De La Salle University

Estimating the Route Measured Capacity using the Four-Step Model of Travel Demand Analysis

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by

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Abstract

Rationalizing existing public transportation routes has been one of the strategies employed by the Department of Transportation and various local government units in addressing the traffic congestion especially in Metro Manila. More specifically, they compute the Route Measured Capacity (RMC), to determine how many public transportation vehicles can serve a particular route. However, the issues on integrity and veracity of data used for computation affected how it is used by the regulatory board. It is still used as a guide in approving developmental routes but was already issued a moratorium for existing routes. This research explores a computational approach in determining the Route Measured Capacity of routes servicing the cities of Valenzuela and Marikina. The passenger demand was estimated through a modified Four-Step model. Trips were distributed to the itineraries retrieved from OpenTripPlanner and later consolidated for each jeepney route. The consolidated number of trips was used as the passenger demand in computing for the RMC of each route. The results were divided into two parts: one focusing on intracity routes or those that are within a city only, and the other on intercity routes, those that went beyond a city. Intracity routes had a 16.82% difference while intercity routes had a greater difference of 25.78%. In validating, the route Malinta - Bagbaguin of Valenzuela City was observed to compare the computed RMC to the actual situation on the field.

Keywords: Route Measured Capacity, Road-based Transport, Travel Demand Analysis

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Chapter 1

Research Description

This chapter includes an introduction to the current state of technology, the flaws discovered in the current use of the Route Measured Capacity method, along with the research objectives to address these issues, the scope and limitations, significance of the research as well as the discussion of the specific steps and activities that were performed by the researchers to accomplish the project.

1.1 Overview of the Current State of Technology

The country's economy has been on an upward trend in recent years, and progress is mostly evident in centers of economic activity like Metro Manila. In effect, a lot of people choose to move from rural areas to urban cities, making its population denser than other cities in the Philippines (Lucas, 2004). Given the current population in the urban areas of the Philippines, more and more automobiles are needed to accommodate the growing travel demand. Since the capacity of road segments are not expanding in line with the number of vehicles, there is no doubt that there will be traffic congestion (Matthew & Xavier, 2014).

According to the National Center for Transportation Studies in 2011, more than half of the total person trips in the Philippines are done by means of public transportation. Of these, road-based modes such as jeepneys, taxis, buses, tricycles dominated the roads. While most of these modes do not have permanent stops to accommodate its passengers; they pick up and drop off them in a nonspecific manner. This kind of practice greatly contributes to traffic congestion which is a result of ineffective and insufficient transport planning according to the assessment of Asian Development Bank in 2012. Due to lack of planning, this also results to some routes not being able to accommodate the current travel demand; one jeepney route in Katipunan was found to be under-serviced by thirteen (13) units (Carreon, 2013).

Moreover, the enforcement of traffic regulations is not strictly implemented in the country and the franchising procedures for road-based urban transport are mostly ineffective. The franchises are issued by the Land Transportation Franchising and Regulatory Board (LTFRB), which is responsible for enforcing and monitoring the laws and regulations of public land transportation services. In approving franchises, LTFRB requires the applicants to submit several documents to support their application. Then, applicants need to prove that there is a public necessity for the provision of road public transport services. "Public Necessity" is to be proven during an open court hearing, where the approval of a franchise application is dependent to the argument between the applicant and the legal counsels. This process, however, is lacking of technical basis for the reason that the approval is based on subjective arguments. This arbitrary process continued until the year 1981, where the Ministry of Transportation and Communication (MOTC) was established and a temporary ban was declared for franchise applications. It was during this time that the Road Transport Planning Division (RTPD), a division under MOTC, conducted several field surveys to estimate the demand and supply of a given route, which paved the way to the formulation of the Route Measured Capacity (RMC) method (Manresa et al., 2015).

The RMC indicates the required number of public vehicles operating in a route to serve the estimated passenger demand. The RMC formula is based mainly on the passenger demand, seasonal factors, load factors, seating capacity and the number of round trips vehicles typically make during the day. The RMC was applied to buses, jeepneys and UV Express vehicles, and for few instances even to tricycles. Once determined, the Department of Transportation and Communications (DOTC), currently known as Department of Transportation, provides the RMC to LTFRB.

To obtain the estimated passenger demand, several survey methods were established by the DOTC and the process was administered by the RTPD. They sent out personnel to conduct surveys in the different regions with the cooperation of LTFRB, its field personnel, and the local government units concerned. They used various methods of assessing the data needed for the formula. Since they used surveys to collect data, the credibility of the data was questionable. Moreover, some of the variables inputted in the formula were provided by investors and therefore, resulted to biased results.

With numerous factors that led to the inconsistency of the values produced as well as a rather arbitrary approach, the RMCs were not fully implemented by LTFRB. It was stated in Department Order No. 92-587 "Defining the Policy Framework on the Regulation of Transport Service" that the route measured capacity test shall be used only as a guide in weighing the merits of each franchise application. They only served as a suggestion with regards to the approval of franchises (Manresa et al., 2015).

As mentioned, the data that is being used by DOTC for the RMC formula was based on surveys. Not only that conducting surveys is very tedious and time-consuming, but is costly as well. To address the aforementioned issues regarding the accuracy of the inputs provided to the RMC formula, the current method of collecting data for the passenger demand should be changed. Instead of acquiring data from surveys, geospatial data such as amenities, land use plans, population and traffic analysis zones were used in getting the passenger demand.

The previous applications of the RMC formula used many assumptions in their data. The integrity of using RMC highly depends on the integrity of the user and the data inputs, which is why as mentioned above, the LTFRB used RMCs only as a guide in approving franchises. The use of a different set of data and approach provides more credible results that can formally be used by LTFRB.

1.2 Research Objectives

1.2.1 General Objective

To estimate the Route Measured Capacity of public utility jeepneys using the four-step model.

1.2.2 Specific Objectives

1. To study and review previous works on route measured capacity.

2. To gather information on the different public utility jeepney routes and their operations.
3. To define an algorithm for traffic assignment of PUJ routes.
4. To validate the model through external validation.

1.3 Scope and Limitations of the Research

To further understand route measured capacity (RMC), previous works were studied, specifically the applications that are focused on modeling transportation systems. The variables that were used in the RMC formula along with their data requirements were studied.

The study covers PUJ routes that are operating within the Valenzuela and Marikina cities, these are routes that originate and end within these cities. The route data comes from the GTFS data of the Department of Transportation. The researchers looked at data from DOTC for the current number of PUJs deployed.

The algorithm assigns weights to the different routes. More weights are given to the routes that have more convenience. The higher the weight, the bigger its portion of the demand.

The model comprises of the algorithm for traffic assignment and the RMC formula. It is validated by comparing the results from the model to actual observations in the real world. In this study, only one PUJ route was observed for a day.

1.4 Significance of the Research

Since this research aims to determine the RMC of public utility jeepneys plying different routes using a different set of data and approach from the current application, the findings and analysis of this research could contribute in future studies and improvement of the RMC. The computed RMC can be used by LTFRB in assessing whether there is a need to increase or decrease the current number of deployed PUJs based on the insights mentioned. With a more reliable set of results and objective approach, RMCs can be strictly implemented and applied in various routes.

1.5 Research Methodology

1.5.1 Review of Related Literature

In this phase, the researchers review existing application of the RMC formula in order to know how it is currently used and how it can be further improved through this research. While reviewing the related works, a number of factors are taken into consideration such as the parameters and data of the formula. Optimization algorithms are also reviewed to determine which algorithm fits better with the model to be developed.

1.5.2 Data Gathering

During this phase, data such as the road network, PUJ routes and stops, and travel demand were gathered. Using an open-source location-based services (LBS) like OpenStreetMap, the map interface and road networks can be obtained. The data on the existing jeepney routes and stops were extracted from GTFS. Other data includes the total distance of the route, travel cost and time, which all comes from OpenTripPlanner. The travel demand came from geospatial data that is being managed by another module, Via.

1.5.3 Software Design

In this phase, the requirements for the system are identified. This includes the analysis of the review of related works and the data gathered from the previous steps. The algorithms, methodologies, and software for the model were analyzed and decided. Moreover, the features, user interface and the overall design of the system were defined.

1.5.4 Software Implementation

After gathering all the data needed and designing of the system, an initial prototype of the system was developed. The system have a module that consolidates all the data to produce the RMC of PUJs per route. The researchers followed Agile practices throughout the development of the system. Furthermore, the process was done iterative as each functionality were done and tested in a cycle.

1.5.5 Verification and Validation

In testing phase, the researchers looked into one PUJ route in Valenzuela, observe real world behaviors and survey jeepney drivers and passengers to validate the variables and results of the model.

1.5.6 Documentation

Throughout the research process, all developments were documented. Documentation were used to keep track of the progress and findings from each phase. It also included the methods used in the research.

1.5.7 Calendar of Activities

Tables 1.1 and 1.2 show a Gantt chart of the activities. Each bullet represents approximately one week worth of activity.

Table 1.1: Timetable of activities for 2016

Activities (2016)	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Review of Related Literature	●●	●●●	●●●●	●●●●	●●●●	●●●●	
Data Gathering				●●●	●●●	●●●●	●●
Software Design							●●
Software Implementation							
Verification and Validation							
Documentation	●●	●●	●●	●●	●●	●●	●●

Table 1.2: Timetable of activities for 2017

Activities (2017)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Review of Related Literature								
Data Gathering								
Software Design	●●●	●●●	●●●					
Software Implementation			●●●	●●●	●●●	●●●	●●●	
Verification and Validation			●●	●●	●●	●●	●●	●
Documentation	●●	●●	●●	●●	●●	●●	●●	●●

Chapter 2

Review of Related Literature

This chapter explores and examines related studies on transport planning and travel demand modeling. It also compares various traffic flow modeling approaches.

2.1 Philippine Transport Planning

2.1.1 Public Transport Efficiency

Back in the 1990s, the Unified Vehicular Volume Reduction Program (UVVRP) or more popularly known as the number coding scheme, was developed to ease the growing number of vehicles traveling in the roads of Metro Manila (Regidor, 2013). Today, UVVRP is still being implemented in major cities of the Philippines. Unlike before, UVVRP might not be as effective as when it was first implemented.

Through the years of implementing UVVRP in the Philippines, commuters have already come up with loopholes of this policy. Some of the commuters either opt to go to their destination in a different time (e.g. during the window time given) or find a different route and use minor roads to travel. Meanwhile, the most often work around of a commuter is to use another vehicle. All of these are factors why UVVRP is ineffective in terms of lowering the number of vehicles in a day.

A study on the effectiveness of UVVRP concluded that "Metro Manila has come to a point where its options for alleviating congestion are becoming more and more limited"(Regidor, 2013). Urbanized cities such as Metro Manila has a lesser number of people who chooses to use a public transport. For this reason, it is important that shared transports like jeepneys, UVs and buses be available to commuters in a way that can suffice the number of demands and still have the leeway for private vehicles to travel.

2.1.2 Estimating Demand for Public Vehicles

In the research of Manresa et al. (2015), it discusses the current use of formula called Route Measured Capacity (RMC) by the Department of Transportation and Communications (DOTC). RMC is used to find the required number of public transport vehicles operating a particular route to serve the estimated passenger demand. It was derived from a number of factors such as passenger demand, seasonal factors, load factors, seating capacity and the number of round trips vehicles. Once RMC is determined, DOTC provides the numbers obtained per route to the Land Transportation Franchising and Regulatory Board (LTFRB), to support their decision in issuing franchises.

Another study by (Mendoza, n.d.) discusses on using the RMC formula in obtaining the required number of bus units. The load factor used for the research is an experiment of using 0.6 and a load factor gotten from dividing the current demand over the supply which resulted with the range 0.1 to 0.3 load factor.

Based on the survey data used in this research, it concluded that there is about 60 percent oversupply of buses in EDSA. The convergence of several routes along EDSA was pointed out to be one of the reasons why there is an oversupply of buses in this area.

2.2 Travel Demand Modeling

2.2.1 Prediction Analysis of Trip Production Using Cross-Classification Technique

This study by Al-Taei & Taher (2006) predicted the trip production based on a method called cross-classification technique. Using 20 zones in the area in Dohuk city. It used multi-level matrices of the cross-classification to be able to come up with the disaggregated trip rates, total vehicle trips and private trips in an area. One main factor pointed out was that car ownership results to trip production that is related to household size, income level and total number of working member.

Using home interview survey data (HIS) collected from each household, cross-classification technique was used to predict the travel pattern of the residents. Some of the information collected from the household are as followed:

1. Total trips (TT)
2. Home-Based Work (HBW)
3. Home-Based School (HBS)
4. Home-Based College (HBC)
5. Home-Based Shop (HBSH)
6. Home-Based Other (HBO)

After identifying the purpose of each trip, each household was also evaluated based on their income, cars owned, household size as well as the number of workers in the family. These information are the most important parameter in coming up with the Cross-classification model.

Trip Production Prediction Model Procedure The study found that the family size and number of workers have the same effect on different trip mode purpose. This is why the prediction models procedure uses family size instead of using both family size and workers. The sets of curves produced by:

- the percentage of household by family size and car

- total trips per household by family size and car
- the percent of trips by family size and trip

can be used to forecast family size and car ownership. These figures will be determining the trip generation production of selected zones. This procedure can be summarized as follows:

1. The curve with family size to determine persons of dwelling units with 0 , 1 , and 2+ or more car owned. Multiply by number of dwelling units to obtain number of household by car ownership class.
2. The curve with family size and number of dwelling units at 0 ,1 , and 2 or more cars owned to determine the person trips rate per dwelling unit and multiply the rate by the number of future households to obtain trips produced.
3. The curve with family size and determine person trips by purpose (HBW , HBNW , and NHB), and multiply by trips produced as calculated above to obtain trips produced by different purposes.

2.3 Traffic Flow Models

2.3.1 Simulation Models of Traffic Flow

A study by Taplin (1999) reviewed the traffic model by microsimulation. Some of the steps involved in modelling by normal traffic assignment would be to identifying the OD pairs with the shortest path to the origin and destination. Afterwards, the network and demand are needed to map out the alternative path that would be used. At the same time, it also discusses about the Stochastic User Equilibrium which is being used to take into account the drivers who doesnt take the shortest path route. This also listed some model which is used to simulated traffic flow.

2.3.2 Collaborative Agents for Modeling Traffic Regulation Systems

Research conducted by Bhouri et al. (2011) focuses on regulating traffic with the use of a multi-agent model. The main objective of the research is "to build a traffic control strategy for bimodal traffic that is able to regulate both private vehicle traffic and public vehicle traffic." With the previous systems not being able to cover private vehicle traffic flow, the researchers have implemented their prototype in lined with their goal of addressing this weakness from past studies.

In order to come up with a Multi-Agent System (MAS), every entity of the real world should be associated to an agent in the virtual world. As such, the researchers have arrived with four agents in the study: junction, stage, bus and bus route.

The MAS computes traffic signals plans based on the actual situation of the roads and on the priority given to buses. This prototype simulation is run on the JADE (Java Agent Development Framework) platform. It projects that using MAS strategy with priority improves the regulatrity and travel time of buses. Additionally, the bimodal MAS strategy reduces delays in buses and also improves the traffic condition of buses and private vehicles.

2.4 Review of Related Software

2.4.1 Aimsun

Aimsun developed by Traffic Simulation Systems (TSS) in Barcelona, Spain for urban and non-urban traffic networks is a microscopic simulation tool that simulate the flow of the individual vehicles. Algorithms and models such as car following algorithm, lane changing algorithm and gap acceptance algorithm are used to emulate the behavior of a vehicle.

Car following algorithm determines the spacing or headway between two vehicles. Mostly, vehicles keeps a safe distance between for safe reaction times however, there are aggressive drivers in real world that follow vehicles more closely. Lane changing algorithm determines how vehicles make lane changes depending on driver behavior and traffic conditions. While Gap acceptance algorithm determines how vehicles make a turn. In Aimsun, the driver characteristics as well as vehicle attributes are assigned once it enters the network. The driver characteristics includes the desired minimum headway and turning speed and speed acceptance. Vehicle attributes are maximum speed, normal acceleration, maximum acceleration and size of the vehicle (Jones et al., 2004).

2.4.2 SIM-ENG: A Traffic Simulation Engine

SIM-ENG by Creagh (1999) is a traffic simulation engine designed for discrete-event simulation of traffic. Discrete-event simulation is the process of simulating the behavior or state of a system as discrete sequence of events happens. The simulation engine inputs MMTS models which can specify for multiple simulation runs.

As multiple simulations will be done, SIM-ENG uses a load sharing mechanism called MS-SHARE or master/slave load sharing to speed up the processing time of these simulations. The task is divided by the master computer into sub-jobs which are then sent to the slave computers. Slave computers execute the sub-jobs and returns the results back to the master.

SIM-ENG has two types of interception points. The engine may be intercepted at the macro-level and micro-level. As for the macro-level interception, the engine is intercepted at the completion of each simulation. At the micro-level interception, the simulation is intercepted at the execution of each event. Micro-level interception significantly increases the processing time considering results can be gathered at the fixed time intervals in a single simulation.

