TRAFFIC SIMULATION ON INTERSECTION

A Thesis Proposal
Presented to the Faculty of the
Information and Communications Technology Program
STI College Ortigas-Cainta

In Partial Fulfilment
of the Requirements for the Degree
Bachelor of Science in Computer Science

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December 9, 2022

ENDORSEMENT FORM FOR PROPOSAL DEFENSE

TITLE OF RESEARCH: **Traffic Simulation on Intersection**

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In Partial Fulfilment of the Requirements
for the degree Bachelor of Science in Computer Science
has been examined and is recommended for Proposal Defense.

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This thesis proposal titled: **Traffic Simulation** prepared and submitted by **Joni Roi Q. Eleda; John Denver F. Patiag; Justin Angelo T. Rebeta**; and **John Adrae C. Sotto**, in partial fulfilment of the requirements for the degree of Bachelor of Science in Computer Science, has been examined and is recommended for acceptance an approval.

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TABLE OF CONTENTS

INTRODUCTION

Transportation has played a big role in humanities' lifestyle and still continues to bring satisfaction until present days. Transportation is the act of moving humans, animals, or goods from one location to another. Brooks et al. (2021) found that good transportation has a significantly positive impact on a community's quality of life. Thus, transportations that operates well without frequently encountering problems can bring society to its greatest extent. This applies to transportations observed on waters, skies, and most evident on lands.

Land vehicles, an example mode of transportation, are designed with the purpose of making conveyance of individuals easier and more comfortable. Some people own a vehicle for personal use, others own vehicles for professional purposes, and the rest who do not own a vehicle, some employees and students, rely on public vehicles such as taxis, buses, tricycles, and jeepneys. These groups of vehicles, including pedestrians, going along a route, road, or highway are referred to as traffic. When the population in a particular area grows, pedestrians and the demand in accessible vehicles increases (Mattson J., 2020). And as the number of pedestrians and transport activities increase, the chance of traffic congestion increases as well.

Traffic congestion is a situation in traffic where the vehicular queueing increases and travelling becomes prolonged and time-consuming. According to Kozlak and Wach (2018), increasing number of vehicles on roads result in traffic pauses or stops in certain areas, where the number of vehicles becomes greater than the vehicle capacity of roads. And when traffic gets interrupted by various traffic issues, society can suffer from negative consequences. In order to handle and manage these traffic issues, traffic rules and regulations are implemented to enforce fairness and proper order for all drivers and pedestrians, specially, to resolve issues in traffic congestion, often with the aid of traffic signal lights. Traffic lights are signal lights which help control the movement of traffic most commonly on road intersections and crossings where traffic congestions are most likely to happen.

Traffic lights were introduced to the world by J.P. Knight for the first time in 1868. The first traffic light was powered by gas and manually operated through a lever on its base. It is revolving at an intersection with only red and green signal lights which represent ‘stop’ and ‘caution’ respectively. A year later, the first traffic light exploded but despite failure, it became a giant step for innovating the first electric traffic lights in 1912 by Lester Wire (Bush et al., 2017). Those previous traffic light innovations have become the foundations of different classification of traffic lights observed and implemented in traffic these days.

According to Federal Highway Administration (2022), traffic signal lights can be classified into pre-timed, fully actuated, and semi-actuated. Pre-timed signals have fixed signal phases regardless of traffic demand. Fully actuated signals are phases based on traffic demand which is detected through sensors or actuators. Lastly, semi-actuated signal is a fusion of pre-timed and fully actuated signals since it may be operating through fixed signal phases, but signal phases may be modified through the use of sensors or actuators.

Background of the Study

Transportation is a significant factor that helps in strengthening the investment climate and enhancing economic growth of a country. In the Philippines, transport is a key sector for its economy, linking population, and economic centers across islands. According to Asian Development Bank (2012), road transport is by far the most dominant mode of transportation in the Philippines thus, occurrences of traffic issues on the road are most likely to happen which include traffic congestion. Traffic congestion is a state where transport is slowed down, travel time is prolonged, and vehicle queues are extensive. Traffic congestion in the Philippines is known to be one of the most severe in the world, particularly in its capital city, Metro Manila.

Japan International Cooperation Agency (2018) stated that if no adjustments are made in Metro Manila, the Philippines is predicted to lose 5.4 billion pesos to traffic daily by 2035, thus, traffic congestions can lead to a great loss in a country's economy. The additional wasted time due to the traffic congestion may be converted into valuable working hours that could help the economy as a whole. Commuters will have to spend more time on the road due to traffic congestion, which has an immediate impact on people's mental and physical health. This can affect mental health and lead to significant levels of stress, sleep disturbance and adverse health effects, such as cardiovascular problems and respiratory risks due to long exposure to pollution. Pollution is not only harmful to humans but it is mostly harmful to the environment, and traffic congestion contributes and worsen the pollution. Traffic congestion results in vehicles' extensive standby and emitting more pollutants which is extremely damaging to the environment (Samal et al., 2020). Thus, traffic congestions' negative consequences mostly affect the economy, health, and environment. In order to reduce the negative effects of traffic congestion, defining the causes of the problem may help in designing possible solutions for the problem.

According to Afrin & Yodo (2020), occurrences of traffic congestion in different locations may be caused by various reasons such as excess demands, bottlenecks and capacity, insufficient infrastructure and the like. An increase in population can be related to traffic congestion because as population increases, the demand in transportation increases as well

resulting in increased volumes of vehicles on the road. The demand in transportation will be supplemented which leads to an increased volume of vehicles on the road. When volume of vehicles increases, insufficient infrastructure such as roads can also lead to bottlenecks and incapacity which both contribute to traffic congestion. When vehicle volume is greater than the capacity of the road, congestion occurs, and road incapacities can result in bottlenecks which refers to problems of traffic in merging road lanes. These problems in traffic congestion can be aided through good traffic management but sometimes, poor traffic management causes the traffic congestion itself. Thus, a systematic planning and modeling of traffic management is significant in solving these traffic related issues sometimes with the aid of simulation.

