A Study of Metro Manila’s Public Transportation Sector: Implementing a Multimodal Public Transportation Route Planner

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Abstract: Public transportation provides commuters with a convenient method to reach their destination faster and cheaper compared with private vehicles. However, this is not always the case for Metro Manila because many Filipinos have a negative perception of using public transportation. This paper first discusses the researchers’ study of the travel behavior of Metro Manila commuters and the status of its public transportation sector based on their Metro Manila Public Transport Travel Survey. Information from the survey was used to implement a multimodal public transportation route planner for Metro Manila, which is designed to provide commuters with facts about public transportation. This should change its negative image and entice more people to use the services. The analysis of the publicly distributed General Transit Feed Specification data provided by the government is discussed. All these findings support the researchers’ goal of improving Metro Manila’s public transportation.

Keywords: Public Transport, Multimodal, Route Planner, Metro Manila Commuters, Travel Survey, OpenTripPlanner

1. INTRODUCTION

Transportation is an integral part of modern life. According to Kumari et al. (2010) and Rehrl et al. (2007), a good transportation network is one of every modernized city’s initial priorities because today’s modern society needs mobility in every aspect of life. Every day, people need to go to work, children need to go to school, and products need to reach the other end of the supply chain. However, because of the continuous population growth in the world, transportation networks are unceasingly being congested. According to Kenyon et al. (2003), many governments worldwide have been pushing for the so-called “modal shift” to solve this problem and reduce the number of vehicles clogging up road networks, i.e., by enticing citizens to shift away from mainly using private transportation modes to using public transportation modes. The National Household Travel Survey (NHTS, 2009) notes that the average vehicle occupancy of private cars is only 1.55 persons. The World Bank’s Implementation Completion and Results Report (2011) notes that the average jeepney occupancy is 10.6 people and bus occupancy is 43.4 people. These statistics illustrate the big difference in numbers of people transported with almost the same road space used. Simultaneously, there has also been a need to shift from monomodal travelling using only one transportation mode per trip to multimodal travelling using more than one transportation
mode per trip. This shift in modes supports the long-term sustainability of transportation networks because each transportation mode would have its proper role and function.

From a technical standpoint, one concrete way to help push for this so-called modal shift and to attract commuters to support this shift is by providing them with relevant and reliable travel information. It is important to note that lack of public transportation information was identified as one reason why some commuters opt to use private vehicles over public ones. This movement gave birth to the popularity of public transport route planners. These applications are designed to provide users with a good route from their given origin point to the destination prior to the user’s journey. Meng et al. (1999) found that the first generation of route planners handled only monomodal travelling and focused on private vehicle use, the new generation of route planners faced greater problems because they have to consider multiple modes of transportation and multiple objective functions (e.g., cheapest travel cost, fastest travel time, shortest travel distance). Implementing a multimodal public transportation route planner for Metro Manila commuters poses a promising solution for decongesting the main roads in Metro Manila.

This research first aims to share the researchers’ findings and analysis regarding the travel behavior of Metro Manila commuters and describe the status of its public transportation sector, as concluded from their Metro Manila Public Transport Travel Survey. The online survey not only helped the researchers understand better the needs and wants of Metro Manila commuters with respect to a route planning system, it also provided an updated study of the current situation of Metro Manila’s public transportation system and its commuters. Information from the survey was used to implement a multimodal public transportation route planner for Metro Manila, which is the next focus of this research. The researchers’ learning and experiences in the implementation of an open-sourced multimodal trip-planning system with the transportation network of Metro Manila using OpenTripPlanner (OTP) software is then discussed. The system would compute an array of available multimodal public transportation routes from the user’s inputted origin and destination points. The routes suggested would be accompanied by other relevant travel information such as estimated travel time, estimated distance to be travelled by foot, and the estimated distance to be travelled in total. The produced system would be uploaded online for public consumption. Realization of its goal of providing commuters with facts about public transportation would change the negative image of Metro Manila and entice more people to use its services. Lastly, the researchers’ careful analysis of the publicly distributed General Transit Feed Specification (GTFS) data provided by the government would be discussed, along with the researchers’ recommendations on how to manage transportation data to create more reliable GTFS data based on their knowledge and experiences from their attempt to create their own GTFS data. All these findings support the researchers’ goal of improving Metro Manila’s public transportation.