2.5 Validating the Model

It is important that models are frequently evaluated to determine whether the programming implementation or abstract model is accurate. This is done through a process that assesses the correctness of the implementation and may also include debugging of the software. In this process, errors and miscalculations in the implementation will be identified. The model undergoes empirical validation to evaluate if a model is an effective representation of the real world (Windrum et al., 2007). Calibration is also done iteratively to adjust unmeasured or underestimated

Table 2.1: Existing traffic simulations

Simulation	**Type**	**Algorithm**	**Features**
Aimsun	Microscopic	car following, lane changing, and gap acceptance algorithms	A traffic simulation for urban and non-urban traffic networks such as freeways, roundabouts and surface street networks
SIM-ENG	Microscopic and Macroscopic	MMTS model and MS-SHARE master/slave load sharing	It is designed for discrete-event simulation of traffic.

parameters in the implementations (Xiang et al., 2005).

Several validation approaches have been suggested for different models. Table 2.2 shows the different evaluation techniques discussed by Xiang et al. (2005).

Xiang et al. (2005) validated a Natural Organic Matter model by inspecting the behavior of the simulation in relation to the heterogeneity of molecules, interaction with mineral surfaces and pollutants. The incorporation of such theory provides an initial face validity for domain experts to decide whether to include more appropriate mechanisms and properties to the model. Their system is a structured system with well-understood rules and transparent behaviors.

For the case of complex systems having a stochastic nature, they are unstructured and more difficult to understand. Therefore, validation methods applied to complex systems that are suitable for using agent-based modeling approach can provide different results. Other validation techniques maybe less important for one modeling approach or maybe more useful or applicable for another one (Xiang et al., 2005).

Table 2.2: Validation techniques and usage by Xiang et al. (2005)

Technique	**Usage**
Face Validity	Domain experts are asked for their subjective judgments on whether the model behaves reasonably and is sufficiently effective.
Tracing	The behavior of entities in a model is followed to determine if the logic of the model is correct.
Internal Validity	The results of several replications of a stochastic simulation model using different random seeds are compared.
External Validity	The results from the model are compared to observations in the real world.
Historical Data Validation	Used when historical data exists. Part of the data (training sets) is used to build the model and the remaining data (test sets) is used to determine the effectiveness of the model.
Parameter Variability - Sensitivity Analysis	The values of the input and internal parameters of the model are modified to determine the effect upon the model and its output.
Predictive Validation	Used to compare the model's prediction with actual system behavior. The system data may come from an operational system or specific experiments.
Turing Test	Experts are given both real system and model outputs and asked to discriminate both outputs.
Model-to-Model Comparison	Various results of the simulation model are compared to the results of other models.

Chapter 3

Theoretical Framework

3.1 Travel Demand Modeling

Travel demand modeling simulates the spatial distribution of all the travel instances within an area. Traffic volume are forecasted based on the demand of the area of study. This goes through a process wherein the travel choices of people are forecasted given the costs of all the other alternative routes. The choices about travel that the people decide about include the choice of destination, the choice of traveling mode, and the choice of the route.

Related Terms for Travel Demand Modeling:

- **Mathematical Model** - Used to describe the different aspects of the real world, their interaction, and their dynamics through mathematics. This is usually used for representing complex behavior of system and tries to make sense of the numbers generated from the variables and parameters involved in the relation.
- **Trips** - Journey from a single point of origin onto another point of destination
- **Trip Production** - Origin of a trip
- **Trip Attraction** - Destination of trip

- **Transport Modes** - Different choices of mode of transportation used to reach a destination. Transport modes available in Manila includes: public utility jeepney, bus, UV Express, taxi, tricycles, train and private cars.
- **Mode Choice** - The used mode of transportation for a trip. Some factors affecting this choice includes: car availability, budget, trip purpose, time of day, travel time, security and comfort.
- **Traffic** - Vehicles on road
- **OD Matrix/Trip Matrix** - The Origin-Destination Matrix specifies the travel demand on the origin and the destination. This is represented by the number of trip production and trip attraction.

3.1.1 Trip Generation

The first stage of the travel demand model is the trip generation. The primary objective of this stage is to generate the total number of trips and to know the number by which the demand is high in a specific zone of the study area. To put it simply, this stage aims to know the travel demand originating on a zone, getting the data from household and socioeconomic attributes.

3.1.2 Trip Distribution

In this stage, the trip from the zones are distributed to its destination. This was represented through the use of OD matrix or the trip matrix which is a two dimensional array that represents the trip pattern in a chosen study area. There are two methods that can be used in distributing the trip, the growth factor model and the gravity model. Both of these methods use the information of the growth rate for the area.

3.1.3 Modal Split

After obtaining the trip distribution and forming the trip matrix for the zones, these numbers undergo modal split. The trip distribution was sliced into matrices that represent each mode of transportation available. There are different factors that influences the mode of choice such as the characteristics of the trip maker, the journey and the transport facility. Based on these factors, the utility of each node was used to calculate the proportion of the trips for each mode of transportation.

3.1.4 Traffic Assignment

Traffic assignment is the process of allocating given set of trip volume to the assigned routes. This stage aims to have a forecast of the transportation system. The distribution of vehicular movements were based on the generated trip matrix. The major aims of traffic assignment procedures are:

1. To estimate the volume of traffic on the links of the network and obtain combined network measures.
2. To estimate travel cost.
3. To analyze the travel pattern of each origin to destination (O-D) pair.
4. To identify weights for the route distribution of the PUJ trips.

3.2 Route Measured Capacity

Route Measured Capacity (RMC) refers to the required number of services in a route, in terms of unit per mode choice (e.g. PUJ or bus units). Manresa et al. (2015) stated that RMC attempts to represents the demand in terms of unit requirement; to know the estimated number of public transport vehicles are needed to accommodate the demand of a route.

The RMC formula is given as

$$RMC = \frac{PD \times SF}{UR \times VLF \times ASC \times NRT}$$

Where:

PD : Passenger Demand of a proposed route obtained from OD table (Network Analyses) or Passenger Load Check Survey (Route Analyses)

SF : Seasonality Factor; Data Source is the DPWH

NRT : Number of Round Trips or determined using route length and average travel speed

ASC : Average Seating Capacity

UR : Utilization Ratio

$$UR = \frac{\text{units in operation}}{\text{actual fleet size}}$$

VLF : Viable Load Factor

$$VLF = \frac{\text{Average Cost/day + Profit/bus/day}}{\text{Average Seating Capacity/bus + Fare}}$$

Sample Scenario

Computing for RMC of air-conditioned buses from Davao going to Surigao

$$\frac{(1107 \times 0.48 \times 0.23) \times (1.155)}{0.70 \times 0.34 \times 61.00 \times 0.50} = 19 \text{ units per day}$$

In this example by Manresa et al. (2015), the Passenger Demand of 1107 was multiplied by 0.48 to get the demand going to one direction of the route. It was further multiplied by 0.23 for the percentage of passengers that uses air-conditioned bus.

The Seasonality Factor of 1.155 based on the Annual Average Daily Traffic of DPWH is multiplied to the Passenger Demand.

After this, it is all divided by the Utilization Ratio which is estimated by the units currently in operation over the actual fleet size based on franchises:

$$UR = \frac{\text{units in operation}}{\text{actual fleet size}} = \frac{49}{70} = 0.70$$

The denominator is further multiplied by the Viable Load Factor, Average Seating Capacity and Number of Round Trips which are 0.34, 61.00 and 0.50 respectively.

Related Terms for Route Measured Capacity:

- **Public Necessity** - Approved by the Land Transportation Franchising and Regulatory Board (LTFRB) during court hearing for the franchise application. Each application should be supported by several documents to prove that there is really a need to increase the road public transport services.

3.3 Data Sources

3.3.1 General Transit Feed Specification (GTFS)

Known as GTFS static or static transit, it provides a common format for public transportation schedules and its geographic information. It allows public transit agencies to publish their transit data to the GTFS feed. Using the data in GTFS feed, developers makes use of this information to make applications. GTFS provides transit information such as stops, routes, trips, and other schedule data.

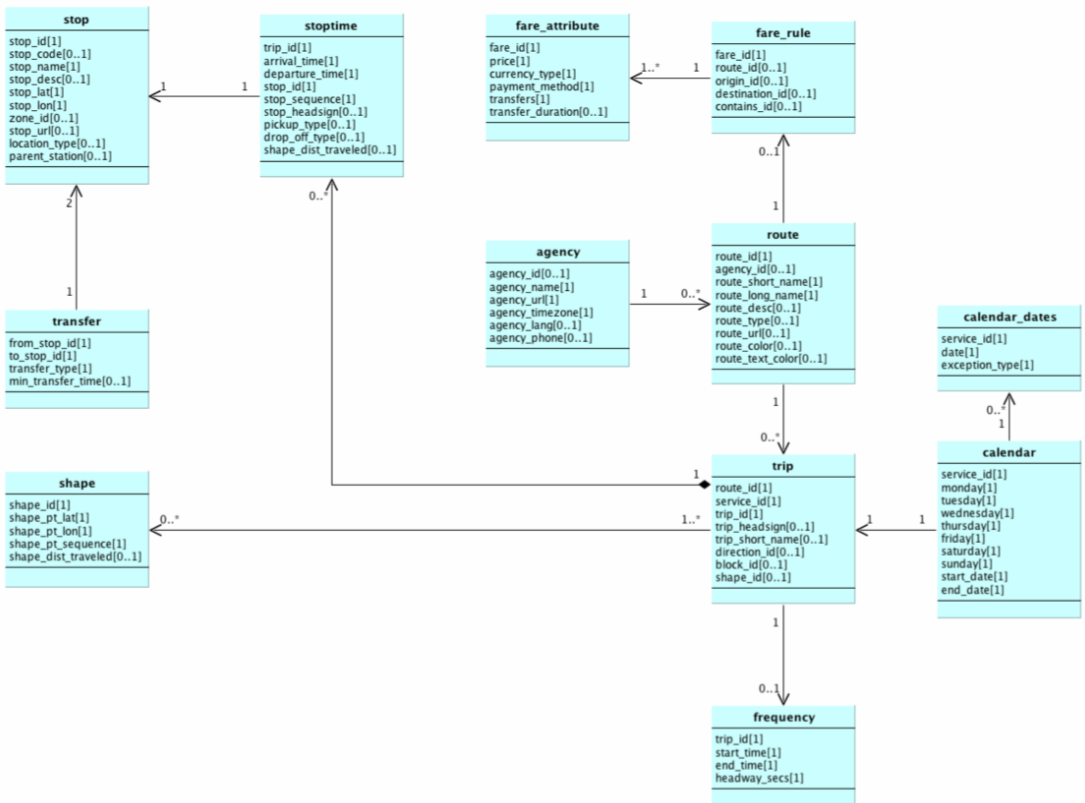


Figure 3.1: Entity relationship diagram of GTFS.

Figure 3.1 shows the 12 files required by GTFS, their relationships and multiplicities. Here is a brief description of some of them:

- **fare attributes** - This contains the fare information for a routes which could be used as a variable for distributing trip to the different routes.
- **fare rules** - Specifies the fare id of an origin and destination
- **routes** - Information about the route such as their id, name, description and type are in this file. This was used to filter out the routes of PUJ.
- **shapes** - Rules for drawing lines on a map to represent a transit organization's routes. It contains several pairs of longitude and latitude points and the travel distance of a route. This was used as basis on the PUJ routes choices available to go to a specified destination.

3.3.2 OpenStreetMap (OSM)

OSM is an open data project that lets users collaborate to create an editable map. It provides different kinds of format of the data generated from the .osm file. The data on OSM are represented as way tags that gives a description on a specified route.

OSM provides users a visualization of the data of a map. By using editing softwares like iD and Potlatch, the map can be edited into a different map layout.

OSM Data Format:

- **Nodes** are points with a geographic position, stored as coordinates (longitude and latitude)
- **Ways** are lists of nodes, representing a route
- **Relations** are ordered lists of nodes, ways and relations, where each element can have a string of description. It is used to represent the connection of nodes and ways to each other.
- **Tags** are key-value pairs of string that has the data about its type, name and physical properties.

3.3.3 Open Trip Planner (OTP)

OTP is an open-source commute planning site that launched in 2009. It uses the transit schedule data from GTFS and traffic network from OpenStreetMap. It provides a map-based web interface as well as API for third-party applications. Currently, OTP is also being used as routing engine of different commuting application.

Through OTP, information of how to commute to a location can be identified through point-to-point, one-to-many or many-to-many query searches. After this, it returns different routes available for commute. Additional feature like computation of the trip cost is also made available by OTP.

Other services of OTP:

- OTP Routing API is a RESTful web service responds to trip requests with itineraries in a JSON or XML representation.
- OTP Transit Index API is also a RESTful web service that gets information from GTFS feeds. The retrieved information includes the routes that pass through a stop, vehicles pass through a stop and number of stops left for a trip.
- OTP Analyst Web Services provides network analysis like travel time maps and route visualization.
- OTP Analyst Batch Processor is a command-line tool with similar data sources and core routing library as other OTP services. It can handle more complex network analysis tasks and can configure the population or opportunity data.
- OTP Scripting API allows routing requests to be made from within scripts such as Python.

Table 3.1: Metro Manila jeepney route characteristic based on route length

	<5 km	5-10 km	10-20 km	20-30 km	30-40 km	>40 km
Percentage of Routes	25.5%	26.0%	36.1%	8.6 %	2.9%	0.9%
Percentage of Jeepney	21.5%	22.9%	42.0%	11.7%	1.7%	0.3%
Average No. of Round Trips per day	9.9	7.1	6.2	4	4	3
Average Hours of Operation per day	13.5	14.1	14.9	14.2	14.25	16
Average Distance Traveled per day (km)	61.5	101.3	191.9	181.7	275.5	348
Average Number of Days per week	5.8	5.6	5.5	6	6	6
Average pax per one way trip	14.5	20.7	27.6	31	35	39
Average pax distance per trip (km)	1.72	3.49	5.77	11	21	40
Average speed (km/h)	11	12.9	15.5	25	25	25

Chapter 4

Maxima

This chapter discusses the high-level specifications and functional requirements of the framework.

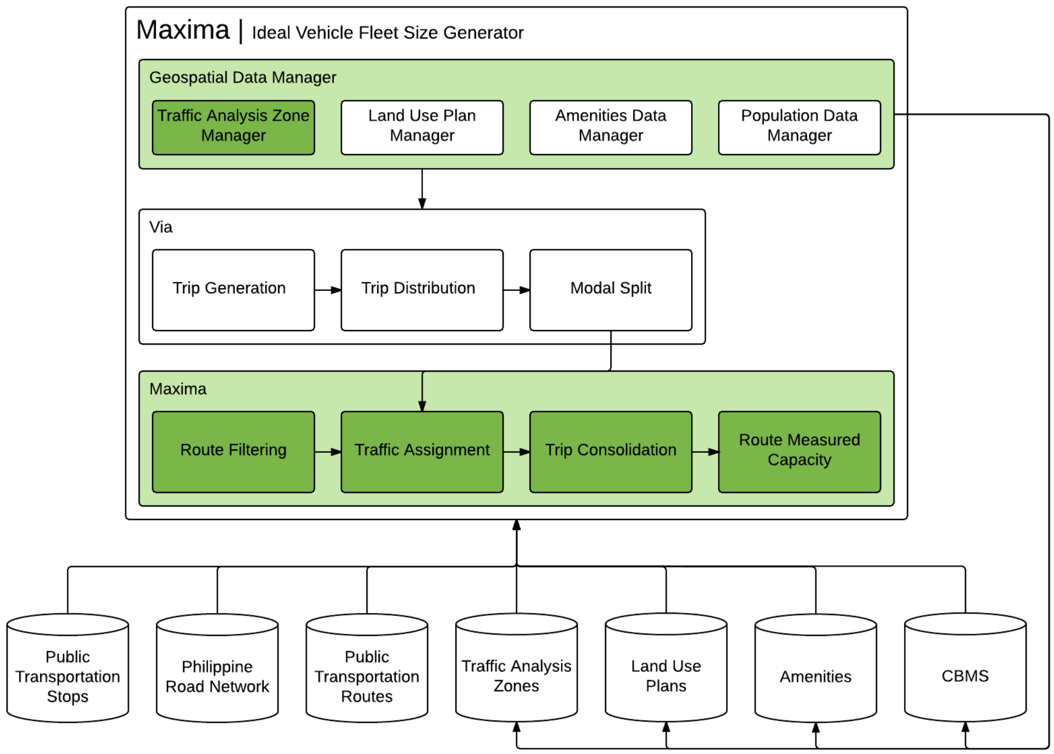


Figure 4.1: Architectural diagram of Maxima.

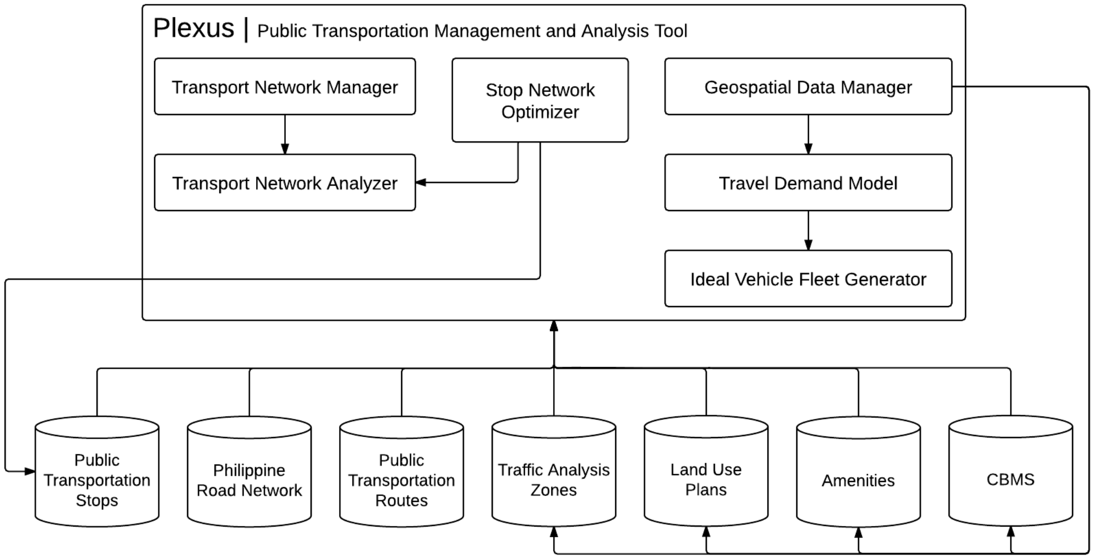


Figure 4.2: Architectural diagram (simple) of Plexus.