Simulations are imitations of real-world operations through modeling. Advancements in technology allow modern resolutions for contemporary issues, particularly traffic related problems. Traffic simulations allow modeling of traffic problems or events which can be utilized to plan for potential resolutions and select the most optimal solution to implement in real life traffic scenarios. Abdelkader et al. (2022) stated that traffic simulators assist policymakers and traffic planners in traffic analysis and modeling for making informed decisions with regards to traffic related issues. Thus, use of simulation should be maximized for research and implementation of traffic schemes, with the results serving as a guide for any future improvements to the road.

The researchers aim to develop a traffic simulation application that will simulate different traffic scenarios on crossroad intersections and provide resolution to the said scenarios by the use of Fuzzy Logic Algorithm. The researchers will use Junction, a crossroad intersection in Cainta, Rizal, as a model to test the simulation application's generation of expected results in accordance with the simulation application's objectives.

Overview of the current state of the technology

Traffic control devices are used to control traffic on the roads and raise awareness of the road safety rules among drivers and pedestrians. In order to be clearly visible to other road users, these devices are available in a variety of shapes and patterns and can be positioned wherever on the road. They can be used to warn about dangers, declare route diversions, declare directions, and so forth. The commonly used types of traffic control devices on the roads are traffic signs, traffic signals, and markings on road surfaces. Traffic signs are commonly used to control road traffic and can be used for three main purposes: traffic regulation, warning users about something, or passing on general information. Traffic signals can be found commonly in most junctions in the country. It regulates traffic and ensures the smooth movement of vehicles/pedestrians on the road. Control signals such as red, yellow, and green are provided for vehicles to stop, prepare, and move respectively. Marking on road surfaces are often in the shape of drawings, objects, or reflector units, which are typically made in vivid and extremely visible colors to emphasize significant/prohibited/dangerous portions of the road so that users can move accordingly. Such marks are made in a way that they are easily seen at night as well, which encourages drivers to relax and control their speed. (City Traffic Police, n.d.)

Objectives of the study

General Objective

- **To design and develop a traffic simulation application that will allow the user to simulate different traffic scenarios and provide resolution to the said scenarios by the use of the Fuzzy Logic Algorithm.**

  The traffic simulation application to be developed will allow the user to input data such as the number of vehicles in the intersection. Once the simulation receives an input, the application shall simulate the traffic scenarios based on data that is provided by the user. The simulation shall also be able to provide resolution to the simulated traffic scenarios by the implementation of the Fuzzy Logic Algorithm.

Specific Objectives

- **To design a module that would allow the simulation of different traffic scenarios**

  Traffic scenarios are representations of real-world driving situations that may occur on the road such as traffic flow during rush hours, vehicles yielding when there is an emergency, and vehicles overtaking. The simulation should be able to simulate these different traffic scenarios. This will inform the users of the different possibilities that might occur on the road.

- **To design a module that would provide resolution to the different traffic scenarios by means of implementing the Fuzzy Logic Algorithm**

  The simulation aims to provide resolution to different traffic scenarios by implementing the Fuzzy Logic algorithm. The algorithm will be applied in the traffic light so that it will adapt based on the levels of flow of traffic congestion. The input data, the volume of vehicles, from the users will be the basis of the adjustment of the traffic light.

- **To design a module that would allow the generation of reports based on the simulation results of the application.**

  The simulation will feature a calculation of traffic flow that will be able to generate reports that the user may use as a guide for future planning and implementation. The reports might also be utilized as research data, case studies, and the like.

Scope of the Study

- **Traffic Simulation**

  The application shall assist traffic planners and policymakers in traffic analysis and modeling through simulation for making informed decisions with regards to traffic management planning. An advantage of the simulation is designing potential resolutions for traffic modeling to minimize project cost, reduce traffic congestion, and maximize utilization of traffic management projects such as traffic lights, traffic predictions, road planning, etc.

- **Traffic light**

  The traffic light will adjust based on the volume of the vehicle. With the implementation of Fuzzy Logic Algorithm, the time for the 'Go' and 'Stop' signal will differ depending on the traffic volume. For instance, the 'Go' signal will be much longer on the road that has a higher traffic volume.

- **Triggers**

  Triggers are forms of user-controlled input. The simulation will feature triggers that the user may adjust, the user will be able to input their own data. The simulation will then display how the data entered by the user affects the traffic condition. Users will be able to modify inputs that influence traffic behavior. Triggers include:

  Vehicle Types

  There are various types of vehicles on the road and those different types differ in shape, weight, or length. The traffic simulation to be developed will include demonstrating different types of vehicles based on the number of the vehicle wheels such as 2-wheeler, 4-wheeler, 6-wheeler, and the like.

  Traffic Flow

  Traffic flow refers to the movement of individual drivers or vehicles and the interaction drivers make with other travelers and infrastructure. The simulation will show the different traffic flow of the vehicles such as left turning, right turning, counter flowing (For Emergency Vehicles), and overtaking.

Road

Vehicles travel through designated pathways and these pathways are referred to as the road. Different road structures have their specific purpose and differ in design, the simulation application will include mainly the traffic scenarios present in intersections namely crossroad, t-intersection and y-intersection. The user will be able to add up to four lanes and remove lanes to test out different traffic flow.

Accidents

The traffic simulation will not be able to simulate actual traffic accidents that may occur on the road, but accidents will be controlled by the users. Traffic accidents include vehicular crashes, breakdowns, and debris in travel lanes. The simulation application will demonstrate how accidents can contribute to traffic scenarios in intersections.

Work Zones

Works zones are the construction activities on the roadway by making physical changes to the highway environment. These occurrences result in narrowing of road widths or road closures. Work zones in the application will be user manipulated and the simulation application will show how these work zones impacts the traffic scenarios in intersections.

Pedestrians

Traffic is not limited in vehicles, but it also includes people traveling on foot which is also referred to as pedestrians. Pedestrians may also contribute to different traffic scenarios. Impacts of pedestrians' behavior, such as pedestrian lanes, towards traffic scenarios in intersection will be included in the simulation application.