1.1 Scope and Limitations

The researchers’ attempted version of Metro Manila GTFS data was based on the officially distributed version from the Department of Transportation and Communications (DOTC) and raw hard copies of route data from the different public transportation governing agencies. Only a couple of routes were implemented because it is just a proof of concept of the researchers’ suggested standard. Completion of more accurate and reliable GTFS data is part of the researchers’ further study. GTFS Editor was used to create the GTFS data. The map of Metro Manila was extracted from OpenStreetMap (OSM) and kept unedited.
The current Metro Manila GTFS data used by the instance of OTP hosted online by the researchers is implemented by the following agencies: Manila Metro Rail Transit Corporation (MRTC), Manila Light Rail Transit Authority (LRTA; for LRT1 and LRT2), Land Transportation Franchising Regulatory Board (LTFRB; for buses and jeepneys), Maritime Industry Authority (MARINA), and Philippine National Railways (PNR). The OSM map that the system runs on only covers Metro Manila as well. This includes the city of Manila and the cities of Caloocan, Las Pinas, Makati, Malabon, Mandaluyong, Marikina, Muntinlupa, Navotas, Paranaque, Pasay, Pasig, Quezon City, San Juan, Taguig, Valenzuela, and Pateros. In the cases in which future researchers and transportation agencies would want to include transportation data outside of Metro Manila, the GTFS data and OSM map used should be adjusted accordingly.

Given the user’s origin and destination, as well as departure or arrival time, the system would return the computed multimodal route along with other additional transportation information. These estimates are based on transportation data acquired from the various public transportation-governing agencies. The system would also not incorporate the actual schedule of the supported transportation modes because the service hours of the supported transportation modes may differ from their actual schedules, as they would be estimates.

This research also does not intend to create a new public transportation route planner. It aims to implement the open source multimodal trip-planning system, OTP.

1.2 Purpose

This paper aims to explore the effectiveness of OTP in the context of Metro Manila. The resulting public transport route planner would then be hosted online for the general reference of Metro Manila commuters. The whole research aims to:

- Produce an analytical study regarding public transportation and its commuters for the use of other researchers, relevant offices, and organizations for further improvements and studies regarding the transportation sector in the Philippines;
- Provide an array of multimodal public transportation directions to commuters on how to reach their destination point from their origin;
- Change the perception of users regarding the negative image of using public transportation (e.g., no public transportation route available, longer travel time as compared to driving) in hopes of urging commuters to shift from using private transportation to public transportation; and
- Establish a standard on how to create, update, and manage Philippines’ public transportation data, which is more accurate and reliable than the one officially issued by the government.

All these objectives follow the researchers’ goal of providing methods for a more sustainable transportation network in the long run.

2. PUBLIC TRANSPORTATION ROUTE PLANNERS

2.1 International Context

Zhang and his team implemented an advanced traveler information system (ATIS) by using Dijkstra’s algorithm and running it using five transportation modes in the Eindhoven region (the Netherlands). Although Dijkstra’s algorithm was not fast enough when inputted with a
large set of data, the generated routes were in good quality, which makes it a good algorithm for creating paths in a realistic network. Their research concluded with recommendations for improving the algorithm by accelerating it with the help of bidirectional search or heuristic methods like A*. Rehrl and company implemented a personal travel companion in the transportation network of Vienna, Austria, that calculates the pedestrian route and proves maps, path descriptions, and data of interchange buildings. However, the implementation of this system was only on a small scale and needs a larger test setting and a larger group of participants to prove its success. These two systems are among the foundations of the conceptual design of route planners and were successful in providing initial results. They also provide good grounds for further research in the field.