4.1 System Overview

The Maxima system focuses on generating the Route Measured Capacity of PUJs based on the current travel demand. Figure 4.1 shows the different modules of Maxima and its data requirements. Maxima makes use of the output generated by Via, which contains the travel demand scores per mode choice. These values are produced from the first three steps of the travel demand modeling. However, the last step which is the allocation of trips to the routes is covered by Maxima.

This module is part of Plexus, a decision-support system that allows urban planners and government stakeholders assess the robustness and resiliency of current public transportation network. Planners can perform a travel demand analysis based on existing amenities and land use in order to plan future developments on the network. It provides mechanisms to manage transportation and geospatial data like routes, amenities and traffic analysis zones. Figure 4.2 shows the different interacting modules of Plexus and the data it requires. The detailed architecture can be found in Appendix F.

4.2 System Objectives

4.2.1 General Objective

To generate the Route Measured Capacity of public utility jeepneys routes.

4.2.2 Specific Objectives

1. To visualize the public utility jeepney routes on the map.
2. To identify the traffic analysis zones covered by the public utility jeepney routes.
3. To filter out the commuter routes while considering factors such as total distance, travel cost and time.
4. To extract actual traffic assignment values from an Origin-Destination matrix.
5. To consolidate the traffic assignment values per route.

4.3 System Scope and Limitations

The visualization of the routes are shown through a map. The routes included in the system was limited only to those within the City of Marikina and Valenzuela. Road networks are shown in the map. It serves as the links between the origin and destination points of the routes. The spatial distribution of the traffic analysis zones (TAZ) are displayed in the map.

The zones was observed to determine whether to include a certain route to its coverage. The closeness of the route to the zone was considered for it to be included in the coverage.

To filter out the routes between two zones, the researchers used OpenTripPlanner in gathering some of the data. For each route, data such as the total distance, travel cost and time in order to determine which routes are more convenient for the commuter. Moreover, routes with multiple or no transfers are also considered in the filtering phase.

The OD matrices generated by Via initially contain all the available mode choices. However, Maxima extracts and utilizes only the trip matrix containing the travel demand scores for PUJs.

A model is developed to consolidate the traffic assignment values for each route from the covered traffic analysis zones.

4.4 System Modules

4.4.1 Traffic Analysis Zone Manager

This module allows the user to manage the traffic analysis zones using a map interface. The TAZs are used for the travel demand modeling of Via and traffic assignment module of Maxima.

4.4.2 Route Filtering Module

This module gets an OD pair from the matrix and determines the existing PUJ routes that can be used by commuters to get from one point to another. With the help of OpenTripPlanner (OTP), commuter routes can easily be identified and filtered. Additional information such as the total distance, travel cost and time of each route is also considered in the filtration. In the case that a multiple transfer route has a shorter distance as compare to a no-transfer route, the multiple transfer are taken into account. This process is done for every OD pair in the matrix. Once that all routes have been filtered, they are used in the traffic assignment module.

4.4.3 Traffic Assignment Module

This module is the one that is connected to Via. Via produces a mode-specific OD matrix in their last step. This module is in charge of extracting the travel demand scores of PUJs from the trip matrices. After extraction, the total trips of an OD pair are divided into the available routes that goes between it. The algorithm used for the splitting of trip values are the same as modal split wherein the distribution of each value is influenced by various factors. Weights are associated for the utility of each route, the route having a higher utility than the others, is given a bigger percentage of the total number of trips.

4.4.4 Trip Consolidation Module

After distributing the total number of trips to the various routes between an OD pair, the trip consolidation module consolidates the values to be able to come up with one value for each route, which was then used as the PD of the RMC formula.

4.4.5 Route Measured Capacity

The passenger demand that was generated in the trip consolidation module is one of the inputs for this module. After plugging all the necessary data to the RMC formula, the required number of PUJs per route is generated.

4.4.6 Route Visualization Module

This module shows the different PUJ routes within Manila using OpenStreetMap. The plotting of the routes are done by using the Python Django framework. In the map interface, the user can view the current attributes of a route which includes the total distance, the current number of deployed PUJs and the calculated RMC.

4.5 System Functions

4.5.1 Screens for the Modules

Figure 4.3 displays the screen of the traffic analysis zone manager. Firstly, zones should be loaded into the system using the "Load" button. When the zones are already shown in the interface, the spatial distribution of a zone can be modified one at a time by selecting a zone first in the dropdown box. Once a zone is selected, click the "Modify" button and the user can modify it by selecting and deselecting areas to be included in the zone.

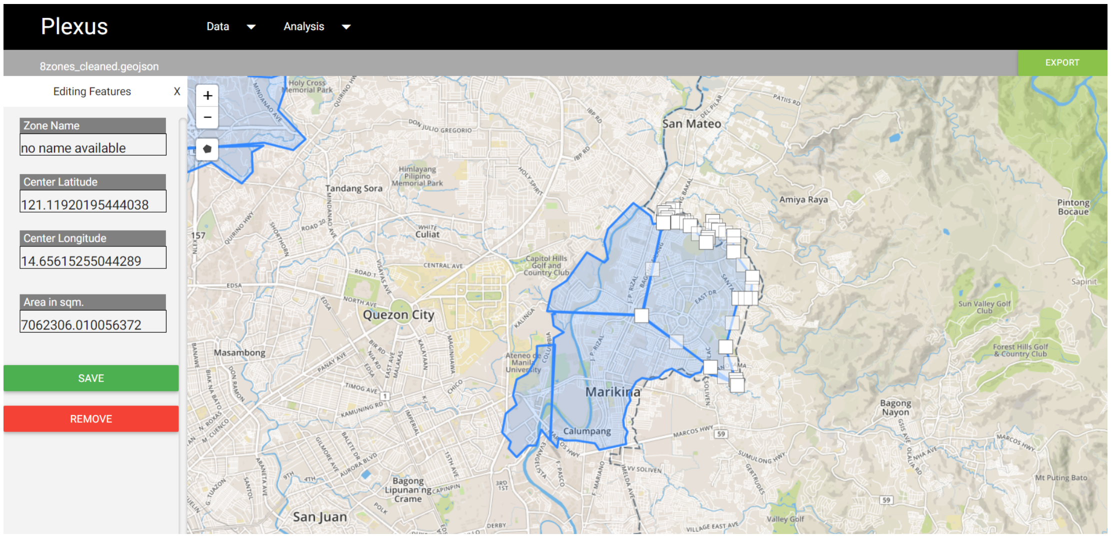


Figure 4.3: Screen of Traffic Analysis Zone Manager.

The visualization of the routes can be seen in Figure 4.4. The system lets the user choose a route from the dropdown box. Once a route is selected, the OD pair is highlighted in the map and details associated to the route are displayed in the lower left box of the screen. The details shown are the overall distance, the current number of PUJs serving the route, and the computed RMC.

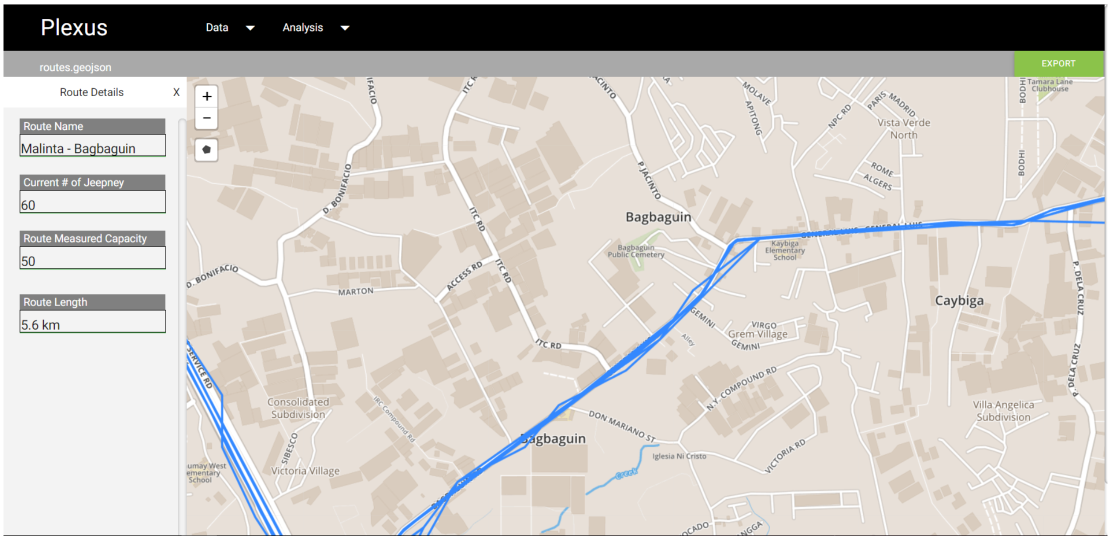


Figure 4.4: Screen of Route Visualization.

4.6 Physical Environment and Resources

4.6.1 Software Resources

General Transit Feed Specification (GTFS)

GTFS contains transit data and other associated geographic information from public transit agencies. This was used to gather data on jeepney routes and stops. The data is in .txt format.

OpenStreetMap (OSM)

OSM is an open-source editable map that can be used in geographic information systems (GIS). The visualization of a map with its corresponding road networks can be done with OSM. Data formats such as JSON and GeoJSON are used to load maps.

OpenTripPlanner (OTP)

OTP is an open-source platform for trip planning. It is used to filter out the commuter routes needed in the modules. Transfers between different public transportation system can also be obtained from OTP, as well as the shortest trips.

Chapter 5

Detailed Implementation

This chapter discusses the detailed implementation of the algorithms, along with sample scenarios for each module.

5.1 Data Preprocessing

The model used the dataset of jeepney routes in GTFS but it contains excess information that the model does not need. Due to this, the dataset was filtered in order to fit into the model.

The routes dataset contains the following information: agency id, url, short name, long name, text color, description, route id and route type. The description contains the stops information of the jeepney routes, was used to identify the jeepney routes within Valenzuela City and Marikina City. Once the routes have been identified, the only attributes that were considered are route id and route long name. Route id serves as the unique identifier for each route, while route long name contains the full name of the route. The routes were categorized into two characteristics: intracity, which refers to a route that operates mainly on one city and intercity, which represents a route that goes far beyond the boundary of a city. The said filtered route data is listed in Appendix G.

5.2 Traffic Analysis Zones

Traffic analysis zones (TAZs) are geospatial divisions of a land area. These zones set the scope for the analysis and set boundaries for the household data. TAZs are specially important for route filtering and in computing for the travel costs. In this study, there are TAZs that represent single or merged barangays. In total, the zones used in the next modules were 17 different sized zone. In the process of experimenting, some zones get merged or split to observe the effects of having a smaller or larger division of zones to the computed passenger demand.

5.3 Route Filtering

Route Filtering identifies the jeepney routes that travel between zones. Figure 5.1 shows the step-by-step process of this module.

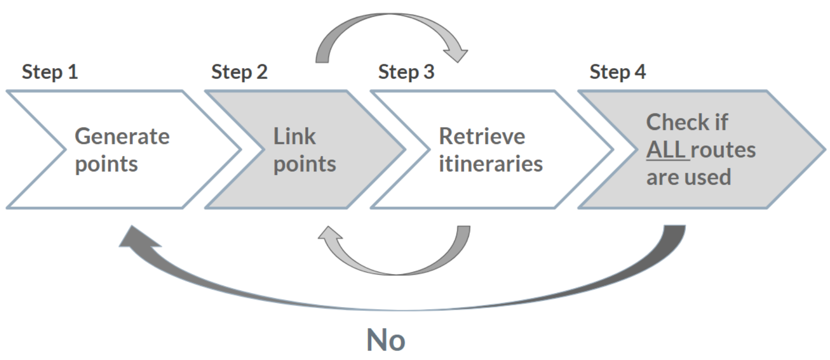


Figure 5.1: Process of Route Filtering.

The process starts by looking at a pair of zones. First, we generate five random points in each zone. We now have a pool of ten (10) points that we paired. Linking can either be within a zone (intrazonal) as shown in Figure 5.2 or across the other zone (interzonal) as shown in Figure 5.3.

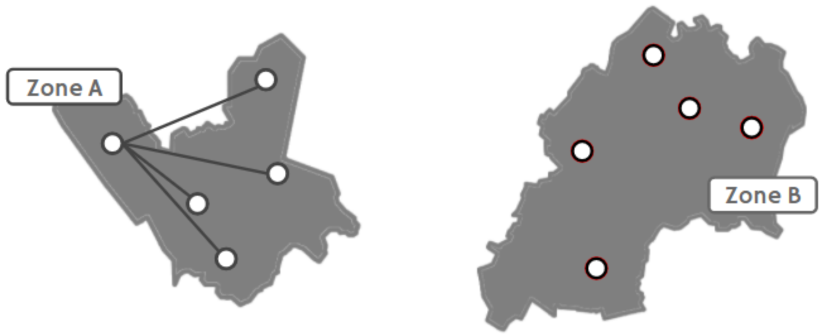


Figure 5.2: Linking of intrazonal points.

Figure 5.3: Linking of interzonal points.

When two points are already linked to each other, third step is to retrieve a list of itineraries from OpenTripPlanner (OTP), an open-source multi-modal planner. An itinerary consists of details on how to get from one point to another using different modes of transportation, including the routes to be used, the travel time and fare. We restricted all itineraries to use only the jeepney routes as they are the ones relevant to the study. At a time, OTP generates a maximum of three itineraries that have the least travel time.

Steps two and three are repeated until all points have been linked to each other. However, the linkage of points from Zone A to Zone B is different from Zone B to Zone A. When there are more than two zones in the study, the first three steps of route filtering are repeated for every zone. After getting all the itineraries between zones, the last step is to check if all routes shown in Appendix G have at least occurred once in the retrieved itineraries. The basis for checking this is through the route id. If otherwise, the first step is repeated, but this time increasing the number of points generated for each zone. This is done in order to retrieve more itineraries, consequently covering more routes. We tried and checked this from two, three, and five points per zone.

The itineraries are then used as the basis for splitting of the trips in the traffic assignment module.

5.4 Traffic Assignment

After we have generated trip itineraries between traffic analysis zones, the next step is to distribute the trips to these itineraries. Itineraries are used instead of routes to better observe the utility of each jeepney route.

The origin-destination matrix for the jeepney mode, as seen in Table 5.1, was used to distribute trips. The matrix contains a balanced distribution of trips for the 17 traffic analysis zones between Valenzuela and Marikina. The complete table of the OD matrix is listed in Appendix H.

Table 5.1: Origin-Destination matrix for the jeepney mode between 17 zones

Zone	**1**	**2**	**:**	**17**
1	2054.20	1243.88	:	:
2	3143.45	1681.74	:	:
:	:	:	:	:
17	:	:	:	:

We first computed for the cost of each itinerary using a multinomial logit model (Equation 5.2). It associates values for the utility of each itinerary based on the data collected from different sources such as OTP and CBMS.

The probability that an itinerary is used gets higher when its utility is higher compared to the other itineraries. However, there is also disutility in the function which is the generalized cost of each itinerary to get from one zone to another and is defined in Equation 5.1.

$$c_{ij}^{I} = t_{ij}^{I} s_i + f_{ij}^{I} \tag{5.1}$$

where

c_{ij}^I is the cost of itinerary I from zone i to zone j;

t_{ij}^I is the travel time of taking itinerary I to get from zone i to zone j;

s_i is the average hourly income of people in zone i; and

f_{ij}^I is the monetary cost of an itinerary I from zone i to zone j.

The hourly income is multiplied to the travel time in order to normalize the unit of measurement of the cost, which is in terms of Philippine currency.

The travel time and total fare using jeepney as the mode of transportation is extracted from OTP and is shown in Table 5.2, while the average hourly income of people per zone that was derived from CMBS is shown in Table 5.3. The complete table of the average income is listed in Appendix I.