- **Simulation Results**

  After running the simulation, it will then show reports of travel time and traffic volume through visual representation. This will aid users in judging potential driving behaviors based on the modified input.

- **Algorithm**

  Fuzzy Logic Algorithm

  The Fuzzy Logic algorithm is utilized to imitate human reasoning and cognition by means of modeling logical reasoning through degrees of truth between 0 and 1. This algorithm allows designing of fuzzy inference systems, a form of artificial intelligence, which use human interpretable rules instead of abstract mathematics. Fuzzy Logic is a way to convert experienced based knowledge to data computers can understand in the form of logical rules. The proponents will implement Fuzzy Logic Algorithm with regards to providing resolutions for the various traffic scenarios.

  Best-First Search Algorithm

  The best first search uses the concept of a priority queue and heuristic search. It is a search algorithm that works on a specific rule. The aim is to reach the goal from the initial state via the shortest path. It is used for finding the shortest path from a given starting node to a goal node in a graph. The algorithm works by expanding the nodes of the graph in order of increasing the distance from the starting node until the goal node is reached. The Best-First Search Algorithm will be implemented on vehicle movements.

Limitations of the study

- **Weather**

  Changes in environmental conditions can affect traffic flow in terms of speed and volume and driver behavior. These factors can contribute to traffic congestion. The simulation will not be able to simulate traffic situations under different weather conditions such as heavy rains, and floods.

- **Absence of Input**

  The traffic simulation requires user input. The application will not be able to operate without any user input

LITERATURE REVIEW

Review of related literature, studies or systems

Foreign Studies

Traffic Modeling & Simulation

According to Abdelkader et al. (2022), advancements in intelligent transportation systems (ITS), including prediction and simulation of traffic behaviors, have contributed to the increased development of traffic modeling. Traffic modeling is significant in predicting changes in traffic behavior and demonstrating the traffic status under different traffic scenarios. Traffic simulations are essential tools for practicing effective implementation of smart mobility devices and evaluating impacts of such services prior to real-world testing. Traffic simulators assist policymakers and traffic planners in traffic analysis and modeling for making informed decisions with regards to infrastructure planning and investments.

Effects of Traffic Congestion

Higgins et al. (2017) emphasized that there are certain costs related with travel under specific circumstances. Congestion consumes more fuel than free-flowing traffic and wears out automobiles. Also, it involves time costs associated with travel delays and unreliability that can limit a person's capacity to engage in other activities and can raise health risks associated with pollution exposure. In addition, congestion increases delays and makes the travel times more unpredictable. Furthermore, congestion can diminish a person's sense of control over the length of their travel, which raises commuters' stress levels. Thus, long journeys and congestion contribute to stress and wellbeing of the commuters.

Chronic stress may increase if one is exposed to the daily annoyances of traffic. Since drivers must wait for the traffic to move and cope with other drivers' mistakes on the road, impatience is a stressor when in a traffic jam. Impatience can grow into resentment, aggressive driving, and fury if it is not dealt with right away, all of which can result in road rage. People are more prone to a number of diseases, including depression, and stress is sometimes known as the "death disease" (Nadrian et al. 2019).

Causes of Traffic Congestion

Afrin & Yodo (2020) stated that traffic congestion can be classified into two categories namely recurring and nonrecurring congestions. Recurring congestion is caused by insufficient infrastructure, variations in traffic flow, bottleneck and capacity, and inadequate traffic controllers. Non-recurring congestion is caused by unpredictable events such as weather, traffic accidents, work zones, or special events like concerts, fiestas, or sports events.

There are principally two factors causing traffic congestion, namely micro-level factors, including the high number of people on the roads at the same time, and the overflow of vehicles on the limited road space; and macro-level factors, such as land use patterns, car ownership trends, and geographical economic development. Congestion is prompted at the micro-level, and steered at the macro-level (Tilak & Reddy, 2016).

Traffic Lights

In metropolitan cities in India, the problem of traffic congestion has become a difficult problem. Longer travel durations and increased queues are caused by vehicles traveling at a reduced speed or stopping altogether due to traffic congestion. When there are more vehicles on the road than it can handle, this is the occurrence of traffic congestion. Furthermore, it has been observed that traditional methods of reducing traffic congestion, such as signal systems with predetermined set times for signals, are ineffective and failing to achieve its aims. As new traffic scenarios arise throughout the day, the current way of operating traffic signals has become outdated (Soni & Saraswat, 2017).

Traffic lights determine a lot of the answers to traffic problems. Instead of holding the heavy traffic through standard red/green lights for several minutes, traffic police can maintain a regular flow by using these options. However, the construction of flyovers or underpasses avoided using traffic lights because of the heavy traffic. Multi-level parking is the ideal option and does wonders for the types of clogged roads surrounding these locations, which are a problem in many large towns in India. Small parking spaces in these

market locations, according to Chen et al. (2020), are insufficient to handle the heavy volume of incoming traffic, particularly during festival season. Moreover, a pedestrian may endure the harm of the considerable traffic and find their way through the jam. In order to reduce traffic, multi-level parking aids in the last inspection of rushing automobiles in the designated public space. It will be simpler for guests to get where they want to go on foot once everyone understands their duty for parking their cars.

Simulation-based design for traffic

Since traffic systems are an application area, they offer a great environment for using simulation-based design and analysis methods. Where the use of sophisticated analytics is limited to the subsystem and sub-problem level, notwithstanding its importance. The typical simulation problem in functional road and street traffic analysis is focused on traffic flow, or the potential and operational properties of infrastructure. Postponements and crossing line wait times are on the rise due to an increase in global enthusiasm in traffic circles. An endless source for analysis and simulation research. It is crucial to model and simulate vehicle flow in current transportation systems, especially large urban road channels. It assists in identifying and resolving traffic problems, improving traffic regulations, and real-time congestion control for unforeseen calamity situations (Besenczi et al., 2021)

Local Studies

Traffic Lights

Nodado et al. (2018) stated that the solution to the limitation of a traditional traffic light system is one of the areas that is being studied. Conventional traffic light system, which is also known as a traditional traffic light system, has a fixed-time cycle in which the signal light changes from one to another through regular intervals. Due to various factors such as peak hours, accidents or collisions, and other circumstances, the traffic situation constantly changes which makes the conventional traffic light system inefficient. For this reason, the Intelligent Transportation System is introduced as a substitute for conventional traffic light system.