Peng and Kim developed a distributed trip-planning system that integrates different trip-planning systems in the context of the United States. Their system allows the different individual transit agencies to maintain and update their own data and transit planner. A mediator server is used to integrate the data and transit planners seamlessly, which allows users to create travel plans that cross different transit system boundaries. Brennan and Meier produced a similar system called a “Smart Traveller Information Service” (STIS) that integrates different preavailable transport systems in Dublin, Ireland. Their system works functionally well in producing different routes for different transportation mode options. However, only one preferred transportation mode is considered per query; supplementary walking routes are provided for routes not traversed by the user’s preferred transportation mode. The system is still just a proof of concept rather than an enterprise-level application.

Abbaspour and Samadzadegan tested the possibility of using a genetic algorithm in a multimodal public transport route planner. Their proposed approach was lab tested in the transportation network of Tehran. However, the current system lacks user preference input and only considers travel time. In addition, the proposed approach still has to be tested with a real-time implementation of the algorithm that considers the contextual information of the user. The above-mentioned systems are noteworthy route planners, but they lack a multimodal aspect as well as the capacity to consider user preference when computing routes.

In Hong Kong, an Internet-based comprehensive public transport enquiry system (PTES) was developed by Lilian Pu-Cheng. PTES helps commuters find the connections between different forms of transportation and how to get to the stops or terminals from their boarding place and/or connection points. Its most important features, aside from its computation efficiency, are its real-time multiple-criterion route search function and fare structure computation. Additional route information and choice of fare types (e.g., student, senior citizen, air-conditioned, non-air-conditioned) are included in future research. In completion of their research, Foo Hee Meng and his team developed a route advisory system (RADS) that ran the algorithm they created and implemented it in the public transport system of Singapore. The system was able to consider user preferences in time, fare, and starting time. However, further improvements can be added by providing commuters with dynamic guidance using real-time traffic information and integrating other transportation modes that would supply missing links for a fully integrated public transport route advisory system.

Spitadakis and Fostieri implemented WISETRIP in Greece, which is an international multimodal journey planner that delivers personalized trip information. WISETRIP is an online unified journey planner that enables cooperation with different journey planners to allow for wide-scale journey planning, especially for international travelers. The system is able to compute for all available trip solutions and is able to provide personalized trip services based on user configuration. Some further improvements to the system includes content and modal extension, pricing and ticketing information, alerts and replanning.
option, concerns for elderly and disabled users, concern for green routes, and mobile application implementation. Zografos and company also developed ENOSIS in Greece. ENOSIS is a passenger information and trip-planning system that aims to provide both urban and interurban multimodal planning services with real-time travel information. ENOSIS considers multiple criteria and incorporates complex scheduling constraints, which can all be customized by the user. It also serves as a travel companion throughout the entire journey travel by providing real-time ordinary and unexpected event alerts. Some other notable route planners include researches from the teams of Zhang, Li, and Jariyasunant, who have all created systems to support mobile-based ATISs in the Californian context. Su, Cheng, and Ho developed a multimodal trip-planning system for intercity transportation in Taiwan using a search algorithm that considers the transit network, timetable, and the restrictions on access stops. Kumar, Singh, and Reddy developed a GIS-based multimodal transport system for Hyderabad, India. Their system provides a convenient and powerful tool for storage and graphical representation of information; it is not limited to road networks, but includes comprehensive information about Hyderabad in general, including hospitals, government and private offices, stadiums, and tourist places within the city limits. These systems are the best multimodal public transport route planners available and the Philippines, with its ever-worsening traffic conditions, has to catch up with these innovations.