Table 5.2: Computed travel time and total fare per itinerary from OTP

Zone i	Zone j	Itinerary No.	Travel Time (hr)	Fare (₱)
1	1	1	1.1494	25.50
		2	2.1536	34.50
		3	2.1883	34.50
		4	0.7969	17.00
		5	1.8781	33.00
		6	1.9128	33.00
		7	1.1492	25.50
		8	2.2394	36.00
		9	2.2883	36.00
		10	0.4817	8.50
		11	0.4817	8.50
		12	0.4817	8.50
		13	0.7964	17.00
		14	1.9633	34.50
		15	2.0119	34.50
		16	0.4811	8.50
		17	0.4811	8.50
		18	0.4811	8.50
1	2	1	1.0853	17.00

		2	1.2172	17.00
		3	1.2511	17.00
		4	1.0869	25.50
		5	1.9039	31.50
		6	1.9386	31.50
		7	1.0450	25.50
		8	1.7347	31.50
		9	1.7694	31.50
		10	1.4783	20.00
		11	1.4783	20.00
		12	1.4786	20.00
		13	0.6947	8.50
		14	0.6947	8.50
		15	0.6950	8.50
		16	0.6528	8.50
		17	0.6528	8.50
		18	0.6528	8.50
		19	1.1775	17.00
		20	1.2022	18.50
		21	1.2022	18.50
		22	0.4186	8.50
		23	0.4186	8.50
		24	0.4189	8.50
		25	0.3767	8.50
		26	0.3767	8.50
		27	0.3767	8.50
2	1	1	1.0906	17.00
		2	1.3036	18.50
		3	1.3522	18.50
		4	1.4778	20.00
		5	1.4778	20.00
		6	1.4786	20.00
		7	1.2022	18.50
		8	1.2022	18.50
		9	1.2031	18.50
		10	1.0861	25.50
		11	1.9892	33.00
		12	2.0378	33.00
		13	0.6942	8.50
		14	0.6942	8.50

		15	0.4186	8.50
		16	0.4186	8.50
		17	1.0453	25.50
		18	1.8211	33.00
		19	1.8697	33.00
		20	0.6533	8.50
		21	0.6533	8.50
		22	0.3778	8.50
		23	0.3778	8.50
		24	0.3778	8.50
		25	1.1694	25.50
		26	2.0725	33.00
		27	0.7775	8.50
		28	0.7775	8.50
		29	0.5019	8.50
2	2	1	1.2281	17.00
		2	1.2281	17.00
		3	1.2289	17.00
		4	1.0589	17.00
		5	1.0589	17.00
		6	1.0597	17.00
		7	1.2281	17.00
		8	1.2281	17.00
		9	1.2281	17.00
		10	0.4022	8.50
		11	0.4022	8.50
		12	0.4022	8.50
		13	1.0600	17.00
		14	1.0600	17.00
		15	1.0603	17.00
		16	0.4033	8.50
		17	0.4036	8.50
		18	0.4036	8.50
		19	1.3114	17.00
		20	1.3114	17.00
		21	1.3114	17.00

Table 5.3: Average hourly income per zone (₱) from CBMS

Zone	Average Hourly Income (₱)
1	120.48
2	63.64
:	:
17	:

Table 5.4 shows the total travel cost of using an itinerary to travel from one zone to another using Equation 5.1.

Table 5.4: Computed travel cost per itinerary

Zone i	Zone j	Itinerary No.	Travel Cost (₱)
1	1	1	163.98
		2	293.96
		3	298.14
		4	113.01
		5	259.26
		6	263.45
		7	163.95
		8	305.80
		9	311.69
		10	66.53
		11	66.53
		12	66.53
		13	112.95
		14	271.04
		15	276.89
		16	66.46
		17	66.46
		18	66.46
1	2	1	147.75
		2	163.65
		3	167.73

		4	156.45
		5	260.88
		6	265.06
		7	151.40
		8	240.49
		9	244.68
		10	198.11
		11	198.11
		12	198.14
		13	92.20
		14	92.20
		15	92.23
		16	87.14
		17	87.14
		18	87.14
		19	158.86
		20	163.34
		21	163.34
		22	58.93
		23	58.93
		24	58.97
		25	53.88
		26	53.88
		27	53.88
2	1	1	86.40
		2	101.46
		3	104.55
		4	114.04
		5	114.04
		6	114.09
		7	95.00
		8	95.00
		9	95.06
		10	94.61
		11	159.58
		12	162.67
		13	52.67
		14	52.67
		15	35.14
		16	35.14

		17	92.02
		18	148.89
		19	151.98
		20	50.08
		21	50.08
		22	32.54
		23	32.54
		24	32.54
		25	99.92
		26	164.88
		27	57.98
		28	57.98
		29	40.44
2	2	1	95.15
		2	95.15
		3	95.20
		4	84.38
		5	84.38
		6	84.44
		7	95.15
		8	95.15
		9	95.15
		10	34.10
		11	34.10
		12	34.10
		13	84.45
		14	84.45
		15	84.47
		16	34.17
		17	34.18
		18	34.18
		19	100.45
		20	100.45
		21	100.45

After deriving all the costs of each itinerary going from zone to zone, the multinomial logit model defined in Equation 5.2 was used to determine the probability that trips are traveled using a specific itinerary as shown in Table 5.5. The computed travel cost is inversely proportional to the portion of trips to be distributed in the itineraries; the higher the cost of traveling from zone i to zone j, the lower probability that trips are distributed to itinerary I.

$$P_{ij}^{I} = \frac{e^{-\beta c_{ij}^{I}}}{\sum e^{-\beta c_{ij}^{I}}} \tag{5.2}$$

In the multinomial logit model (Equation 5.2), the proportion of trips by itinerary I from zone i to zone j and the costs of traveling from zone i to zone j using the itinerary I are denoted by P_{ij}^{I} and c_{ij}^{I}, respectively. Moreover, β denotes the parameter for calibration of the generalized cost.

Table 5.5: Probability of trips distributed to each itinerary

Zone i	**Zone j**	**Itinerary No.**	**Probability**
1	1	1	0.0524
		2	0.0254
		3	0.0248
		4	0.0696
		5	0.0308
		6	0.0301
		7	0.0524
		8	0.0238
		9	0.0230
		10	0.0902
		11	0.0902
		12	0.0902
		13	0.0696
		14	0.0289
		15	0.0280
		16	0.0902
		17	0.0902
		18	0.0902
1	2	1	0.0312
		2	0.0278
		3	0.0270
		4	0.0293
		5	0.0138
		6	0.0134
		7	0.0304

		8	0.0160
		9	0.0155
		10	0.0217
		11	0.0217
		12	0.0217
		13	0.0465
		14	0.0465
		15	0.0465
		16	0.0483
		17	0.0483
		18	0.0483
		19	0.0288
		20	0.0279
		21	0.0279
		22	0.0591
		23	0.0591
		24	0.0591
		25	0.0613
		26	0.0613
		27	0.0613
2	1	1	0.0312
		2	0.0262
		3	0.0253
		4	0.0227
		5	0.0227
		6	0.0227
		7	0.0282
		8	0.0282
		9	0.0282
		10	0.0284
		11	0.0134
		12	0.0130
		13	0.0459
		14	0.0459
		15	0.0562
		16	0.0562
		17	0.0292
		18	0.0152
		19	0.0147
		20	0.0473

		21	0.0473
		22	0.0579
		23	0.0579
		24	0.0579
		25	0.0267
		26	0.0126
		27	0.0432
		28	0.0432
		29	0.0528
2	2	1	0.0343
		2	0.0343
		3	0.0342
		4	0.0395
		5	0.0395
		6	0.0395
		7	0.0343
		8	0.0343
		9	0.0343
		10	0.0770
		11	0.0770
		12	0.0770
		13	0.0395
		14	0.0395
		15	0.0395
		16	0.0769
		17	0.0769
		18	0.0769
		19	0.0319
		20	0.0319
		21	0.0319

The number of trips distributed to an itinerary is derived from multiplying the trip value of an OD pair to the resulting probability of the itinerary obtained earlier. Each route that is present on that itinerary gets the same number of trips that was distributed to that itinerary. Table 5.6 shows the sample output for traffic assignment.

Table 5.6: Output of Traffic Assignment

Zone i	Zone j	Itinerary No.	Number of Trips
1	1	1	108
		2	52
		3	51
		4	143
		5	63
		6	62
		7	108
		8	49
		9	47
		10	185
		11	185
		12	185
		13	143
		14	59
		15	57
		16	185
		17	185
		18	185
1	2	1	39
		2	35
		3	34
		4	36
		5	17
		6	17
		7	38
		8	20
		9	19
		10	27
		11	27
		12	27
		13	58
		14	58
		15	58
		16	60
		17	60
		18	60
		19	36

		20	35
		21	35
		22	74
		23	74
		24	74
		25	76
		26	76
		27	76
2	1	1	98
		2	82
		3	80
		4	71
		5	71
		6	71
		7	89
		8	89
		9	89
		10	89
		11	42
		12	41
		13	144
		14	144
		15	177
		16	177
		17	92
		18	48
		19	46
		20	149
		21	149
		22	182
		23	182
		24	182
		25	84
		26	40
		27	136
		28	136
		29	166
2	2	1	58
		2	58
		3	58

		4	66
		5	66
		6	66
		7	58
		8	58
		9	58
		10	129
		11	129
		12	129
		13	66
		14	66
		15	66
		16	129
		17	129
		18	129
		19	54
		20	54
		21	54

5.5 Trip Consolidation

After distributing all the trips to the different itineraries, jeepney routes have independent number of trips depending on which itinerary/s they belong to. This module determines the total number of trips that a certain route has been distributed to, by consolidating the trip values per route based on their id. The next to be consolidated is the trips of routes that have the same name but different ids.

A pseudocode of the process is shown below:

Algorithm 1 Consolidation of Trips

```
routes_list ← filteredJeepneyRoutes

function getIndexByRouteID(routeID)
    for i to n do
        if route_list.n == routeID then
            return n                    ▷ n is the index of current route in route list
        end if
    end for
end function

for zone i do
    for zone j do
        for itinerary k do
            for route m do
                n ← getIndexByRouteID(m.id)
                routes_list.n ← routes_list.n + m.trips
            end for
        end for
    end for
end for
```

The *routes_list* is defined as the list that contains the filtered routes and also a container for the consolidated trips for each of the route. Every time a route is encountered in the for loop, it goes in the function getIndexByRouteID in order to get the specific container of that route in the routes_list. When this is already known, it gets the current number of trips distributed into that route and stores it into the container. The value for each route adds up until all trips have been consolidated.

However, the current routes dataset (Appendix G) used in this module is different from the dataset we got from an expert, which is to be used for the computation of the RMC. Due to this, there is a need to map the filtered GTFS routes to the new routes dataset.

5.5.1 Mapping of Jeepney Routes

The GTFS routes that have the same name are immediately mapped to a single route in the new dataset. For the routes having a number of en route to a destination, they are mapped with the more general route name as shown in the sample in Table 5.7.

Table 5.7: Mapped jeepney Routes

<table>
<tr><th>Route Long Name (GTFS)</th><th>Route Name</th></tr>
<tr><td>Calumpang - Cubao via 20th Ave., P. Tuazon</td><td rowspan="5">Calumpang-Cubao</td></tr>
<tr><td>Calumpang - Cubao via 20th Ave., P. Tuazon</td></tr>
<tr><td>CUBAO - CALUMPANG via H ROXAS</td></tr>
<tr><td>CUBAO - KALUMPANG</td></tr>
<tr><td>CUBAO - KALUMPANG</td></tr>
<tr><td>Karuhatan Sta Cruz via Fuentes</td><td rowspan="2">Karuhatan-Sta Cruz</td></tr>
<tr><td>Karuhatan Sta Cruz via Fuentes</td></tr>
<tr><td>Malanday - Pier South via Rizal Ave., P. Burgos</td><td rowspan="4">Malanday-Pier South 15</td></tr>
<tr><td>Malanday - Pier South via Rizal Ave., P. Burgos</td></tr>
<tr><td>PIER-MALANDAY</td></tr>
<tr><td>PIER-MALANDAY</td></tr>
</table>

After mapping all GTFS routes to the new set of routes, the trips are consolidated once again, but this time using the mapped routes. Once all routes contain the consolidated trip value, this value is used as the passenger demand of the routes in the RMC formula.

5.6 Route Measured Capacity

Once the number of trips have been consolidated for each route, we then used it as the passenger demand for computing the Route Measured Capacity (RMC) using Equation 5.3. The RMC is represented by the following formula:

$$RMC = \frac{PD}{UR \times VLF \times ASC \times NRT} \tag{5.3}$$

with the following notations:

RMC: the route measured capacity for a specific route

PD: the passenger demand derived from consolidating the jeepney trips for a jeepney route

UR: the utilization ratio of a jeepney route

$$UR = \frac{\text{units in operation}}{\text{actual fleet size}} \tag{5.4}$$

VLF: the viable load factor of a jeepney route

$$VLF = \frac{C_a + I_a}{S_c \times f} \tag{5.5}$$

ASC: the average seating capacity of jeepneys

NRT: the number of round trips of a jeepney route

After consolidating the values for all routes, the value of each becomes the passenger demand of the route. Originally in the RMC formula, seasonality factor is further multiplied to the passenger demand to consider certain times of the year that have much more commuters in the country. However in this study, we did not consider it.

The utilization ratio is derived by dividing the current number of operating units to the actual fleet size based on franchise records. We extracted the data from the dataset upon consultation with an expert. Take for an example the Antipolo-Cubao (via Sumulong Hi-way) route, currently it has 146 units and a fleet size of 124 as per franchise records. By applying the formula, we get a utilization ratio of 1.18.

For the average seating capacity, we used a constant value of 22 for all the routes as the seating capacity ranges from 12-32.

The load factor expresses the ratio of the demand to the supply. It demonstrates the average load on a route throughout the day. The higher it is, the more profitable the operation. We computed for it by dividing the revenue to the product of the average seating capacity of jeepney to the fare rate per kilometer which is ₱1.50. Having a revenue of 11.32 divided by the product of 22 and 1.50, the resulting load factor is 0.34.

The number of round trips is based on the distance of the route derived from Table 3.1. The route in the example has a total distance of 19.72, which is equivalent to 6.2 round trips.

Table 5.8 contains the data mentioned in the sample computation and the resulting RMC for the route, which is 63 units. The complete table for the RMC results is listed in Appendix J.

Table 5.8: Route Measured Capacity per route

Route Name	UR	VLF	ASC	NRT	PD	RMC
Antipolo-Cubao (via Sumulong Hiway)	1.18	0.34	22	6.2	3441	63

Chapter 6

Results and Analysis

This chapter discusses the methodology used in validating the computed Route Measured Capacity (RMC) and the analysis and interpretation of the results. It also presents the different scenarios along with the test results from each module.

6.1 Evaluation Strategy

This section discusses the strategy done by the researchers in evaluating the results. Firstly, fieldwork was done to validate some of the input data that was used in the computation of RMC. Furthermore, the effects of modifying the parameters of the cost function was also observed.

6.2 Validation of Input Data

Since most of the data used in the calculation of RMC was dated 2012, the researchers decided to validate these data through field investigation. Interviews and surveys were conducted in order to validate some of the parameters used for the RMC formula. The chosen route for observation is Malinta–Bagbaguin whose route starts at Mavanoda terminal in Valenzuela, was chosen for the following reasons:

1. the route covers shorter distances; and
2. the route travels within the scope of study Valenzuela.

The route Malinta – Bagbaguin was the focus of the observation of the researchers. This specific route was selected since it is an intercity route, i.e. most of the route covered are within Valenzuela.

The investigation began by riding the jeepney for a whole day. This started at 7 AM and ended at 7 PM. Although the initial plan was to follow only one jeepney for a day, the plan changed since the jeepneys typically stop operating after about 2–3 round trips. Every time the jeepney being followed stops operating, another jeepney from the terminal is chosen to be followed. Usually, the jeepey drivers stop operating during non-peak hours 10 AM to 3 PM in the afternoon and 7 PM onwards.

Load Capacity

The first ride departed at exactly 7:02 AM. In the first round trip, the common stops were taken note of. These common stops became the checkpoint marker at which point in time the current passenger load is recorded. In the process of recording the passenger load, the two seats occupied by the researchers were not counted. These two seats are always subtracted to the seating capacity and passenger count.

As it can be seen in Figure 6.1, it shows the current load factor per stop when traveling out of the terminal. The average loading factor for the jeepney going to and from Bagbaguin was 71.17%. For each stop going out of the terminal, it remained nearly above 60% all throughout until the final stop. This can be an indicator that this route has a high demand of people commuting out of Malinta area.

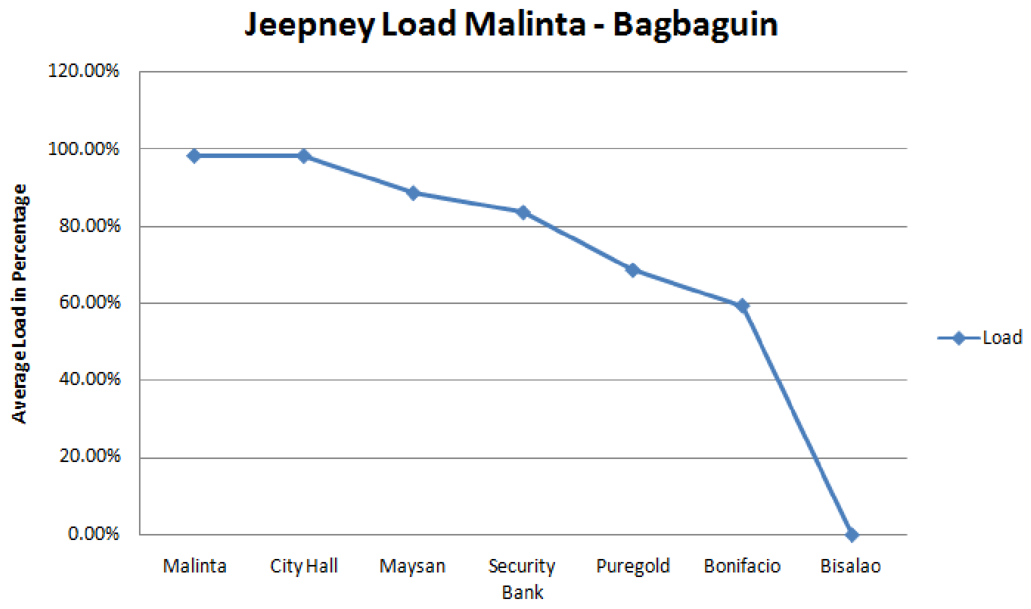


Figure 6.1: Average loading capacity per stop going to Bagbaguin.