Evaluating the traffic management and urban planning practices

In many urban cities, traffic congestion is a very common thing. Due to the number of people using both private and public transportation, as well as the cities' implementation of their respective traffic regulations, Metro Manila is frequently plagued by high traffic congestion. Whichever organization can administer traffic restrictions has been a point of contention due to the Metro Manila Development Authority's administrative control over the National Capital Region. The overall goal of this research is to evaluate the traffic management and urban planning practices of four (4) local governments that have significant commercial business districts, namely Mandaluyong, Makati, Taguig, and Quezon City, and to relate these to the MMDA's coordination mechanisms and policies. Interviews and data collection have shown that there were inconsistencies in the traffic ordinances, which are reflective of the coordination mechanism of MMDA with the LGUs, through data analysis of comparing and the use of the three indicators of the study's framework, which are socio-legal, socio-technical, and socio-psychological. These were demonstrated in the different interviewees' responses to the following codes, which were discovered to be inconsistent with one another: the presence of traffic enforcers on major roads, programs that had been implemented or, more specifically, number coding, monthly meetings, and their communication source. The research study concludes that while the MMDA's current system for coordinating with the four (4) LGUs with relation to traffic

management and urban planning is functional, there is still room for improvement (Mangahas, Medes 2019).

Technological advancements enable the simulation of environments in a faster way. The simulated environment can provide results ahead of time than the experiment can provide if it was conducted in a real environment. Microscopic simulation models are becoming an essential tool for transport system analysis and management. Now, traffic schemes and techniques can be implemented without interfering with actual traffic scenarios. It was also stated that through software simulation tools, the traffic in EDSA can be managed better instead of implementing strategies through trial and error. Traffic congestion can waste a lot of resources by prolonging travel times. Thus, the use of technology should be maximized for research and implementation of traffic schemes, with the results serving as a guide for any future improvements to the road (Ejercito et al., 2017).

According to Bagas et al. (2018), the purpose of Microsimulation is to simulate the overall behavior of a specific subject over time. This overall behavior may or may not be limited to a particular level, but it is set to a specific environment that closely resembles how it could appear in reality. They developed a software that will assist entrepreneurs in visualizing the potential outcomes of their businesses through the use of 3D microsimulation and the heuristics technique. The software includes valuable information or reports such as estimated visitors, competitor comparisons, simulation time duration, and overall simulation summary reports. Moreover, it also enables the user to evaluate different areas in order to determine whether a specific area is more practical or better compared to the other. This is useful in selecting different areas with similar quality in terms of space and location. In addition, it can also determine whether the selected location is feasible, whether it is near a potential ally or competitor. Furthermore, it also enables the identification of ally or competitor infrastructure whether such infrastructure will enable the business to grow or play a competitive role.

Cenar et al. (2016) stated that roadwork planning and implementation are not as accurate as expected. Unorganized road construction, such as pedestrian lanes, unfinished road works, and overpasses, are making pedestrians more disobedient. As a result, it is difficult

for government and private groups to determine whether a particular project, such as an overpass, would be beneficial to the public and the chance that such project will be used. Thus, an application was developed to simulate how pedestrians react to various stimuli, objects, or obstacles via Crowd Analysis and Neural Networks. This would be useful in demonstrating how pedestrian behavior affects traffic situations. By modeling pedestrian behavior and how they respond to stimuli, users will have a better idea of what the project's final output will be and how likely it will be used by most pedestrians. The application allows the user to plan the road design. The user may determine whether an alternate route, construction of a bridge, creating pedestrian lanes, or constructing a new facility, among other things, will aid in solving the traffic condition in the area. In addition, after running the simulation as well as through observation, it will provide outputs that may be utilized by government agencies to collect data for research, experiments, or case studies. These outputs can be utilized in the planning, construction, and implementation of numerous projects. The application also demonstrated the relationship between pedestrians and traffic conditions. The users may interpret results by analyzing pedestrian behavior and how they react to their environment at a specific time using the application itself and the triggers.

Foreign Literature

Effects of Traffic Congestion

Retallack and Ostendorf (2019) indicated that congestion is an interesting factor that may affect the chance of a traffic accident to occur. In addition, numerous studies found that there is a positive correlation between accidents and congestion index which implies that an increased traffic volume is responsible for higher accident rates. Moreover, it was also emphasized that a better understanding of the factors that contribute to traffic accidents, particularly congestion, would help to lower the financial and societal costs related to accidents. This may be accomplished by encouraging better traffic infrastructure design and traffic management.

Traffic Lights

The purpose of Traffic Lights (TLs) is to manage traffic at the intersections. Changing of lights to red, yellow, or green is operated by the traffic light control mechanism which depends on a fixed periodic schedule. In the early morning or late at night, a different schedule may be used. Such a fixed light control is unaware of traffic congestion and does not adapt to fluctuating traffic situations (Younis and Moayeri, 2017).

Synthesis

Traffic congestion is a serious problem in everyday living since transportation has become a significant portion of people's life. Traffic congestion is a condition in transportation wherein vehicles going along the same route is more than the capacity that the road can accommodate resulting in travel delays, extensive vehicle queueing, and longer waiting time. When traffic congestion occurs, the society, environment, or economy can be faced with a lot of negative consequences.