2.2 The Philippine Context

Google Maps, which is perhaps one of the most well-known route-planning systems in the world, has its own version of a public transport route planner called Google Transit. Google Transit is able to calculate a number of routes including distance to be travelled and travel time. However, the system only incorporates buses, MRT, LRT1, and LRT2 routes. The system does not include Jeepneys, which is the main transportation mode used in the Philippines. Transportation costs are also not included in the generated route plan. Transit.com.ph, a system produced by the Philippine Transit App Challenge 2013, aimed to produce a local version of Google Transit by adding more local transportation modes. The system is currently running on the transportation network of Cebu city. The Metro Manila routes are not yet fully functioning; it is only able to return walking routes from the origin to the destination point. Sakay.ph, which was also produced by the Philippine Transit App Challenge 2013, was successful in creating a local version of the Google Transit application. Their system is able to compute an array of multimodal public transportation routes for the given origin and destination points, complete with supplementary transportation information. They were also able to incorporate jeepney routes, which was the main shortcoming of Google Transit. The main difference of the researchers’ system from its inspiration “Sakay.ph” would be the GTFS data used to run the system.

Figure 1 illustrates the tree diagram representation of notable public transport route planners. It summarizes the positions of known public transport route planners compared with the proposed system in a graphical manner. As seen, PTES, RADS, WISETRIP, ENOSIS, Transit.com.ph, and Sakay.ph, are the closest systems to the researchers’ proposal. Although these systems already implement most of the functionalities that the researchers wish to include in their proposed route planner, the research behind these systems are not readily available to the public.

Most route planners only compute for the shortest path while the researchers want to give users all possible multimodal paths from the origin to the destination. Most route planners only consider the shortest travel time; the proposed system would return an array of possible routes so commuters would have the choice of a number of options. Some
route planners only return the computed path; the proposed system would provide additional travel information such as estimated travel time, transportation expense, and distance to be travelled.

No updated data about the public transportation sector of the Philippines and its users is available, which drove the researchers to create their own data using the Metro Manila Public Transport Travel Survey.

![Route Planner Tree Diagram](image)

**Figure 1. Route Planner Tree Diagram**

### 3. FRAMEWORK

As stated in the Introduction, the main purpose of this research is to learn the effectiveness of implementing a public transportation route planner for the road network of Metro Manila using the open source multimodal trip-planning system, OTP. This section discusses the framework behind the research and system implementation.

#### 3.1 OpenTripPlanner (OTP)

OpenTripPlanner is an open source, multimodal trip-planning system collaboratively developed by a team of passionate developers worldwide coordinated by OpenPlans and TriMet. It is a collaborative effort among TriMet, OpenPlans, and the developers of Five Points, OneBusAway, and Graphserver. OTP was identified as the most promising open source multimodal trip-planning software system. Not to mention the merit it receives from its big active developer community as described by McHugh. The system would be set up using geographic data from OSM and GTFS data from relevant transit agencies, which are both discussed in detail below.

OpenTripPlanner contains most of the main desired features of a multimodal public transportation trip planner. It is also important to note that OTP has an active community that continues to add new features and improve the software. What adds to the system’s effectiveness and efficiency is its flexibility in being able to accommodate open data specifications and repositories, such as GTFS and OSM, to be able to support multimodal trip planning. It is also able to accept other sources of data including USGS National Elevation Dataset (NED) files and ESRI’s shape files to help supplement OSM data, as stated in Barbeau’s technical report.
Also according to Barbeau’s final report, the next step to extend research of the OTP project is to create a public pilot deployment of OTP for a city or a country. A pilot deployment of OTP would be very valuable to researchers as a basis for conducting studies on topics such as including applying changes to the OSM tagging system to improve its usefulness for multimodal trip planners, research on what information needs to be communicated to travelers for multimodal trips, and how best to effectively communicate with them, and much more. Congruently, a working example of the system would help stir up interest by other communities, not only in OTP, but also in similar trip-planning software applications. The researchers also want to take part in this with their own implementation of OTP for Metro Manila.