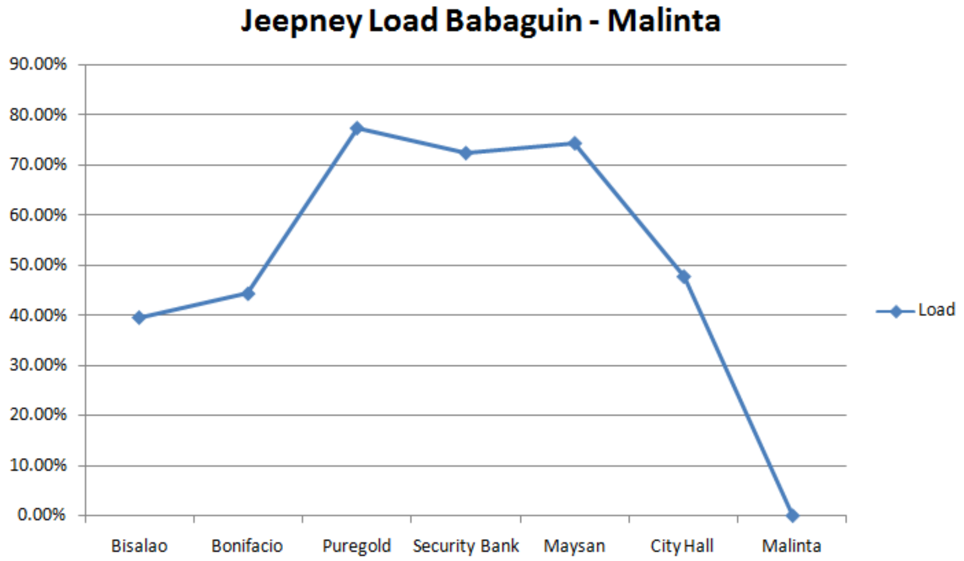


Figure 6.2: Average loading capacity per stop going back to the terminal.

Comparing the two graphs, it can be seen that the Figure 6.2 has a rather lower passenger load since the starting point is not a terminal. Returning to Mavanoda terminal, the jeepneys on average still reach the threshold of 60% passenger load along their trip. These passengers are mostly coming from establishments such as shopping malls, banks and schools.

Passenger Demand

Another data collected from the field investigation was the total number of passengers who went up and down the jeepney. This data was also recorded since it is not possible to count the passenger demand from the current passenger load every major stop. Some passengers go up and down in between the stops since jeepneys in general do not have a designated stops and people can board and alight anywhere.

Using the passenger data from the field investigation, it was counted that there are 117 passengers in a day for a jeepney. This was further multiplied to 60 to take into account the number of jeepneys in operation. This resulted with the total of 7020 passengers in a day.

Using this value for the PD parameter in the RMC formula from Equation 5.3, we arrived at the following results. (Shown on Table 6.1)

Table 6.1: Computed RMC from Field Investigation

PD	UR	VLF	ASC	NRT	RMC
7020	1.07	0.717	22	6	69

Based from this calculation, it means that the recommended number of jeepneys for the jeepney route Malinta–Bagbaguin is approximately 69 units.

6.3 Comparison of computed RMC with existing data on the number of franchises and units

The percent difference of the computed RMC with regards to the existing data on the number of units and franchise is in Appendices K and L.

6.3.1 Results and Analysis of an Intercity Route

Table 6.2 is an example of an intercity route. It can be observed that its resulting RMC has a high discrepancy with the actual number of jeepney. Observing this in the route visualization module, it is noted that with its 19 km route distance, only a part of this route actually passes through the city of Marikina. Since the travel demand data that was distributed to this route was only from Marikina, it is possible that other zones such as Quezon, Pasig and Manila City, which this route also passes through might have been overlooked. The hypothesis is that it has failed to take into account all the passenger demand value when computing for its RMC which is why intracity routes were analyzed.

Table 6.2: Percent Difference of Antipolo-Cubao (via Imelda Avenue) to the current number of units and franchises

Route Name	No. of Current Units	No. of Franchises	RMC	Percent Difference (with current units)	Percent Difference (with franchises)
Antipolo-Cubao (via Imelda Avenue)	112	86	32	111.11%	91.53%

6.3.2 Results and Analysis of an Intracity Route

The route Parang-Marikina is an intracity route of Marikina City, it can be seen in Table 6.3 that the computed RMC has low discrepancies with the actual jeepney units. The list of intracity RMC computation can be seen in appendix L. On average, the percent difference for intracity is better compared the results of the intercity.

Table 6.3: Percent Difference of Parang-Marikina to the current number of units and franchises

Route Name	No. of Current Units	No. of Franchises	RMC	Percent Difference (with current units)	Percent Difference (with franchises)
Parang-Marikina	111	97	97	13.46%	0.00%

6.4 Effects of Changing Parameters

The sensitivity of each parameter of the generalized cost for an itinerary was observed, in order to know how can it affect the distribution of trips and RMC of routes.

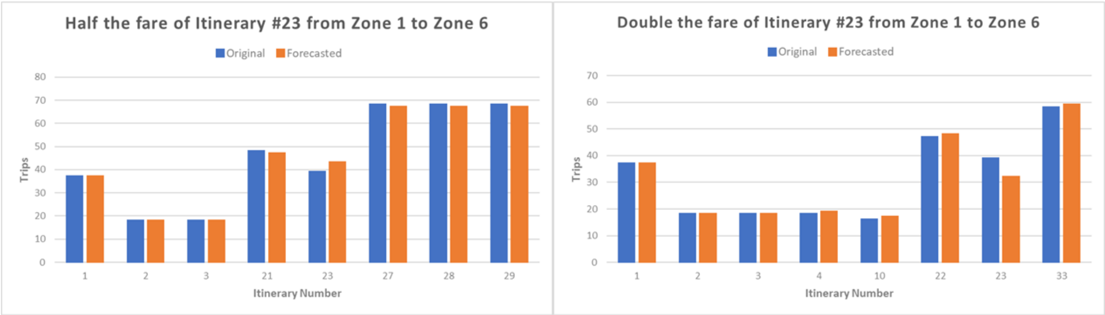
In the following experiments, the observed itinerary was the Itinerary No. 23 of Zone 1 to 6. This itinerary was chosen because it is the first instance which covers the maximum number of routes that are all within the study area. It contains the following routes: Heritage Homes-Monumento (via NLEX), Karuhatan-Ugong (Valenzuela), Malanday-Pier South 15 and Novaliches-Malinta.

6.4.1 Traffic Assignment

The experiments under traffic assignment modifies the generalized cost. The distribution of trips to the itineraries was observed to see how the calibration of the parameters affects how the trips were distributed.

Increasing and Decreasing of Fare

For this experiment, the parameter that was changed is the travel fare of the cost function. Its effect to the traffic assignment module was observed.



(a) Halved Travel Fare (b) Doubled Travel Fare

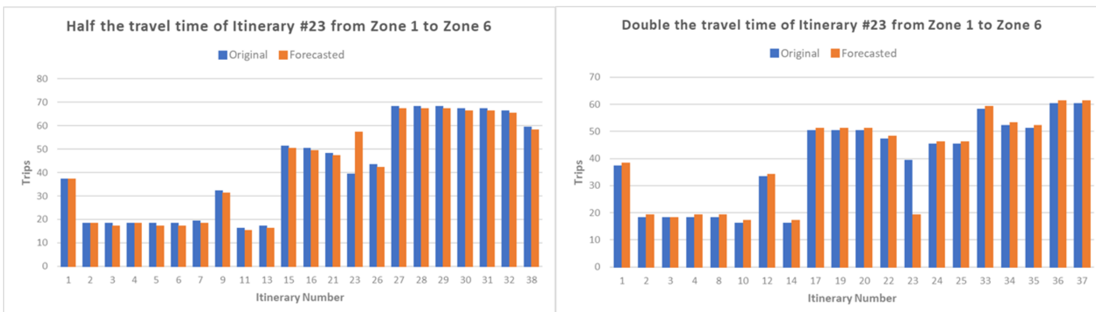
Figure 6.3: Trips of Itineraries from Zone 1 to Zone 6 Trips With Varied Travel Fare of Itinerary No. 23.

Figure 6.3a shows how the decrease in travel fare of Itinerary No. 23 affects the distribution of trips for all itineraries going from Zone 1 to Zone 6. In this experiment, the fare of Itinerary No. 23 was halved. As seen in the graph, the decreasing of fare caused the forecasted number of trips to slightly increase as compared to its original value. With a lesser fare cost, Itinerary No. 23 became more ideal, thus its trips increased. The increased trips from Itinerary No. 23 were taken from other itineraries, in this case from Itinerary Nos. 21, 27, 28 and 29.

Whereas, Figure 6.3b shows how the increase in travel fare of Itinerary No. 23 affects the distribution of trips for all itineraries going from Zone 1 to Zone 6. In this experiment, the fare of Itinerary No. 23 was doubled. As seen in the graph, the increasing of fare caused the forecasted number of trips to slightly decrease as compared to its original value because with a higher fare cost, Itinerary No. 23 became less ideal, thus its trips decreased. The trips reduced from Itinerary No. 23 were transferred to Itinerary Nos. 4, 10, 22 and 33.

Increasing and Decreasing of Travel Time

For this experiment, the parameter that was changed is the travel time of the cost function. Its effect to the traffic assignment module was observed.



(a) Halved Travel Time　　(b) Doubled Travel Time

Figure 6.4: Trips of Itineraries from Zone 1 to Zone 6 Trips With Varied Travel Time of Itinerary No. 23.

Figure 6.4a shows how the decrease in travel time of Itinerary No. 23 affects the distribution of trips for all itineraries going from Zone 1 to Zone 6. In this experiment, the travel time of Itinerary No. 23 was halved. As seen in the graph, the decreasing of travel time caused the forecasted number of trips to significantly increase as compared to its original value because with a lesser travel time, Itinerary No. 23 became more ideal, thus its trips increased. Due to the increased trips from the observed itinerary, the trips of Itinerary Nos. 3, 5, 6, 7, 9, 11, 13, 15, 16, 21, 26, 27, 28, 29, 30, 31, 32 and 38 decreased accordingly. The total number of trips decreased in the said itineraries is equal to the number of trips increased in Itinerary No. 23.

On the other hand, Figure 6.4b shows how the increase in travel time of Itinerary No. 23 affects the distribution of trips for all itineraries going from Zone 1 to Zone 6. In this experiment, the travel time of Itinerary No. 23 was doubled. As seen in the graph, the increasing of travel time caused the forecasted number of trips to significantly decrease as compared to its original value because with a higher travel time, Itinerary No. 23 became less ideal, thus its trips decreased. Due to the reduced trips from the observed itinerary, the trips of Itinerary Nos. 1, 2, 4, 8, 10, 12, 14, 17, 19, 20, 22, 24, 25, 33, 34, 35, 36 and 37 increased accordingly.

Similar to the experiments done by changing the fare, the number of trips of the observed itinerary either increase or decrease. The increase or decrease in trips were taken from or transferred to the other itineraries of the same Origin-Destination pair.

The previous experiments also proves that the cost is inversely proportional to the number of trips. When the fare and travel time were decreased, the number of trips of that itinerary increases but when they were increased, the number of trips decreases thus, proving the statement.

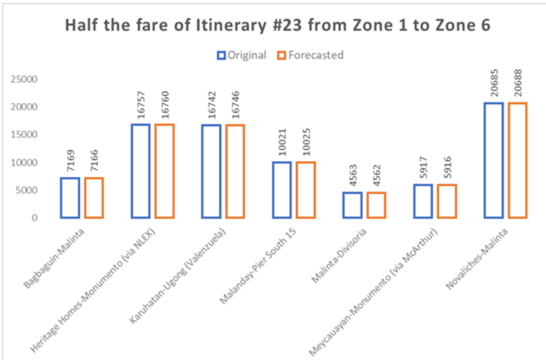
As explained in the earlier paragraphs, the effect of increasing and decreasing the fare was insignificant while increasing and decreasing the travel time had a significant effect on the distribution of trips to the itineraries. This can mean that between fare and travel time, the latter is more likely to be the deciding factor on whether a certain itinerary will be used to travel from a one zone to another.

6.4.2 Trip Consolidation

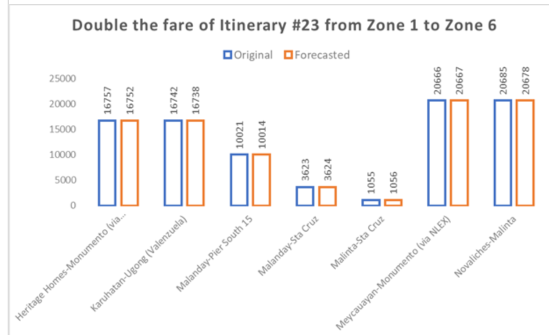
The experiments from the previous module are passed down to trip consolidation, wherein the parameters of the generalized cost are modified. The number of trips consolidated per route was observed to see how the calibration of the parameters affects it, specifically those of the following routes under Itinerary No. 23: Heritage Homes-Monumento (via NLEX), Karuhatan-Ugong (Valenzuela), Malanday-Pier South 15 and Novaliches-Malinta.

Increasing and Decreasing of Fare

For this experiment, the parameter that was changed is the travel fare of the cost function. Its effect to the trip consolidation module was observed.



(a) Halved Travel Fare



(b) Doubled Travel Fare

Figure 6.5: Trips of Itineraries from Zone 1 to Zone 6 Trips With Varied Travel Fare of Itinerary No. 23.

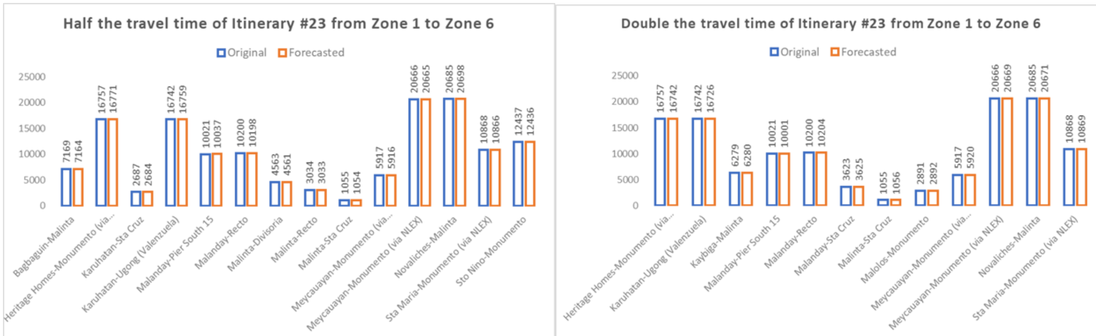
As seen in the experiments from the previous module, there is an insignificant change in the forecasted number of trips when the fare is changed. There is only a 0.024% increase and 0.027% decrease in the forecasted trips to its original value. In this experiment, only 7 out of the 58 routes were affected as shown in Figure 6.5a. The consolidated trips of the routes under Itinerary No. 23 increased due to the increased trips from Itinerary No. 23 on the traffic assignment module.

Figure 6.5b shows the decrease in the consolidated trips of the routes under Itinerary No. 23 when the fare is doubled. There is only a 0.042% increase and 0.039% decrease of the forecasted trips to its original value. In this experiment, there are also only 7 routes affected by the changed generalized cost. The consolidated trips of the routes under Itinerary No. 23 decreased due to the reduced trips from Itinerary No. 23 on the traffic assignment module.

As seen in this experiment, both the percent increase and percent decrease are low. This is because the effect of changing the fare on the previous module is very minimal. Subsequently, the consolidated trips of the routes in trip consolidation also show a minimal change.

Increasing and Decreasing of Travel Time

For this experiment, the parameter that was changed is the travel time of the cost function. Its effect to the trip consolidation module was observed.



(a) Halved Travel Time

(b) Doubled Travel Fare

Figure 6.6: Trips of Itineraries from Zone 1 to Zone 6 Trips With Varied Travel Time of Itinerary No. 23.

Figure 6.6a shows the increase in the consolidated trips of the routes under Itinerary No. 23 when the travel time is halved. The effect of changing the travel time produces a greater change between the forecasted and the original trips, however, it is still an insignificant change. There was a 0.102% percent increase and only a 0.042% percent decrease. In this experiment, there were much more routes that were affected as compared to the previous experiment on the fare. Out of the 58 routes, there were 14 routes affected this time.

On the other hand, Figure 6.6b shows the decrease in the consolidated trips of the routes under Itinerary No. 23 when the travel time is doubled. The percent increase this time was 0.039%, while the percent decrease was 0.113%. There are 12 routes affected in this experiment.

Both the percent increase and percent decrease of changing the travel time are still low, but it is higher compared to changing the fare. This is due to the greater effect of travel time to the distribution of trips in the itineraries on the previous module. Subsequently, there are more routes affected when changing the travel time, as opposed to the fare.

6.4.3 Route Measured Capacity

The experiments from the previous module are passed down to route measured capacity, wherein the parameters of the generalized cost are modified. The desired fleet size per jeepney route was observed to see how the calibration of the parameters affects it.