A country encountering traffic issues, specifically congestion, is studied to suffer massive negative effects from the traffic delays. For instance, traffic congestion that leads to long journeys may contribute to a drivers' or commuters' mental and physical health risks by having to stand by for an extensive amount of time due to long vehicle queues which increase chronic stress, while health issues can result from exposure to extreme pollution. Pollution caused by vehicles on standby can also have harmful effects on the environment and vehicles waiting in long queues will have to consume more fuel which also have negative impacts on our environment. Traffic congestion affects human life and environment negatively but traffic congestion is investigated to greatly affect the economy as well due to unnecessary time wasted on extensive travels which may have been used in other activities that may produce potential profits. These are a few of the negative effects of traffic congestion and in order to mitigate or prevent these consequences from occurring, comprehensive understanding of the causes of traffic congestion is necessary.

Transportation has significantly made life easier and more comfortable, thus, increase in population correlates to an increase in transportation demands which results in more vehicles on the road. Higher number of vehicles going along the same limited road space results in traffic congestion. A few traffic congestion can be caused by factors that were not highly anticipated or unpredictable cases, for instance, inclement weathers such as heavy rains and flash floods; traffic accidents; work zones such as road construction; or it can be special events like concerts, sports events, or fiestas. Traffic congestion is mostly evident on intersections, two roads that are intersecting, thus, implementation of traffic

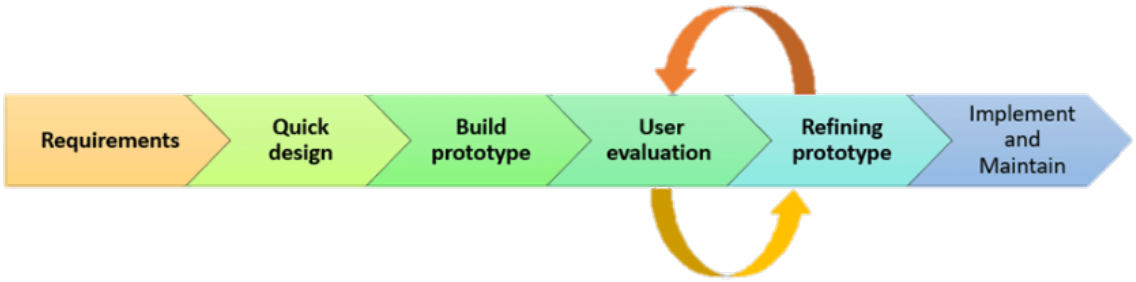
lights are studied to be a great solution for controlling traffic flow and reducing chances of traffic accidents.

Traditional traffic light system has a predetermined time in which the signal lights are changed through regular intervals. Since traffic scenarios are constantly changing on a daily basis, such traffic light system is inefficient in managing the current traffic conditions. Given that it has a fixed time cycle, it does not have the ability to adapt to the fluctuating traffic conditions. Innovations of intelligent traffic lights resolve some weaknesses of a traditional traffic light, specifically the inability to adapt in real time traffic behavior. Intelligent traffic lights are actuated traffic lights that operate with the aid of sensors which gather real time traffic behaviors used for updating traffic light timers. Since, intelligent traffic lights respond dynamically to real time conditions, it helps in increasing traffic efficiency by reducing congestion. Implementing a suitable traffic light in a specific location is significant, thus, simulation modelling of traffic is necessary before implementing traffic lights in real life traffic models.

Simulation modelling is used to safely and effectively address real-world situations. It provides an important method of analysis that is simple to check, analyze, and understand. By giving clear insights into complex systems, simulation modelling provides key solutions across industries and disciplines. Simulation is a virtual imitation or modelling of a real environment that allows ideas to be tested and can validate findings from other types of studies, creating a thorough understanding of study issues. Traffic simulation, also known as transportation system simulation, is the mathematical modelling of transportation systems using computer software to help in transportation system planning, design, and operation.

METHODOLOGY

Methodology



The Prototyping model is an iterative method that occurs between potential users and developers.

As traffic lights are designed to assist in traffic management in order to achieve an orderly flow of vehicles and reduce chances of traffic congestion. Traffic data required in the traffic simulation is dynamic, and building a prototype, user evaluation, and constant refining can be used to achieve the required simulation. The main focus of this model is to continuously refine the working prototype of a system until a satisfactory outcome is achieved.

Requirements gathering and analysis

Traffic simulation aids in traffic analysis and traffic modeling which is significant in predicting changes in traffic behavior and demonstrating traffic status under various traffic conditions. The researchers interviewed a professional in the field of traffic management and requested to identify the fundamental requirements for the simulation. The gathered information from the interview are the foundations of building the initial prototype.

Quick design

Quick design is a preliminary design which is not a complete design. The researchers create and form the traffic simulation's basic design which will provide users a brief but clear overview of the simulation. Quick design is necessary for the developers and users to understand how the prototype will work and how it will be developed.

Build a Prototype

The researchers gathered information from the quick design and used it as the basis for building an actual prototype of the traffic simulation. An algorithm is implemented in order to build the prototype in accordance with the requirements of the traffic simulation. It is an initial working model of the final simulation that is expected to be achieved.

Initial user evaluation

The actual prototype of the traffic simulation is introduced to the users by the researchers in order to acquire their initial evaluation. Users' initial evaluation is used to determine the strengths and weaknesses of the prototype. Suggestions and feedback of the users will be used by the developer for the betterment of the prototype.

Refining Prototype

The initial user evaluation, feedback, and suggestions collected is used by the researchers as the basis of refining the traffic simulation's prototype. Improving the prototype is iterative and will continue until all the specified requirements of the users are met. The prototype is finalized when the users' satisfactions are met and the final prototype will be the basis of developing the final traffic simulation which will be implemented.

Implement Product and Maintain

The final traffic simulation developed based on the final prototype built is going through an in depth testing and then will be deployed to the subjects of the study. The final system will be implemented and delivered to the users. The researchers' task is to do routine maintenance to identify potential problems and prevent these problems from resulting in simulation failure.

Hardware

Model	**Microsoft Surface Pro 2017**
Operating System	**Windows 10 Pro**
Processor	**Intel core i7-7660U 2.50Ghz**
RAM	**8GB**
Memory	**256gb**
Display	**10.3” 2736 x1824 (267 ppi)**

Software

Unity - is a cross-platform game engine developed by Unity Technologies, which is primarily used to develop video games and simulations for computers, consoles and mobile devices**.**

Arduino - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus.