3.1. OpenStreetMap (OSM)

OpenStreetMap is an open source and freely available international repository of geographic data that individuals contribute to about their local community. It is currently maintained by the non-profit OpenStreetMap foundation. The general public and various organizations, such as transit agencies with public-domain data, are free to add their geographic information into the system. Although most contributors are volunteers, there have been an increasing number of both commercial organization and government bodies contributing to the project. These data contributors gather information by driving, cycling, or walking along streets and paths, recording their every move using global positioning system (GPS) data.

Data from the system can easily be shared and viewed by requesting a download or viewing a simple Internet-based application. Anyone with an interest in providing and using data about any area is free to do so. In addition, when someone finds an error in the data, he or she is free to correct it accordingly. The system has the ability to gather information from multiple different sources using crowd-sourcing techniques. The general public is able to contribute large amounts of data instead of only one organization being held responsible for creating and updating all of the data. A number of existing open-source software tools work well with OSM data. Software like these allow communities to collaborate on software projects, which provides a robust and stable base for improvements, as described in Barbeau’s technical report.

3.2. General Transit Feed Specification (GTFS)

Google’s offer of a free GTFS-based online trip planner has made GTFS, in practice, the standard for describing transit systems and platform for many other Internet and mobile applications. The Google Transit trip-planning service was able to encourage 125 public transportation agencies in the United States alone to put their data into the GTFS format for Google Transit. However, although the GTFS format is open, Google Transit does not serve as a common data repository where the underlying information can be shared freely without licensing fees or copyright restrictions, as described in Barbeau’s technical report.

3.2.1 GTFS Editor

One of the most popular open source GTFS formatting tools is GTFS Editor, which is able to help researchers and public transportation agencies transform raw public transportation data into GTFS data, which is the transportation data format accepted by OTP. GTFS Editor is a web-based GTFS editing framework that uses PostgreSQL 9.1+, PostGIS 1.5+, and Play
framework 2.x+. Its operational status is under development by Conveyal and their supporters. This tool is downloadable through their official GitHub website.

Figure 2 illustrates the theoretical framework behind this research. Raw public transportation data was collected from various public transportation agencies, especially the LTFRB. Separately, DOTC also produced a set of data that is formatted according to the GTFS standards for the purpose of a hackathon they held back in 2013.

GTFS data along with the extracted Metro Manila map from OSM would be inputted to OTP’s graph builder module to produce the graph object of Metro Manila. This graph would then be the basis of OTP’s web application to produce the computed routes for a given origin and destination points. The target market of the system was assumed as the same group of people who completed the Metro Manila Public Transport Travel Survey. Their responses were analyzed by the researchers to produce their study for not only the use of different public transportation agencies, but also for other researchers.

![Figure 2. Theoretical Framework](image)

### 4. METHODOLOGY

Figure 3 illustrates the methodology behind the research and system development that would assist the researchers in answering their research questions. The first step, data gathering, includes the collection of public transportation data from various transportation agencies, as well as the study of the transportation sector through the Metro Manila Public Transport Travel Survey. This part would assist in achieving the first subobjective of “providing an up-to-date analysis of the condition of Metro Manila’s public transportation sector and its users, and to learn whether there is a need to implement a multimodal public transportation route planner.” The second step, which is data formatting, would aid the researchers in meeting the second subobjective of “providing a good approach in formatting transportation data from various public transportation agencies to produce an accurate and reliable GTFS data, not only for the proposed system’s use, but for other applications systems as well.” The third step, which is the modification of the OTP web application, is focused on meeting the main objective of the researchers, “to see the effectivity of OTP as a multimodal public transportation route planner in the context of Metro Manila road networks using OTP.” Step four comprises the testing and revision of the system, before going to step five, which is system deployment. After everything has been completed, the researchers would then focus on developing the research paper for conclusions and further studies, hopefully to entice further research about the researchers’ topics.
4.1 Data Gathering

The first step in the methodology is data gathering because transportation data is not readily available to the public in the Philippines. It is also important to take note that transportation data in the country is not integrated and is currently housed by different governing bodies. Data gathering is an integral part of the whole process because it will set the foundations of the system and also set the scope and limitation of the project.