Decreasing of Travel Time

For this experiment, the parameter that was changed is the travel time of the cost function. Its effect to the route measured capacity was observed.

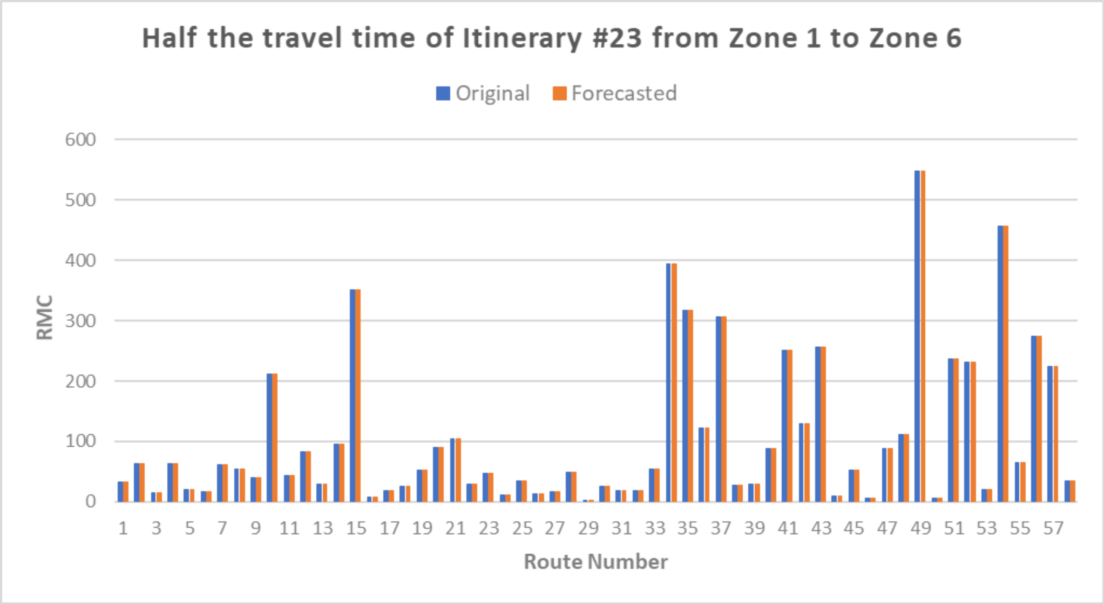


Figure 6.7: Halved Travel Time.

In Figure 6.7, it can be seen that all forecasted trips stayed the same as the original values due to the insignificant change brought by the previous modules. The change in the consolidated trips or the passenger demand was very minimal, resulting to the RMC values staying the same.

It is observed that before a value can either increase or decrease, there must be a significant change between the original and forecasted RMC. However, the average difference in the increase and decrease between the values is only 6 units.

Chapter 7

Conclusion & Recommendations

7.1 Conclusion

For each OD pair in the matrix obtained from the Travel Demand Module, its travel demand value was further distributed to the different jeepney routes. The data obtained from OpenTripPlanner was used to incorporate weights to the distribution of the demand. After this, each value distributed to a route is consolidated to be used as the passenger demand of a jeepney route. The total demand was later on plugged in to the RMC formula.

The researchers were able to extend the study on RMC by changing the method of obtaining the data on Passenger Demand. Using geospatial data, the passenger demand was able to be estimated. This method can be a good alternative since the current method used in getting the passenger demand is through conducting surveys and that will require a lot of manual processing before getting the data.

Next, the result of the RMC for the route Malinta-Bagbaguin was validated through field investigation. Comparing the actual observed passenger demand to the generated demand of Maxima, the results for the intracity routes were not very far apart. This can signify that estimating the passenger demand using the geospatial data is a possible alternative when computing for RMC of a certain route given that all zones passed through by the route has travel demand data.

The visualization of the GTFS route data was displayed on Maxima. This data was cleaned by the Plexus team upon using. This visualization is the basis of the list of jeepney routes for the OTP. After computing for the result, the calculated RMC for each jeepney route is also reflected in the visualization.

Upon validating the RMC of Malinta-Bagbaguin route, it was discovered that the computed RMC for this intracity route was close to the actual number of units. Since the study only has data for Valenzuela and Marikina City, not all jeepney routes used by the two cities were successfully given a close estimation.

Upon testing, it was discovered that changing the fare and travel time both have an effect on the forecasted output. Since fare and travel time are the parameters of the cost function, the total cost of going from one zone to another was affected. The results show that if the cost gets higher, the number of trips distributed to an itinerary gets lower. Between fare and travel time, it was also discovered that the travel time has a bigger impact to the results. This trend is true for all the modules: traffic assignment, trip consolidation and route measured capacity. In traffic assignment, this trend was clearly reflected on the distribution of trips to the itineraries going from one zone to another. Since the itineraries are observed one at a time, the increase or decrease in their forecasted output is evident. The same goes for trip consolidation, but the change in the consolidated trips was very minimal since there are a lot of itineraries involved and only one itinerary was changed on the previous module. Moreover, the results in the RMC stayed the same due to the minimal change in the consolidated trips or the passenger demand of the routes.

7.2 Recommendations

Estimate for the PUJ Franchise

Researchers who wish to further continue this study can further expand the scope of the study. Since this research only focused and used the Travel Demand data from the cities of Marikina and Valenzuela. Expanding the research area may take into consideration more distribution of passenger demand from trips coming from other zones. Data from the urban regions if not for the whole Philippines should be taken into consideration since these places may are the ones that produces the most travel demand.

Underestimation of RMC

Based on the current implementation of solving for the RMC, some of the results are not consistent with the current number of jeepneys. Comparing the current values to the results, there are some routes with a higher RMC as compared to the original, and some with lower.

Since RMC is not strictly implemented into the franchising of current route, it is possible that urban planners might have overestimated or underestimated the demand for certain PUJ routes. While this may not be the only cause of the inconsistency of values, there is also a possibility that the lack of travel demand data from the other zones may have caused the deficiency of the passenger demand to a route. Whether it is an intracity or intercity route, there can still be a chance that these routes may be the best choice for traveling in between cities, specifically farther cities that may possibly use these PUJ routes as one of their connecting route.

Overestimation of RMC

On the other hand, results of overestimation of RMC may be caused by the way the jeepney routes were specifically restricted in the process of route filtering. It was observed that some route itinerary returned by the OTP were not the optimal ones. Since OTP was modified to use legs restricted to only PUJ routes and walking routes, it returns some itinerary that were unrealistic to be used. With this, it is suggested that during route filtering, all modes should have been considered. This way, PUJ routes that are not optimal will not be considered and will not be assigned with trips that should have been assigned to the ideal routes.

Parameters of the Generalized Cost

The parameters used in the cost function only considers the fare and travel time of each itinerary. Looking into other parameters such as the number of transfers and the walking distance between these transfers may improve the current equation in computing for the travel cost. By doing this, the distribution of trips to the itineraries may be more precise.

Validation of RMC

Conducting a field investigation is tedious and time-consuming since it takes up a whole day to validate a single route. An agent-based simulation can be an option in validating the computed RMC. It can help speed up the validation process since it will already show a visualization of the flow of vehicles depending on the inputted passenger demand.

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Appendix A

Research Ethics Documents

De La Salle University

DE LA SALLE UNIVERSITY
General Research Ethics Checklist

This checklist is to ensure that the research conducted by the faculty members and students of De La Salle University is carried out according to the guiding principles outlined in the Code of Research Ethics of the University. The investigator is advised to refer to the De La Salle University Code of Research Ethics and Guide to Responsible Conduct of Research before completing this checklist. Statements pertinent to ethical issues in research should be addressed below. The checklist will help the researchers and evaluators determine whether procedures should be undertaken during the course of the research to maintain ethical standards. The University's Guide to the Responsible Conduct of Research provides details on these appropriate procedures.

Details of the Research	
Students	Shaila Mae Choa Jaylica Anne Tan
Thesis Adviser	Briane Paul Samson
Department	Software Technology
Title of the Research	Estimating the Route Measured Capacity using the Four-Step Model of Travel Demand Analysis
Term(s) and Academic year in which research is to be conducted	Term 1,2,3 AY '16'17

This checklist must be completed AFTER the* De La Salle University Code of Ethics *has been read and BEFORE gathering data.

Questions	Yes	No
1. Does your research involve human participants (this includes new data gathered or using pre-existing data)? If your answer is **yes**, please answer **Checklist A (Human Participants).**	✓	
2. Does your research involve animals (non-human subjects)? If your answer is **yes**, please answer **Checklist B (Animal Subjects).**		✓
3. Does your research involve Wildlife? If your answer is **yes**, please answer **Checklist C (Wildlife)**.		✓
4. Does your research involve microorganisms that are infectious, disease causing or harmful to health? If your answer is **yes**, please answer **Checklist D (Infectious Agents).**		✓

5. Does your research involve toxic/chemicals/ substances/materials? If your answer is **yes**, please answer **Checklist E (Toxic Agents).**		✓

Research with Ethical Issues to address:

If you have a YES answer to any of the above categories, you will be required to complete a detailed checklist for that particular category. A YES answer does not mean the disapproval of your research proposal. By providing you with a more detailed checklist, we ensure that the ethical concerns are identified so these can be addressed in adherence to the University Code of Ethics.

Declaration of Conflict of Interest

[✓] I do not have a conflict of interest in any form (personal, financial, proprietary, or professional) with the sponsor/grant-giving organization, the study, the co-investigators/personnel, or the site.

[ ] I have a personal/family or professional interest in the results of the study (family members who are co-proponents or personnel in the study, membership in relevant professional associations/organizations).

Please describe the personal/family or professional interest: ____________________

____

[ ] I have propriety interest vested in this proposal (with the intent to apply for a patent, trademark, copyright, or license)

Please describe propriety interest: ____________________

____

[ ] I have significant financial interest vested in this proposal (remuneration that exceeds P250,000.00 each year or equity interest in the form of stock, stock options or other ownership interests).

Please describe financial interest: ____________________

____

Declaration

We certify that we have read and understand the De La Salle University Code for the Responsible Conduct of Research and will abide by the ethical principles in this document. We will submit a final report of the proposed study to the DLSU-Research Ethics Office. We will not commence with data collection until we receive an ethics review approval from the College Research Ethics Committee.

Shaila Mae Choa	Jaylica Anne Tan

Endorsement from thesis adviser to the thesis panel for proposal defense…

Briane Paul Samson	Date

Endorsement from thesis adviser to the thesis panel for final defense…

This is to certify that the research was conducted in a manner that adheres to ethical research standards. I am thus endorsing the group for final defense.

	August 20, 2017
Briane Paul Samson	Date

De La Salle University

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

DE LA SALLE UNIVERSITY

Checklist A

Research Ethics Checklist for Investigations involving Human Participants

This checklist must be completed AFTER the* De La Salle University Code of Research Ethics and Guide to Responsible Conduct of Research *has been read and BEFORE gathering data. The University Code of Research Ethics is available at http://www.dlsu.edu.ph/offices/urco/forms/URCO-Code-of-Research-Ethics_August2011.pdf

NOTE: This checklist is completed after the research proponent fills out the General Checklist Form.

Only answer this Checklist if you answered YES on question 1 of the General Checklist.

Researcher Details	
Students	Choa, Shaila Mae Tan, Jaylica Anne
Thesis Adviser	Samson, Briane Paul
Department	Software Technology Department
Title of the Research	Estimating the Route Measured Capacity using the Four-Step Model of Travel Demand Analysis
Term(s) and Academic year in which research is to be conducted	Term 1,2,3, AY’16’17

Provide a brief description of the data collection procedure to be undertaken in the research:
Researchers will get on a jeepney at the terminal station.
Survey jeepney drivers about their :

1. Revenue
2. Number of round trips in a day
3. Start and end time of deployment
4. Waiting time in the terminal line

Survey Passenger about their:

1. Waiting time before they are able to get jeepney

Record the number of passengers riding from and alighting at common stops.

De La Salle University	**Research Ethics Review Committee** **Research Ethics Office, 3F Henry Sy Sr. Hall** **De La Salle University Manila** **2401 Taft Avenue, Manila 1004, Philippines** **REO@dlsu.edu.ph (632) 524-4611 loc. 513**	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

The following should be attached to the checklist:

- A copy of the informed consent form to be used in the study.
- A copy of the instrument/tool that will be administered to the participants.
- If applicable, a copy of the letter seeking permission to collect data from participants who are under the supervision of an agency, institution, department, or office.
- If applicable, a copy of the parental consent form for participants below 18 years old.

The following items refer to important ethical considerations in the conduct of research with human participants. Provide a check for the appropriate answer to each question.

Source of data *Please check all that apply:*		
	1. New data will be collected from human participants If you checked this item, how will the new data be gathered? Please check all that apply. **After answering this question, please proceed to page 3**	
		Experimental Procedures/Intervention/ Treatments
		Focus Group
	✔	**Personal Interviews**
		Self-administered Questionnaire
		Researcher-administered Questionnaire
		Internet survey
	✔	**Observation**
		Telephone survey
		Others, please specify:
	2. Pre-existing data from human participants, i.e., from a dataset **If you checked this item, please proceed to page 7**	

If both options are checked (both new data and pre-existing data), **answer all of the questions in this document.**

ONLY ANSWER IF NEW DATA WILL BE COLLECTED (item 1 above)

Sampling Details	
Number of Participants/Subjects	**5 Jeepney Drivers / 30+ Jeepneys along the route**
Location where the participants will be recruited/ where subjects will be obtained?	**Valenzuela City, Jeepney Terminal**
How long will the data collection take place?	**1 day**

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

Who will perform the data collection?	**Choa, Shaila Mae** **Tan, Jaylica Anne**
Location(s) where data collection will take place	**Along Malinta-Bagbaguin jeepney route**
What procedures will be employed to ensure voluntary consent from participants?	**Interviewers will state in the beginning of the interview that the participants can choose not to answer their questions if they do not want to.**
Data Retention	
How long will data with participant identifiers be kept after the publication of the first paper from the project?	**N/A**
How long will anonymized data be kept after the publication of the first paper from the project?	**The anonymized data will be kept available for a maximum of 2 years or until a new data collection activity takes place, whichever happens first.**
Procedure for Informed Consent	
How will informed consent be recorded? (check all that applies) Reminder: please attach informed consent that will be used in the study	[ ]Written Consent [ ] Audio-recorded Consent [ ] Online/Email recorded Consent [✔] Others, please specify: Not obtained.

If you will not obtain a recorded informed consent, answer the questions that follow:

Why does the waiver of informed consent not pose a threat to the welfare and rights of the participants? **The data that will be collected can hardly be traced back to the participants. This does not pose threat to participants because they will not be held accountable for their responses. The researchers will inform the participants for each survey that this is only voluntary and that they have the right to refuse to answer any of the questions asked.**

Why is recording an informed consent not practical for the proposed study? **Researchers will perform data collection while jeepneys are en route to its destination. It would not be practical if we were to record an informed consent while our participants are busy driving and commuting. Acquiring a written consent form cannot be guaranteed since this is in a moving vehicle, passengers might alight at anytime. Audio-recording is also not a suitable answer since this is in a crowded jeep. Not only will it be deemed useless if the sounds do not get heard, it might also put risk into the researchers when collecting the data.**

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	Yes	No	Not Applicable
1. Will the research involve students who will be receiving course credits for their participation? **If YES, please attach a copy of the consent form and a summary of the debriefing process that will help participants understand how their participation in the research has provided arelevant learning experience to the crediting course.**		✔	
2. Does the study involve participants below 18 years old or those who are unable to give their informed consent? **If YES, please attach a copy of the parental consent form.**		✔	
3. Is there a possibility that the research can induce physical and/or psychological harm to the participants? Will they experience pain or some discomfort as a result from their participation in the research? **If YES, please attach an acceptable argument that outlines the benefits of doing the research and how they outweigh the cost of harming the participants.**		✔	
4. Will the participants be deliberately falsely informed or made unaware that they are being observed? Will they be misled in a way that they will possibly object to or show unease when told of the real purpose of the study? **If YES, please attach an acceptable argument that outlines the benefits of doing the research and how they outweigh the cost of harming the participants.**		✔	
5. Will the research involve the discussion of, or questions on, sensitive topics (e.g. sexual activity, substance abuse, or mental health)? **If YES, please make sure that the informed consent form explicitly states that sensitive questions will be posed and that you will safeguard the anonymity of the**		✔	

participants and ensure confidentiality. Please attach a copy of your informed consent form and your instrument.			
6. Will the research involve the administration of drugs, or other substances to the participants? **If YES, please attach an acceptable argument that outlines the benefits of doing the research and how they outweigh the cost of harming the participants.** **Please also attach a description of the procedure that will ensure that the participants will be brought back to their physical and psychological states prior to their participation in the research.**		✔	
7. Will biological samples (e.g. blood, saliva, urine) be obtained from the participants? **If YES, will this involve invasive procedures? Please attach a description of these procedures.**		✔	
8. Will genetic materials be obtained from the biological samples? **If YES, please attach a description of the procedures that will ensure confidentiality. Please attach the informed consent form.**		✔	
9. Will financial inducements (other than reasonable expenses, like transportation or meal allowances) be offered to the participants for their participation in their research? **If YES, the researcher(s) should be mindful of how the inducements can influence the participants' responses or behaviors during the research. Indicate the financial inducements offered to the participants:** ____		✔	
10. Is there a possibility for groups or communities to be		✔	

De La Salle University	**Research Ethics Review Committee** Research Ethics Office, 3F Henry Sy Sr. Hall De La Salle University Manila 2401 Taft Avenue, Manila 1004, Philippines REO@dlsu.edu.ph (632) 524-4611 loc. 513	SOP No.: 2 Form No.: 2.03 Version No.: 1 Effectivity Date: July 2016

harmed by the dissemination of the research findings? **If YES, please attach a description of procedures to ensure the anonymity and confidentiality of the research findings.**			

Answering <u>YES</u> to most of the above items will signal an ethical issue that needs to be addressed. Some actions that will allow adherence to research ethical principles are provided with each item. The researcher is advised to refer to the University's Guide to the Responsible Conduct of Research for the appropriate procedures to ensure adherence to ethical principles in the conduct of research.