Gantt chart of Activities

	THESIS 0																THESIS 1																THESIS 2							
MONTH	SEPTEMBER				OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY				MARCH				APRIL				MAY				JUNE				SEPTEMBER				OCTOBER			
ACTIVITY	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Chapter 1																																															
Introduction																																															
Background of the Problem																																															
Overview of the Current state of technology																																															
Objectives																																															
Scope & Limitation																																															
Chapter 2																																															
Review of Related Literature																																															
Synthesis																																															
Chapter 3																																															
Methodology																																															
Hardware/Software																																															
Calendar of Activities																																															
Budgetary Estimate																																															
Human Resources																																															
Chapter 4																																															
Results and Discussion																																															
Chapter 5																																															
Results & Conclusion																																															

Legend: **Blue – Finished** **Yellow – Ongoing**

Budgetary Estimate

THESIS 0	
Specifics	**Approximate Cost**
Transportation	**500**
Food	**1000**
Electricity	**1000**
Water	**200**
Internet	**1500**
Document Printing	**600**
TOTAL	**₱4 800**

THESIS 1	
Specifics	**Approximate Cost**
Transportation	**500**
Food	**1000**
Electricity	**1000**
Water	**200**
Internet	**1500**
Document Printing	**750**
TOTAL	**₱4 950**

THESIS 2	
Specifics	**Approximate Cost**
Transportation	**500**
Food	**1000**
Electricity	**1000**
Water	**200**
Internet	**1500**
Document Printing	**900**
Arduino Kit	**1500**
TOTAL	**₱6 600**

TOTAL : ₱16 350

Curriculum Vitae of

Joni Roi Q. Eleda

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09456490047

EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	August 2020 – present	STI College Ortigas-Cainta
Vocational/Technical	June 2018 – March 2020	Sumulong Memorial High School
High School	June 2014 – March 2018	Sumulong Memorial High School
Elementary	June 2008 – March 2014	Juan Sumulong Elementary School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
N/A	N/A	N/A

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
N/A	N/A	N/A

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Java Programming	5/10	January 2021
C# Programming	4/10	May 2021
SQL	5/10	June 2022
HTML, CSS	6/10	May 2021
, JavaScript	3/10	May 2021
PHP Programming	5/10	November 2022

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
N/A	N/A

Listed in reverse chronological order (most recent first).

Curriculum Vitae of

John Denver F. Patiag

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EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	August 2020 – present	STI College Ortigas-Cainta
Vocational/Technical	June 2018 – March 2020	Siena College of Taytay
High School	June 2014 – March 2018	Siena College of Taytay
Elementary	June 2008 – March 2014	Felix M. Sanvictores Elementary School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
August 2020 – February 2021	Factory Worker	JOV Wood Furniture – Taytay, Rizal
September 2019	Service crew	Rancho Verde – Taytay, Rizal

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
September 2019 – present	Gregoria Youth Council	Vice President of Internal Affairs
September 2018 - present	Lumen Christi	Member
September 2015 - present	Legion of Mary	Member

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Java Programming	7/10	January 2021
C# Programming	6/10	May 2021
HTML, CSS, JavaScript	6/10	May 2022
PHP Programming	7/10	November 2022

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
March 2017	LEGO Robotics
March 2016	Animation
March 2015	Adobe Photoshop

Listed in reverse chronological order (most recent first).

Curriculum Vitae of

Justin Angelo T. Rebeta

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EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	2020 - Present	STI College Ortigas- Cainta
Vocational/Technical	2018 - 2020	Our Lady of Fatima University Antipolo Campus
High School	2014 - 2018	Concepcion Integrated School Secondary Level
Elementary	2008 - 2014	H. Bautista Elementary School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
N/A		

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
N/A	N/A	N/A

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
PHP	5/10	2022
HTML	7/10	2021
Java	4/10	2020

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
N/A	N/A

Listed in reverse chronological order (most recent first).

Curriculum Vitae of

JOHN ADRAE C. SOTTO

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sottojohn0510@gmail.com
09617476096

EDUCATIONAL BACKGROUND

Level	Inclusive Dates	Name of school/ Institution
Tertiary	August 2020 – 2024	STI College Ortigas-Cainta
High School	September 2016 – May 2020	Secaucus High School
Middle School	December 2015 – June 2016	Secaucus Middle School
High School	June 2014 -December 2015	Sta. Lucia High School
Elementary	June 2008 – March 2014	De Castro Elementary School

PROFESSIONAL OR VOLUNTEER EXPERIENCE

Inclusive Dates	Nature of Experience/ Job Title	Name and Address of Company or Organization
May 2022	Customer Service Representative	Sitel Philippines OJV Site/ 1 Doña Julia Vargas Ave, Pasig, Metro Manila

Listed in reverse chronological order (most recent first).

AFFILIATIONS

Inclusive Dates	Name of Organization	Position
N/A	N/A	N/A

Listed in reverse chronological order (most recent first).

SKILLS

SKILLS	Level of Competency	Date Acquired
Java	6/10	January 2021
SQL	6/10	June 2022
HTML	6/10	May 2021
CSS	4/10	September 2022
PHP	6/10	November 2022
C#	5/10	May 2021

TRAININGS, SEMINARS OR WORKSHOP ATTENDED

Inclusive Dates	Title of Training, Seminar or Workshop
N/A	N/A

Listed in reverse chronological order (most recent first).

