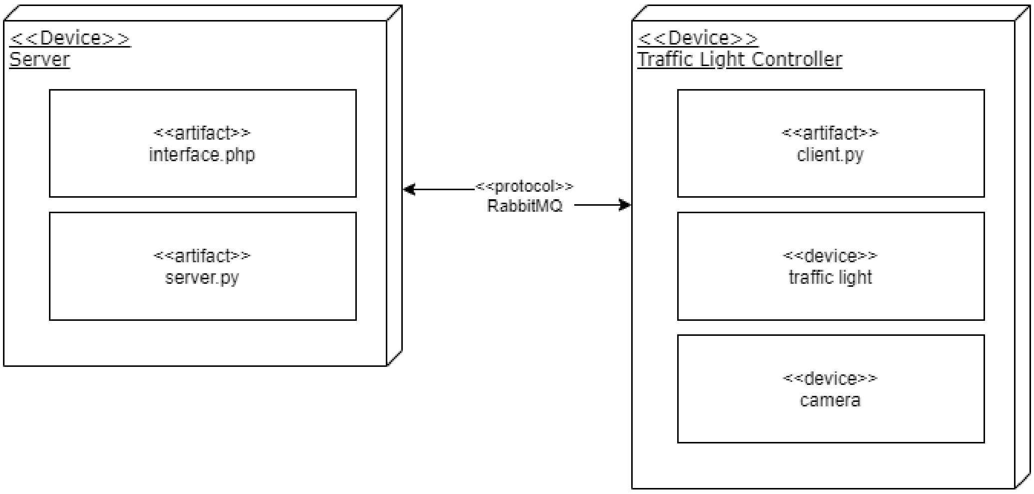

Figure 5: Deployment Diagram

5 Conclusions

We are working in designing an intelligent transportation system that is used to shorten the average trip time for normal drivers and help emergency vehicles get to their destination much faster. The system consist of a traffic lights network connected with a cloud server to control it. We reached a point where we have a clear idea of the system design and designed the system requirements and specifications along with use-case diagram, activity diagrams, and system architecture. We still have much more to do and we have a plan to follow and continue develop the project till the end of this semester.

6 References

References

[1] "Riyadh traffic report: Tomtom traffic index."

[2] I. Lovett, "To fight gridlock, los angeles synchronizes every red light," *The New York Times*, Apr 2013.

[3] X. J. Hong, H. Sik Yang, and Y. H. Kim, "Performance analysis of restful api and rabbitmq for microservice web application," in *2018 International Conference on Information and Communication Technology Convergence (ICTC)*, pp. 257–259, 2018.

7 Appendices

This section contain information about the solution the team has chosen in order test the system.

7.1 Simulation Snapshot

One of the main disadvantages in online teaching is being unable to work on hardware project such as the intelligent transportation project physically. To overcome that issue the team decided to user Anylogic as a simulation tool. The figure 6 shows a simulation done using the program. The simulation simulates a cross-section in the Dammam's corniche. However, currently the simulation has two type of vehicles which are the ambulance vehicle and residents' vehicle. Finally, the current purpose of implementing such simulation is to analyze different type traffic management algorithms to choose best suitable one.

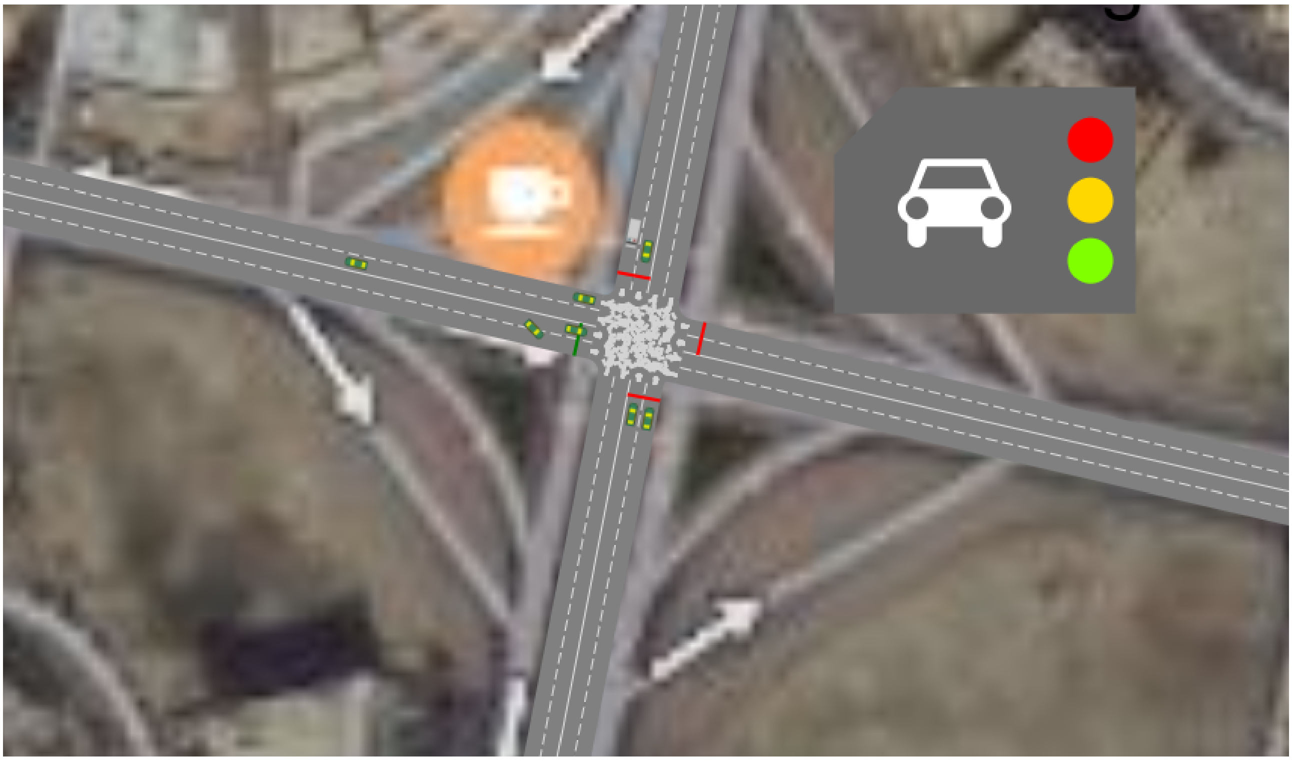

Figure 6: Simulation Snapshot