MRT capacity and schedules were directly collected from the MRTA office; all other data about the MRT were gathered from their official website. LRT capacity was also directly collected from the LRTA office while all other information was downloaded from their official website. All data relating to bus and jeepneys were collected directly from LTFRB. Data that were collected from the MRTA, LRTA, and LTFRB offices were hard copies. Bus data were raw hard copies. They included around 1,100 routes with only their case number, operator name, and route names; there were no exact details on where these buses could legally pass through during their journey. Jeepney data were contained in 516 individual Excel files including their route, well known and important landmarks, distance of landmark from origin point, regular and special fares, but there are still no exact details on where these jeepneys are authorized to pass through during their journey. Bus and jeepney data were gathered from the LTFRB offices. However, readily available GTFS-formatted data was published by DOTC in late 2013.

The map data for Metro Manila would be extracted from OSM. However, since extraction of large amounts of data cannot be directly performed through OSM’s home website, Metro Extracts was used instead.

4.1.1 Metro Manila Public Transport Travel Survey

As part of phase one, a study was performed by the researchers to observe the travel behavior of Metro Manila commuters. This aims to produce up-to-date information about Metro Manila’s public transportation situation and its commuters and to see whether there is indeed a need to implement a multimodal public transportation route planner. The Metro Manila Public Transport Travel Survey can also be considered as a stand-alone research.
The Metro Manila Public Transport Travel Survey was made with the help of Google Drive’s Google Form, and was propagated through various websites including Facebook, Moodle, and Twitter. The survey was intended to record the travel details of all kinds of commuters travelling within Metro Manila. The survey, which was published from September to October 2014, was able to garner a total of 265 respondents, with 264 valid responses.

There were also data corrections performed on obviously erroneous data entry. For the length of travel per transportation mode, those that are more than 180 minutes (3 hours) were changed to their corresponding minutes. One entry was treated as invalid because the response showed that the respondent only used one transportation mode, taxis, which the researchers do not consider a public transportation mode. In addition, this input would be an outlier for the length of time and cost of travel and would cause bias and distortion in other computed values. This reduced our number of valid responses to 264.

Survey data were analyzed with the help of Microsoft Excel and StatPlus. For overall information, charts and graphs were generated by Excel; for more detailed statistical analysis, StatPlus was used as an add-on Excel tool.

4.2 Database Formatting

Transportation data was formatted according to the GTFS discussed in the previous chapter because it is the format accepted by the OTP software.

The researchers attempted to create their own version of Metro Manila’s GTFS data with the help of the open tool, GTFS Editor. Installation was performed using instructions from the official GitHub website. Below is the detailed description of the researchers’ suggested standard for creating a GTFS feed:

1) Create an account: After the GTFS editing framework was up and running, the first step was to create an account. The researcher’s personal username, password, and e-mail address was used for this purpose.

2) Setup database: The database was set up to create the default agency because the tool assumes that the user is a public transportation management agency.

3) Manage route types: After configuration, the text task was to manage the route types. This includes the Bus as BUS - BUS_UNSCHEDULED, Jeepney as BUS - MISCELLANEOUS, LRT as RAIL - RAIL, Marina as FERRY - WATER, and MRT as RAIL - URBANRAIL_METRO, PNR as RAIL - RAIL_LD.

4) Manage agencies: Managing the agencies that govern the transportation modes included in the research were then added. This includes Manila LRTA, LTFRB, MARINA, MRTC, and PNR.

5) Create route: The different routes of each transportation modes were then added one by one by adding a unique route under the agency in charge. For LRT, MRT, MARINA, and PNR routes, the standard way of creating routes was performed by providing basic information, then the stops and/or stations, then the trip patterns, then the trip schedules.