ADVISER'S ACCEPTANCE FORM

NAME OF PROPONENTS:	**Joni Roi Q. Eleda** **John Denver F. Patiag** **Justin Angelo T. Rebeta** **John Adrae C. Sotto**
APPROVED RESEARCH TITLE:	**Traffic Simulation on Intersection**
AREA OF STUDY:	**Algorithm Implementation**

CONFORME:

Salvador T. Gascon Jr.
Thesis

APPROVED BY:

Merriam T. Muyco **Date: December 2022**
Thesis Coordinator

NOTED BY:

Salvador T. Gascon Jr.
Program Head

REFERENCES

Abdelkader et al. (2022). *A Comparative Study on Traffic Modeling Techniques for Predicting and Simulating Traffic Behavior.* Retrieved from https://www.mdpi.com/1999-5903/14/10/294/pdf

AbdulFattaha et al. (2022, June 30). *Insights into the socio-economic impacts of traffic congestion in the port and industrial areas of Chittagong City, Bangladesh. Transportation Engineering.* Retrieved November 28, 2022. Retrieved from https://www.sciencedirect.com/science/article/pii/S2666691X22000203

Abugan et al. (2018). *Intelligent Traffic Light System Using Computer Vision with Android Monitoring and Control. TENCON 2018 - 2018 IEEE Region 10 Conference*, 2018, pp. 2461-2466, doi: 10.1109/TENCON.2018.8650084.

Afrin & Yodo. (2020). *A Survey of Road Traffic Congestion Measures Towards a Sustainable and Resilient Transportation System.* Retrieved from https://www.mdpi.com/2071-1050/12/11/4660/pdf?version=1591529391

Arifin et al. (2021). *Recent Development of Smart Traffic Lights.* ResearchGate. Retrieved from https://www.researchgate.net/publication/349891471_Recent_development_of_smart_traffic_lightsyou

Bagas, C. P., Binondo, J. S., Magsombol, D. G., & Melarpis, L. B. (2018). *Location Feasibility Analysis Through 3D Microsimulation Via Crowd Analysis Incorporating Heuristic Techniques and Neural Networks For East Road Kitty Cafe.*

Batfai et al. (n.d.). *Large-scale simulation of traffic flow using Markov model.* Retrieved December 3, 2022. Retrieved from https://www.researchgate.net/publication/349175483_Large-scale_simulation_of_traffic_flow_using_Markov_model

Besenczi, R., Jeszenszky, P., Batfai, N. (n.d.). *Large-scale simulation of traffic flow using Markov model.* Retrieved December 3, 2022, from https://www.researchgate.net/publication/349175483_Large-scale_simulation_of_traffic_flow_using_Markov_model2

Brooks et al. (2021). *Transportation, community quality of life, and life satisfaction in metro and non-metro areas of the United States.* Retrieved from https://reader.elsevier.com/reader/sd/pii/S2666558121000294?token=636AFCD3DE3CBD1C39FF91E1489635484175EE96241670F80FF7D063CB84BD0F6D646C4C95F0AE4420866D8F0EA73581&originRegion=us-east-1&originCreation=20221119121532

Bush et al. (2017). *Self-Organization in Traffic Lights: Evolution of Signal Control with Advances in Sensors and Communications.* https://arxiv.org/ftp/arxiv/papers/1708/1708.07188.pdf

Cenar, M. J., Esteban, M. N., & Gomez, B. A. (2016). *Pedestrian Behavior Microsimulation Incorporating Heuristic Crowd Analysis via Neural Network.*

City Traffic Police, G. o. (n.d.). *Traffic Control Devices.* Retrieved from https://ctplahore.gop.pk/control-devices

Dirpal et al. (2018, December 1). A*ssessing the causes & impacts of traffic congestion on the Society, Economy and Individual: A Case of Mauritius as an emerging economy.* Retrieved November 27, 2022. Retrieved from https://sciendo.com/article/10.2478/sbe-2018-0045

Ejercito et al. (2017). *An analysis of EDSA traffic using advanced tools and techniques. 2017 8th International Conference on Information, Intelligence, Systems & Applications (IISA).*doi:10.1109/iisa.2017.8316414

Eom M. and Kim B. (2020). *The traffic signal control problem for intersections.* Retrieved from https://etrr.springeropen.com/articles/10.1186/s12544-020-00440-8#Sec3

Federal Highway Administration. (2022). *Traffic Control Systems Handbook: Chapter 7. Local Controllers.* Retrieved from https://ops.fhwa.dot.gov/publications/fhwahop06006/chapter_7.htm

Francesca C. & Medes H. (2019, December 3). *An assessment on the coordination of the Metro Manila Development Authority with the local government units of Mandaluyong, Makati, Taguig, and Quezon in addressing traffic congestion. SSRN*. Retrieved December 4, 2022. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3497226

Higgins et al (2018). All minutes are not equal: travel time and the effects of congestion on commute satisfaction in Canadian cities. *Transportation*, 45, 1249–1268. https://doi.org/10.1007/s11116-017-9766-2

Kozlak A. and Wach D. (2018). *Causes of Traffic Congestion. Case of Poland.* Retrieved from
https://www.shs-conferences.org/articles/shsconf/pdf/2018/18/shsconf_infoglob2018_01019.pdf

Mattson J. (2020). *Relationships between density, transit, and household expenditures in small urban areas.* https://reader.elsevier.com/reader/sd/pii/S2590198220301718?token=0FD33524CF7299FA8EE1C3C13543CFA8CF286C6CFA2BD897C648FF5AAEF43D15053B497F407DA61EB9811908C40BA967&originRegion=us-east-1&originCreation=20221122032123

Moayeri N. & Younis O. (2017). Employing Cyber-Physical Systems: Dynamic Traffic Light Control at Road Intersections. *IEEE Internet Of Things Journal*, 4(6), 2286-2296.

Retallack A. E. & Ostendorf B. (2019). Current Understanding of the Effects of Congestion on Traffic Accidents. *International Journal of Environmental*

Research and Public Health, *16*(18), 3400. https://doi.org/10.3390/ijerph16183400

Samal, S. R. (n.d.). Analysis of traffic congestion impacts of Urban Road Network under Indian Condition- iopscience. Retrieved November 25, 2022, from https://iopscience.iop.org/article/10.1088/1757-899X/1006/1/01200

Saraswat J. & Soni N. B. (2017). A review of IoT Devices for Traffic Management Systems. *2017 International Conference on Intelligent Sustainable Systems (ICISS)*, 1052-1055. doi: 10.1109/ISS1.2017.8389341.