<u>Declaration</u>

We certify that we have read and understand the De La Salle University Code for the Responsible Conduct of Research and will abide by the ethical principles in this document. We will submit a final report of the proposed study to the DLSU-Research Ethics Office. We will not commence with data collection until we receive an ethics review approval from the College Research Ethics Committee.

Jaylica Anne Tan

Shaila Mae Choa — Jaylica Anne Tan

Endorsement from thesis adviser to the thesis panel for proposal defense…

Briane Paul Samson — Date

Endorsement from thesis adviser to the thesis panel for final defense…

This is to certify that the research was conducted in a manner that adheres to ethical research standards. I am thus endorsing the group for final defense.

August 20, 2017

Briane Paul Samson — Date

De La Salle University

RESEARCH ETHICS CLEARANCE FORM
For Thesis Completion[1]

Names of student researcher/s :	CHOA, Shaila Mae D. TAN, Jaylica Anne R.
College:	College of Computer Studies
Department:	Software Technology Department
Course:	BS Computer Science with specialization in Software Technology
Expected duration of project:	from: T1 AY '16-'17 to: T3 AY '16-'17

Ethical considerations

The jeepney route data to be used is publicly available data.
The data that will be collected from jeepney drivers and passengers during system validation will not contain personal information that can be traced back to the respondents.

To the best of our knowledge, the ethical issues listed above have been addressed in the research.

Briane Paul V. Samson

Name and signature of adviser/mentor

Date: 8/17/17

Shirley Chu

Name and signature of panelist

Date: 8/17/17

Dr. Angelyn Lao

Name and signature of panelist

Date: 8/16/2017

Appendix B

Similarity Report

Turnitin Originality Report

Redef by Jaylica Anne Tan

From THSST Document (THSST)

Processed on 02-Aug-2017 00:27 PHT
ID: 830386363
Word Count: 13539

Similarity Index	Similarity by Source	
9%	Internet Sources:	5%
	Publications:	4%
	Student Papers:	4%

sources:

1 1% match (student papers from 14-Apr-2016)
Submitted to Technological Institute of the Philippines on 2016-04-14

2 1% match (Internet from 31-May-2016)
http://www.accessecon.com/pubs/CEDWP/default.aspx?ID=20532&page=ViewDirectory

3 < 1% match (publications)
J.M. Creagh. "SIM-ENG: a traffic simulation engine", Proceedings 32nd Annual Simulation Symposium SIMSYM-99, 1999

4 < 1% match (Internet from 09-Mar-2015)
http://nptel.ac.in/courses/105101087/downloads/Lec-10.pdf

5 < 1% match (Internet from 18-Oct-2010)
http://www.nd.edu/~nom/Papers/agent2005kennedy.doc

6 < 1% match (Internet from 03-Jan-2015)
http://www.getebook.in/resources/civil_ebook/new_ebook_30092014/Transport-Engineering.pdf

7 < 1% match (student papers from 01-Apr-2013)
Submitted to Sheffield Hallam University on 2013-04-01

8 < 1% match (publications)
Neïla Bhouri. "An agent-based computational approach for urban traffic regulation", Progress in Artificial Intelligence, 05/26/2012

9 < 1% match (Internet from 08-Jun-2009)
http://www.lawphil.net/judjuris/juri1994/dec1994/gr_115381_1994.html

10 < 1% match (student papers from 23-May-2017)
Submitted to University of the Philippines Los Banos on 2017-05-23

Appendix C

Record of Contribution

This appendix consists of the Departmental Record of Contribution.

De La Salle University

Departmental Record of Contribution

This form should be submitted along with the THSST-3 final deliverables. The contribution disclosed herein will formalize the contribution of each of the proponents and the adviser to the research. It is important that the proponents and the adviser agree with the figures and remarks imparted here, and it is expected that all has arrived to the same conclusion in good faith.

Title	Proponents	
Estimating the Route Measured Capacity using the Four-Step Model of Travel Demand Analysis	*Proponent 1 (P1)*	*Choa, Shaila Mae*
	Proponent 2 (P2)	*Tan, Jaylica Anne*
	Adviser (A)	
	Samson, Briane Paul	

Key Event	Remarks			
	P1	*P2*	*A*	
Idea conceptualization	22.5	22.5	55	
Research formalization	45	45	10	
Tool development	45	45	10	
Overall contribution*	37.5	37.5	25	

Shaila Mae Choa
Proponent

Jaylica Anne Tan
Proponent

Briane Paul Samson
Adviser

* this row must be filled

Appendix D

Definition of Terms

Amenities

Facilities, buildings or places (e.g. schools, residences, malls, hospitals, etc.).

Department of Transportation and Communications

Also called as DOTC, an entity of the executive branch of the Philippine government who regulates plans and programs to provide a more reliable and coordinated network of transportation and communications systems.

Franchise

A right granted by a government or corporation to an individual or group to market its services or product.

Land Transportation Franchising and Regulatory Board

Also called as LTFRB, an agency under the Department of Transportation of the Philippine which monitors the public land transportation services.

Public Utility Jeepney

Known as PUJ, Jeepney or simply Jeep. One of the most popular mode of transportation in the Philippines.

Traffic Analysis Zone

Also known as TAZ, is the unit of geography most commonly used in transportation planning models.

Appendix E

User Stories

1. As a user, I want to see all jeepney routes.
2. As a user, I want to add a new traffic analysis zone.
3. As a user, I want to modify an existing traffic analysis zone.
4. As a user, I want to search for a route in the transportation network using one of their attributes so that I can easily filter through the network.
5. As a user, I want to select a route and check its current attributes.
6. As a user, I want to see the recommended fleet size of PUJs in a route.

Appendix F

Architectural Diagram (Detailed) of Plexus

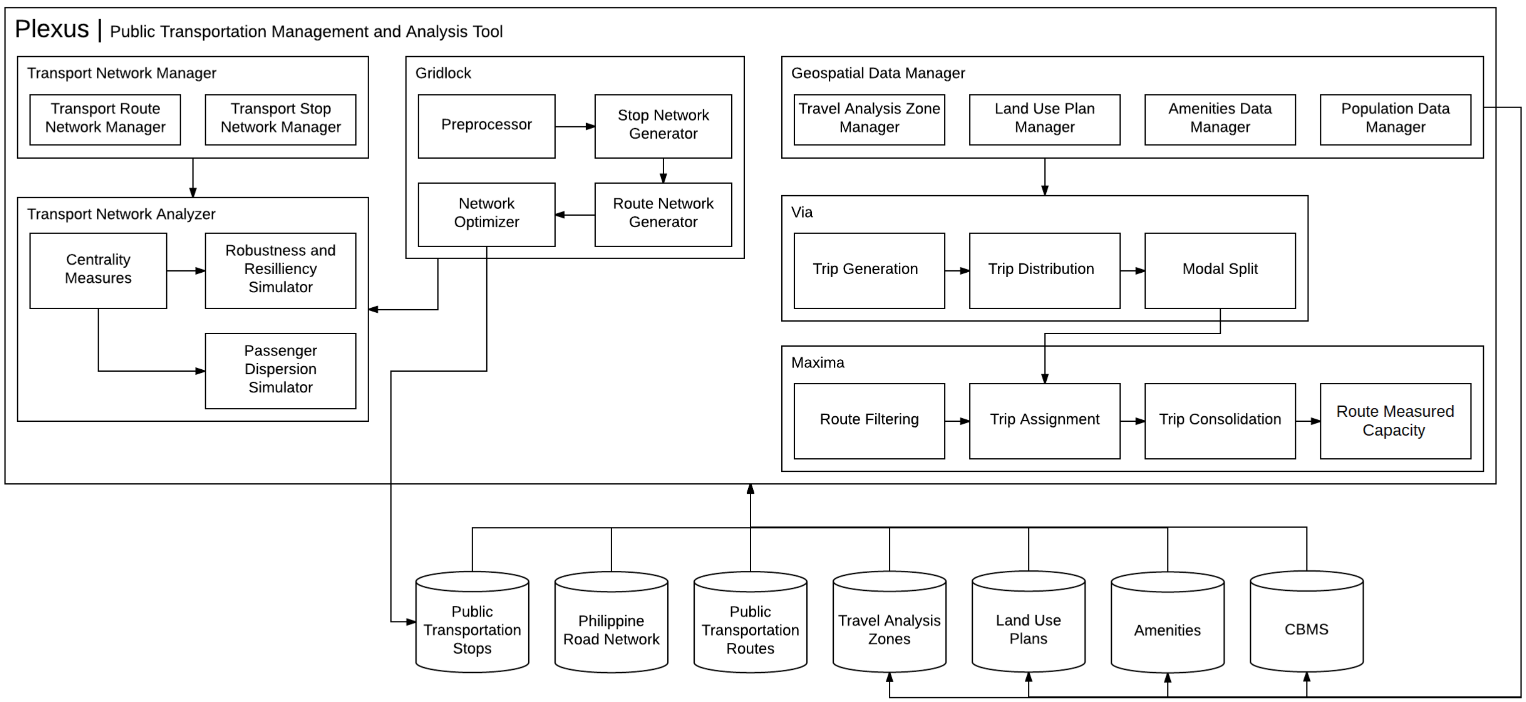

Figure F.1: Architectural Diagram (Detailed) of Plexus

Appendix G

Filtered Route Data

Table G.1: Attributes of the Valenzuela and Marikina Routes

Route ID	Route Long Name	Characteristic
LTFRB_PUJ1043	Antipolo - Cubao via Marcos Highway	Inter
LTFRB_PUJ1044	Antipolo - Cubao via Marcos Highway	Inter
LTFRB_PUJ1045	Antipolo - Cubao via Sumulong	Inter
LTFRB_PUJ1046	Antipolo - Cubao via Sumulong	Inter
LTFRB_PUJ1051	Antipolo (Cogeo) - Marikina via Sumulong	Inter
LTFRB_PUJ1107	Bagong Nayon II - Marikina Town	Inter
LTFRB_PUJ1108	Bagong Nayon II - Marikina Town	Inter
LTFRB_PUJ1200	Cainta Junction - Cubao via Ortigas Ave. Ext.	Inter
LTFRB_PUJ1201	Cainta Junction - Cubao via Ortigas Ave. Ext.	Inter
LTFRB_PUJ1204	Calumpang - Stop & Shop via Aurora Blvd.	Inter
LTFRB_PUJ1205	Calumpang - Stop & Shop via Aurora Blvd.	Inter
LTFRB_PUJ1218	Cogeo - Cubao via Marcos Hi-way	Inter
LTFRB_PUJ1219	Cogeo - Cubao via Marcos Hi-way	Inter
LTFRB_PUJ1264	Divisoria - Malinta via J.A. Santos	Inter
LTFRB_PUJ1265	Divisoria - Malinta via J.A. Santos	Inter
LTFRB_PUJ1374	Heritage Homes - Monumento via NLEX	Inter
LTFRB_PUJ1375	Heritage Homes - Monumento via NLEX	Inter
LTFRB_PUJ1424	Malanday - Bulacan	Inter
LTFRB_PUJ1425	Malanday - Bulacan	Inter
LTFRB_PUJ1426	Malanday - Recto via F. Huertas, Oroquieta	Inter
LTFRB_PUJ1427	Malanday - Recto via F. Huertas, Oroquieta	Inter
LTFRB_PUJ1428	Malanday - Pier South via Rizal Ave., P. Burgos	Inter

LTFRB_PUJ1429	Malanday - Pier South via Rizal Ave., P. Burgos	Inter
LTFRB_PUJ1430	Malinta - Bocaue via McArthur Hi-way	Intra
LTFRB_PUJ1431	Malinta - Bocaue via McArthur Hi-way	Intra
LTFRB_PUJ1432	Malinta - Meycauayan via McArthur	Intra
LTFRB_PUJ1433	Malinta - Monumento via McArthur Hi-way	Inter
LTFRB_PUJ1434	Malinta - Novaliches (TP)	Intra
LTFRB_PUJ1435	Malinta - Novaliches (TP)	Intra
LTFRB_PUJ1438	Malinta Exit - McArthur Highway via T. Santiago	Inter
LTFRB_PUJ1439	Malinta Exit - McArthur Highway via T. Santiago	Inter
LTFRB_PUJ1446	Marikina - Paenaan (Antipolo)	Inter
LTFRB_PUJ1447	Marikina - Paenaan (Antipolo)	Inter
LTFRB_PUJ1448	Marikina - Pasig	Inter
LTFRB_PUJ1449	Marikina - Pasig	Inter
LTFRB_PUJ1453	Marikina - Pateros via Pasig	Inter
LTFRB_PUJ1454	Marikina - Pinugay (Philcomsat)	Inter
LTFRB_PUJ1455	Marikina - Pinugay (Philcomsat)	Inter
LTFRB_PUJ1456	Marikina - San Mateo	Intra
LTFRB_PUJ1457	Marikina - San Mateo	Intra
LTFRB_PUJ1458	Marikina - SM Fairview	Inter
LTFRB_PUJ1459	Marikina - SM Fairview	Inter
LTFRB_PUJ1468	Meycauayan - Monumento via McArthur Hi-way	Inter
LTFRB_PUJ1469	Meycauayan - Monumento via McArthur Hi-way	Inter
LTFRB_PUJ1476	Monumento - Sto. Nino via Expressway	Inter
LTFRB_PUJ1477	Monumento - Sto. Nino via Expressway	Inter
LTFRB_PUJ1520	Parang - Recto	Inter
LTFRB_PUJ1521	Parang - Recto	Inter
LTFRB_PUJ1522	Parang - Stop & Shop via Aurora Blvd.	Inter
LTFRB_PUJ1523	Parang - Stop & Shop via Aurora Blvd.	Inter
LTFRB_PUJ1576	Recto - SSS Village via Aurora Blvd., Espana	Inter
LTFRB_PUJ1577	Recto - SSS Village via Aurora Blvd., Espana	Inter
LTFRB_PUJ1588	SSS Village - Stop & Shop via Aurora Blvd.	Inter
LTFRB_PUJ1589	SSS Village - Stop & Shop via Aurora Blvd.	Inter
LTFRB_PUJ1614	Malanday-Sta Cruz	Inter
LTFRB_PUJ1615	Malanday-Sta Cruz	Inter
LTFRB_PUJ1626	Prenza (Marilao) - Monumento via McArthur Hi-way	Inter
LTFRB_PUJ1627	Prenza (Marilao) - Monumento via McArthur Hi-way	Inter
LTFRB_PUJ1645	Malinta - Malolos via McArthur Hi-way	Inter
LTFRB_PUJ1657	Monumento - Polo via Acacia, M.H. del Pilar	Inter

LTFRB_PUJ1658	Monumento - Polo via Acacia, M.H. del Pilar	Inter
LTFRB_PUJ1691	PASIG CITY-Marikina CITY	Inter
LTFRB_PUJ1890	MONUMENTO - STA MARIA via EXPRESSWAY	Inter
LTFRB_PUJ1891	MONUMENTO - STA MARIA via EXPRESSWAY	Inter
LTFRB_PUJ1892	MONUMENTO - MEYCAUAYAN via EXPRESSWAY	Inter
LTFRB_PUJ1893	MONUMENTO - MEYCAUAYAN via EXPRESSWAY	Inter
LTFRB_PUJ1902	Marikina - PATEROS SAN JOAQUIN via PASIG	Inter
LTFRB_PUJ1903	Marikina - PATEROS SAN JOAQUIN via PASIG	Inter
LTFRB_PUJ1904	Marikina - PARANG	Intra
LTFRB_PUJ1905	Marikina - PARANG	Intra
LTFRB_PUJ1906	Marikina - MONTALBAN	Inter
LTFRB_PUJ1907	Marikina - MONTALBAN	Inter
LTFRB_PUJ1908	Marikina - MAMBUGAN	Inter
LTFRB_PUJ1909	Marikina - MAMBUGAN	Inter
LTFRB_PUJ1910	MALINTA - STA MARIA	Inter
LTFRB_PUJ1911	MALINTA - STA MARIA	Inter
LTFRB_PUJ1912	MALINTA - MALOLOS	Inter
LTFRB_PUJ1913	MALINTA - MALOLOS	Inter
LTFRB_PUJ1914	MALINTA - KAYBIGA	Intra
LTFRB_PUJ1915	MALINTA - KAYBIGA	Intra
LTFRB_PUJ1990	CUBAO - SSS VILLAGE	Intra
LTFRB_PUJ1991	CUBAO - SSS VILLAGE	Intra
LTFRB_PUJ1992	CUBAO - SILANGANAN	Intra
LTFRB_PUJ1993	CUBAO - SILANGANAN	Intra
LTFRB_PUJ1999	CUBAO - PARANG	Inter
LTFRB_PUJ2000	CUBAO - PADILLA	Inter
LTFRB_PUJ2001	CUBAO - PADILLA	Inter
LTFRB_PUJ2002	CUBAO - MONTALBAN	Inter
LTFRB_PUJ2003	CUBAO - MONTALBAN	Inter
LTFRB_PUJ2004	CUBAO - KALUMPANG	Intra
LTFRB_PUJ2005	CUBAO - KALUMPANG	Intra
LTFRB_PUJ2006	CUBAO - CALUMPANG via H ROXAS	Intra
LTFRB_PUJ2018	CALUMPANG - KATIPUNAN	Intra
LTFRB_PUJ2019	CALUMPANG - KATIPUNAN	Intra
LTFRB_PUJ2020	CAINTA - CUBAO	Inter
LTFRB_PUJ2021	CAINTA - CUBAO	Inter
LTFRB_PUJ2149	MONUMENTO - MEYCAUAYAN via EXPRESSWAY	Inter