APPENDIX A

(Interview Questions)

1. What is your position in the municipality?

2. How long have you been working in this profession?

3. How many minutes is the duration of the red traffic light?

4. How many minutes is the duration of the green traffic light?

5. What is the basis with a specific time as a countdown timer in traffic light?

6. How do you monitor and handle traffic situations during rush hour?

7. How do you monitor and handle traffic situations during off hour?

8. Do you manually change the traffic light countdown timer?

9. What are the equipment that are you currently using in handling traffic?

10. Do you have any means in gathering data about the current traffic?

APPENDIX B

(Interview with Resource Person)

Date of Interview: November 29, 2022 **Time:** 2:56 PM

Name of Interviewee: Noel Bernas

Rebeta: Ito po yung una naming tanong. Ano pong posisyon n'yo po sa munisipyo po, sa traffic?

Sir Noel: Sa traffic? Operator ng command center traffic bureau, traffic command center.

Rebeta: Ilang taon na po kayo nagta-trabaho?

Sir Noel: Dito? 8 years na.

Rebeta: May tanong lang po kami do'n sa stop light, ilang minuto po ba…

Sir Noel: Traffic light. Iba yung stop light. Intersection is traffic light, pedestrian and ano is stop light.

Rebeta: Ilang minuto po 'yung red light?

Sir Noel: Red light? Depende pero ang normal 60 seconds

Rebeta: 60 seconds? For do'n sa apat na ano po na yon

Sir Noel: Hindi

Rebeta: Ano 'yung sa papunta po sa..

Sir Noel: Normal 'yun.

Rebeta: Ah normal po

Sir Noel: Yung kukunin n'yo ba mismong ito?

Rebeta: Opo yung sa Junction po talaga

Sir Noel: Ito, sa Junction talaga, 'no?

Rebeta: Opo sa Junction po

Sir Noel: Ang Ortigas natin going to Antipolo and Antipolo going to Pasig, sa intersection is almost 1 minute, 100 seconds 'no. Tapos 'yung from Imelda going to A. Bonifacio and then 'yung Bonifacio going to Imelda naman is 60(seconds). 60(seconds) depende don sa round-off, meron kasi 'yang cut-off, meron 'yang reset 'no, may 80(seconds), depende kase kung…katulad n'yan, pagdating ng hapon nagbabago 'yan, 80(seconds) 'yan kase nga traffic diba, traffic na

Rebeta: Rush hour po

Sir Noel: Oo, rush hour. Sa umaga rin naman gano'n din, pagdating naman ng 10 o'clock, 60(seconds) yan

Rebeta: Ah nag-iiba po talaga s'ya

Sir Noel: Nag-iiba 'yan. Tapos pagdating ng madaling araw, iba rin

Rebeta: Ah iba rin po?

Sir Noel: Oo, mas maiksi naman, kasi 'di naman kailangang ano…maluwag naman ng time na yun

Rebeta: Ngayon naman po, yung green light naman po, ilang segundo po sila?

Sir Noel: Ganon din, vice versa

Rebeta: Vice versa rin po?

Sir Noel: Vice versa

Rebeta: Same lang s'ya?

Sir Noel: Same lang s'ya

Rebeta: May pinag-basehan po ba kayo do'n sa specific na oras, segundo nung traffic light?

Sir Noel: Hmm?

Rebeta: May pinagbasehan po ba kayo?

Sir Noel: Yes meron, kung saan 'yung daloy ng traffic, so kung heavy dito sa ano, moderate dito sa ganito, so doon namin pinase-set yung CPU, yung mismong CPU, yung system ng traffic light

Rebeta: Pano n'yo po mino-monitor 'yung mga sitwasyon ng traffic pagka po rush hour?

Sir Noel: Mino-monitor? Through..ngayon kasi bog down yung CCTV dahil nung Ulysses, nung kumidlat, so di na namin namo-monitor. Yung monitoring namin is through manpower

Rebeta: So by traffic enforcer

Sir Noel: By traffic enforcer, syempre on and on by radio, communicating them for updating every now and then

Rebeta: So gano'n din po s'ya katulad ng mga hindi po rush hour?

Sir Noel: Oo, gano'n din.

Rebeta: As in…

Sir Noel: As in 'dun sa ano 'yon..

Rebeta: May mga naka-standby po?

Sir Noel: Doon sa routine, na every now and then 'yung mga traffic enforcer magbibigay ng update do'n sa area nila

Rebeta: Cino-control nyo po ba manually 'yung traffic light timer?

Sir Noel: Hindi

Rebeta: Ah hindi po?

Sir Noel: Hindi po, 'yan po ay may system po 'yan, ang system na 'yan is locked by MMDA. Sa MMDA system kasi sila, do'n namin binili

Rebeta: Ano po 'yung mga ginagamit n'yo ngayon? Sa pag-handle ng traffic?

Sir Noel: What do you mean?

Rebeta: Mga equipment po, pano nyo po s'ya cinocontrol?

Sir Noel: About tow truck, towing system for accident, vehicle accident, towing system, or by manpower pa rin

Rebeta: Manpower pa rin po?

Sir Noel: Oo, kung di available syempre tatawag tayo ng tropa para itabi 'yung sasakyan ganyan and then do'n sa mga intersection, small intersection tulad nito sa munisipyo mga ganyan, manpower, manual ika nga

Rebeta: Nagkakaroon po ba kayo ng mga data sa current traffic natin? May mga information po kayo 'nung..

Sir Noel: Information? Nako..

Rebeta: Wala po ba?
Sir Noel: Meron pero nahinto e

Rebeta: Ah nahinto po?

Sir Noel: Magy-year end saka ko lang kinu-kumpleto yun e

Rebeta: Ah okay po

Sir Noel: Meron kaming data, di pa sya organized. Kakalapin namin sya through logbook or through records, by pen saka lang namin s'ya sini-system, manually.

Rebeta: Ayun lang po, salamat po.

[End of Interview]