LTFRB_PUJ2150	MONUMENTO - MEYCAUAYAN via EXPRESSWAY	Inter
LTFRB_PUJ2151	Marikina - ANTIPOLO via MARCOS HIGHWAY	Inter
LTFRB_PUJ2152	Marikina - ANTIPOLO via MARCOS HIGHWAY	Inter
LTFRB_PUJ2189	COMMONWEALTH MARKET STA LUCIA Q PLAZA	Inter
LTFRB_PUJ2190	COMMONWEALTH MARKET STA LUCIA Q PLAZA	Inter
LTFRB_PUJ2203	CUBAO TAYTAY	Inter
LTFRB_PUJ2204	CUBAO TAYTAY	Inter
LTFRB_PUJ2331	Karuhatan Sta Cruz via Fuentes	Inter
LTFRB_PUJ2332	Karuhatan Sta Cruz via Fuentes	Inter
LTFRB_PUJ2333	Karuhatan Ugong	Intra
LTFRB_PUJ2334	Karuhatan Ugong	Intra
LTFRB_PUJ2343	Malinta Bagbaguin	Intra
LTFRB_PUJ2344	Malinta Bagbaguin	Intra
LTFRB_PUJ2345	Malolos BBB (Val) via MacArthur Highway	Inter
LTFRB_PUJ2346	Malolos BBB (Val) via MacArthur Highway	Inter
LTFRB_PUJ2347	Marikina City SM Santolan LRT	Inter
LTFRB_PUJ2348	Marikina City SM Santolan LRT	Inter
LTFRB_PUJ2395	Polo Sangandaan via Tenejeros	Inter
LTFRB_PUJ2396	Polo Sangandaan via Tenejeros	Inter
LTFRB_PUJ2484	BBB Malolos via McArthur Hway	Inter
LTFRB_PUJ2485	BBB Malolos via McArthur Hway	Inter
LTFRB_PUJ2496	Cainta Junction Cubao via Imelda Avenue	Inter
LTFRB_PUJ2497	Cainta Junction Cubao via Imelda Avenue	Inter
LTFRB_PUJ2520	Karuhatan Monumento	Intra
LTFRB_PUJ2521	Karuhatan Monumento	Intra
LTFRB_PUJ2528	Malinta-Rizal Ave via Banal	Inter
LTFRB_PUJ2529	Malinta-Rizal Ave via Banal	Inter
LTFRB_PUJ2530	Malinta-Sta Cruz	Inter
LTFRB_PUJ2531	Malinta-Sta Cruz	Inter
LTFRB_PUJ2532	Malinta Hagonoy via MacArthur Highway	Inter
LTFRB_PUJ2533	Malinta Hagonoy via MacArthur Highway	Inter
LTFRB_PUJ2535	Malinta Hagonoy via Meycauayan	Inter
LTFRB_PUJ2538	Malinta Pier via Monumento	Inter
LTFRB_PUJ2539	Malinta Pier via Monumento	Inter
LTFRB_PUJ2540	Malinta Recto via F Huertas	Inter
LTFRB_PUJ2541	Malinta Recto via F Huertas	Inter
LTFRB_PUJ2548	Meycauayan Recto via BBB Monumento	Inter
LTFRB_PUJ2549	Meycauayan Recto via BBB Monumento	Inter
LTFRB_PUJ2553	Monumento Bocaue	Inter
LTFRB_PUJ2554	Monumento Bocaue	Inter

LTFRB_PUJ2557	Monumento Malanday	Inter
LTFRB_PUJ2558	Monumento Malanday	Inter
LTFRB_PUJ2559	Monumento Malolos	Inter
LTFRB_PUJ2560	Monumento Malolos	Inter
LTFRB_PUJ2561	Monumento Polo	Inter
LTFRB_PUJ2562	Monumento Polo	Inter

Appendix H

Jeepney OD Matrix

Table H.1: Origin-Destination matrix for the jeepney mode between 17 zones

Zone	1	2	3	4	5	6	7	8
1	2054.2	1243.88	1321.76	694.1	956.68	1623.88	1899.92	339.88
2	3143.45	1681.74	1885.03	926.26	1253.92	1965.43	1998.62	407.34
3	1525.23	884.39	1402.46	475.96	570.25	1044.82	1436.61	202.74
4	2344.59	1335.87	1390.98	1553.56	2745.93	5060.13	2492.8	808.03
5	763.96	415.47	397.81	633.07	3590.32	4644.61	997.89	648.74
6	758.96	403.62	478.79	755.33	2721.45	11762.33	1371.12	1069.29
7	2978.82	1297.09	1768.75	1103.78	1853.13	3562.2	2647.32	643.6
8	668.49	326.5	335.72	505.98	1605.51	4863.05	954.41	1321.79
9	573.29	255.89	267.03	375.73	1286.54	4177.35	862.32	1278.49
10	71.29	29.55	26.43	20.97	42.66	65.48	47.32	16.47
11	169.56	71.28	63.76	53.96	114.87	167.44	117.3	42.14
12	168.15	72.57	63.94	55.89	120.4	173.03	116.44	43.5
13	284.41	122.95	111.15	95.51	206.45	292.56	201.82	73.5
14	221.29	112.35	92.48	85.86	191.15	262.84	165.98	64.17
15	131.25	60.74	51.89	47.86	105.78	147.44	94.89	36.12
16	93.01	41.86	37.5	32.88	72.78	102.29	67.33	24.67
17	221.61	116.84	96.31	92.4	205.89	279.98	173.18	67.64

Table H.2: Origin-Destination matrix for the jeepney mode between 17 zones

Zone	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
1	208.06	130.8	476.82	244.32	836.43	967.84	673.81	46.87	1174.47
2	203.98	130.15	473.54	248.03	820.92	1030.49	700.89	47.17	1206.94
3	105.24	53.64	194.72	101.78	344.63	426.23	299.97	20.57	511.06
4	431.39	126.09	472.41	247.47	841.98	1048.41	724.99	47.56	1257.63
5	333.96	61.7	237.04	127.35	435.79	550.53	386.47	25.21	660.76
6	682.19	58.9	217.2	118.04	398.53	519.37	350.49	23.18	638.09
7	358.47	115.53	445.44	226.24	784.42	914.86	644.65	44.22	1087.16
8	994.67	61.68	237.32	123.88	424.79	526.45	363.9	24.13	644.55
9	161.7	49.04	181.23	94.88	324.93	407.8	274.83	18.64	502.17
10	8.44	1118.17	2141.55	971.9	1562.89	1427.65	1631.22	141.18	1250.64
11	21.38	915.45	8338.16	2649.46	5136.04	4160.16	4507.8	392.87	3769.03
12	22.52	222.14	1220.82	3024.07	2096.82	6612.96	7671.03	519.14	5054.77
13	37.63	269.45	1146	549.05	26231.3	7882.47	1304.22	93.43	7213.41
14	32.96	201.09	802.63	489.85	1628.74	5773.05	1237.41	91.62	13943.75
15	18.82	120.02	464.11	243.91	8646.3	5975.51	7398.13	1299.4	4867.46
16	13.29	78.03	476.71	162.61	2588.15	3215.46	12055.1	1671.1	2983.7
17	35.02	205.83	840.23	439.63	1318.23	2324.63	1276.13	85.79	17564.18

Appendix I

Average Hourly Income

Table I.1: Average hourly income per zone (₱) from CBMS

Zone	**Average Hourly Income (₱)**
1	120.48
2	63.64
3	75.17
4	66.42
5	75.18
6	129.95
7	73.69
8	76.42
9	80.53
10	130.90
11	121.25
12	122.24
13	143.88
14	124.00
15	247.05
16	96.57
17	129.64

Appendix J

Computed Route Measured Capacity

Table J.1: Route Measured Capacity per route

Route Name	UR	VLF	ASC	NRT	PD	RMC
Antipolo-Cubao (via Imelda Avenue)	1.3	0.36	22	6.2	2040	32
Antipolo-Cubao (via Sumulong Hi-way)	1.18	0.34	22	6.2	3441	63
Antipolo-Marikina (via Sumulong)	1.29	0.46	22	6.2	1136	14
Bagbaguin-Malinta	1.07	0.68	22	7.1	7169	63
Bagong Nayon II-Marikina	1.04	0.52	22	6.2	1,447	20
Bocaue-Malinta	1	0.5	22	6.2	1073	16
Bulacan-Malanday	1	0.51	22	6.2	4211	61
Cainta-Cubao (via Imelda Ave)	1.08	0.46	22	6.2	3760	55
Cainta-Cubao (via Ortigas Ave)	1	0.52	22	6.2	2840	40
Calumpang-Cubao	1.12	0.41	22	7.1	6412	89
Calumpang-Katipunan	1.1	0.49	22	9.9	5009	43
Calumpang-Stop N Shop	1.28	0.54	22	6.2	7737	82
Cogeo-Cubao	1.21	0.46	22	6.2	2303	30
Hagonoy-Malinta	2	0.22	22	4	3707	96
Heritage Homes-Monumento (via NLEX)	1	0.35	22	6.2	16757	351
Karuhatan-Monumento	1	0.44	22	9.9	663	7
Karuhatan-Sta Cruz	1.77	0.58	22	6.2	2687	19
Karuhatan-Ugong (Valenzuela)	4.35	0.68	22	9.9	16742	26
Kaybiga-Malinta	1.2	0.64	22	7.1	6279	52

Malanday-Pier South 15	2.09	0.39	22	6.2	6923	62
Malanday-Recto	1.66	0.43	22	6.2	10200	105
Malanday-Sta Cruz	1.97	0.45	22	6.2	3623	30
Malinta-Divisoria	1.2	0.59	22	6.2	4563	47
Malinta-Monumento	1	0.66	22	7.1	1130	11
Malinta-Recto	1.09	0.6	22	6.2	3034	34
Malinta-Sta Cruz	1.05	0.58	22	6.2	1055	13
Malolos-BBB	22.5	0.24	22	4	7907	17
Malolos-Malinta	1.48	0.28	22	4	1763	48
Mambugan-Marikina	1	0.56	22	7.1	171	2
Marikina-Pasig	1.1	0.63	22	6.2	2438	26
Marikina-Pateros	1.08	0.58	22	6.2	1603	19
Meycauayan-Malinta	1	0.48	22	7.1	242	3
Meycauayan-Monumento (via McArthur)	1.29	0.62	22	6.2	5917	54
Meycauayan-Monumento (via NLEX)	1.1	0.35	22	6.2	20666	394
Montalban-Cubao	1.02	0.34	22	6.2	14920	317
Montalban-Marikina	1.1	0.53	22	6.2	9793	123
Novaliches-Malinta	1.08	0.4	22	7.1	20685	307
Padilla-Cubao	1.07	0.44	22	6.2	1779	28
Paenaan-Marikina	1.08	0.32	22	4	886	29
Parang-Cubao	1.05	0.49	22	7.1	7080	88
Parang-Marikina	1.14	0.54	22	7.1	9470	98
Parang-Recto	2.52	0.36	22	6.2	16028	129
Parang-Stop N Shop	1.16	0.43	22	6.2	17341	256
Pinugay-Marikina	1	0.59	22	6.2	705	9
Polo-Monumento	1.09	0.45	22	7.1	3,972	52
Polo-Sangandaan	1.15	0.6	22	7.1	609	6
Prenza-Monumento	1	0.4	22	6.2	4775	88
San Mateo-Marikina	1	0.66	22	7.1	11417	111
Silangan-Cubao	1.02	0.49	22	6.2	17385	256
SM City Marikina-Pasig	1	0.54	22	6.2	397	5
SM Fairview-Marikina	1.24	0.37	22	6.2	14683	236
SSS Village-Cubao	1.03	0.62	22	6.2	20123	232
SSS Village-Recto	24	0.35	22	6.2	24380	21
SSS Village-Stop N Shop	1.14	0.41	22	6.2	29066	457
Sta Maria-Malinta	1	0.38	22	6.2	1405	27
Sta Maria-Monumento (via NLEX)	1.29	0.35	22	4	10868	274
Sto Nino-Monumento	1.02	0.4	22	6.2	12437	224
Taytay-Cubao	1.06	0.4	22	6.2	1978	34

Appendix K

Percent Difference of Intercity Routes

Table K.1: Percent difference of Intercity routes with existing data

Route Name	No. of Current Units	No. of Franchises	RMC	Percent Difference (with current units)	Percent Difference (with franchises)
Antipolo-Cubao (via Imelda Avenue)	112	86	32	111.11%	91.53%
Antipolo-Cubao (via Sumulong Hi-way)	146	124	63	79.43%	65.24%
Antipolo-Marikina (via Sumulong)	223	173	14	176.37%	170.05%
Bagong Nayon II-Marikina	149	143	20	152.66%	150.92%
Bulacan-Malanday	18	18	61	-108.86%	-108.86%
Cainta-Cubao (via Imelda Ave)	64	59	55	15.13%	7.02%
Cainta-Cubao (via Ortigas Ave)	25	25	40	-46.15%	-46.15%
Calumpang-Stop N Shop	141	110	82	52.91%	29.17%
Cogeo-Cubao	320	265	30	165.71%	159.32%
Hagonoy-Malinta	2	1	96	-191.84%	-195.88%
Heritage Homes-Monumento (via NLEX)	50	50	351	-150.12%	-150.12%
Karuhatan-Sta Cruz	23	13	19	19.05%	-37.50%
Malanday-Pier South 15	267	128	62	124.62%	69.47%
Malanday-Recto	366	220	105	110.83%	70.77%
Malanday-Sta Cruz	142	72	30	130.23%	82.35%

Malinta-Divisoria	60	50	47	24.30%	6.19%
Malinta-Monumento	1	1	11	-166.67%	-166.67%
Malinta-Recto	58	53	34	52.17%	43.68%
Malinta-Sta Cruz	40	38	13	101.89%	98.04%
Malolos-BBB	45	2	17	90.32%	-157.89%
Malolos-Malinta	169	114	48	111.52%	81.48%
Mambugan-Marikina	16	16	2	155.56%	155.56%
Marikina-Pasig	454	411	26	178.33%	176.20%
Marikina-Pateros	117	108	19	144.12%	140.16%
Meycauayan-Monumento (via McArthur)	130	101	54	82.61%	60.65%
Meycauayan-Monumento (via NLEX)	210	191	394	-60.93%	-69.40%
Montalban-Cubao	259	255	317	-20.14%	-21.68%
Montalban-Marikina	180	164	123	37.62%	28.57%
Padilla-Cubao	165	154	28	141.97%	138.46%
Paenaan-Marikina	282	260	29	162.70%	159.86%
Parang-Cubao	23	22	88	-117.12%	-120.00%
Parang-Recto	58	23	129	-75.94%	-139.47%
Parang-Stop N Shop	399	345	256	43.66%	29.62%
Pinugay-Marikina	29	29	9	105.26%	105.26%
Polo-Monumento	186	170	52	112.61%	106.31%
Polo-Sangandaan	113	98	6	179.83%	176.92%
Prenza-Monumento	11	11	88	-155.56%	-155.56%
SM City Marikina-Pasig	15	15	5	100.00%	100.00%
SM Fairview-Marikina	21	17	236	-167.32%	-173.12%
SSS Village-Recto	24	1	21	13.33%	-181.82%
SSS Village-Stop N Shop	322	283	457	-34.66%	-47.03%
Sta Maria-Malinta	10	10	27	-91.89%	-91.89%
Sta Maria-Monumento (via NLEX)	121	94	274	-77.47%	-97.83%
Sto Nino-Monumento	190	187	224	-16.43%	-18.00%
Taytay-Cubao	249	234	34	151.94%	149.25%

Appendix L

Percent Difference of Intracity Routes

Table L.1: Percent difference of Intracity routes with existing data

Route Name	No. of Current Units	No. of Franchises	RMC	Percent Difference (with current units)	Percent Difference (with franchises)
Bagbaguin-Malinta	60	56	63	-4.88%	-11.76%
Bocaue-Malinta	18	18	16	11.76%	11.76%
Calumpang-Cubao	120	107	89	26.67%	18.37%
Calumpang-Katipunan	11	10	43	-118.52%	-124.53%
Karuhatan-Monumento	13	13	7	60.00%	60.00%
Karuhatan-Ugong (Valenzuela)	714	164	26	185.95%	145.26%
Kaybiga-Malinta	12	10	52	-125.00%	-135.48%
Meycauayan-Malinta	6	6	3	66.67%	66.67%
Novaliches-Malinta	403	374	307	27.04%	19.68%
Parang-Marikina	111	97	98	12.44%	-1.03%
San Mateo-Marikina	18	18	111	-144.19%	-144.19%
Silangan-Cubao	189	186	256	-30.11%	-31.67%
SSS Village-Cubao	41	40	232	-139.93%	-141.18%

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