The MRT track, which runs from Taft Avenue to North Avenue and vice-versa, was reflected on the system by blue color-coded lines. Stop and stations were acquired from their home website; operating times uploaded on the site were also used to create the trip patterns (northbound and southbound trips for weekdays and weekends). To create a more true-to-life train schedule than the one uploaded in the MRT website, some modifications were performed to the uploaded data to reflect the researcher’s and commuters’ first-hand travel experiences. The speed of MRT trains was set at 30 kilometers per hour with a 30-second dwell time per station, which means that they take up to 30 minutes to complete a
one-way trip. The MRT service times were based on their officially announced times in their website.

Two LRT tracks are managed by the LRTA. The first is LRT1, which runs from Baclaran to Roosevelt and vice-versa; the other is LRT2, which runs from Recto to Santolan and vice-versa. Yellow or purple color-coded lines indicated LRT1 and LRT2 trips in the system, respectively. Stops, stations, and operating times were obtained from the LRTA website to create the trip patterns (north and southbound for weekdays and weekends). Similar to the MRT track, to create a more realistic train schedule than the one publicly announced by the agency, some changes were made by the researchers based on the researchers’ and commuters’ observations and experiences. The speed of LRT1 was set to 20 kilometers per hour with a 30-second dwell time per station, which made a one way-trip from one end station to the other around 50 minutes. The speed of LRT2 was set to 30 kilometers per hour with a 30-second dwell time per station, which made each one-way trip take around 30 minutes. The servicing time was based on their officially announced time in their home website.

The creation of bus and jeepney routes did not follow the usual convention because buses and jeepneys in the Philippines are treated as “special cases.” They have no specific stops and stations, they sometimes do not follow their designated trip patterns, and do not have trip schedule timetables. These factors and several other reasons made it hard to create realistic transportation data for them. The researchers decided to implement only a couple of routes, with which they were personally familiar to uphold the integrity and accuracy of data. Their focus was then shifted to creating a standard for formatting public transportation data into GTFS data.

4.3 OpenTripPlanner Implementation

Complete with the needed data, the researchers started the actual implementation of OTP. Source code was downloaded from OTP’s GitHub page. An instruction manual to set up the system was also obtained from the same web page. In cases of bugs and errors, the researchers contacted the official OTP developer and user community in Google Groups.

4.4 Testing and Revisions

Testing of the application was done by randomly selecting popular places in Metro Manila and inputting them as origin and destination points in the provided text boxes, or randomly clicking on the provided map. The Metro Manila Public Transport Travel Survey also helped by giving the researchers origin and destination points travelled by actual commuters. The routes computed by the system were then compared with those submitted by respondents.

4.5 System Deployment

After the system passed the testing stage, it was hosted online using Ateneo’s server for the consumption of Metro Manila commuters. The researchers and colleagues promoted the web application using various social media networking sites to urge people to use the system. The researchers also gave away flyers to commuters in strategic locations, such as the main MRT and LRT stations, as well as major bus terminals.

4.6 Conclusion and Discussions
After the development and deployment of the system, the researchers went back to their research objectives to draw out their conclusions. Important details of the study and research are discussed not only for the project’s purpose, but also in hopes of attracting people to do future research in the same field.

5. RESULTS AND ANALYSIS

5.1 Metro Manila Public Transport Travel Survey

Of the 264 valid responses garnered by the survey, 53% were male and 47% were female. Fifty-nine percent of the respondents were aged 18 to 25 years, 20% were 26 to 33 years, 6% were 34 to 41 years, 6% were 42 to 49 years, 5% were 50 to 60 years, and the last 4% were younger than 18 years of age. This shows that survey was mostly answered by the younger generation, which is assumable as the survey was conducted online and their generation is easily reached by the Internet. Seventy percent of them were working employees, 26% were students, 3% were self-employed, and the last 1% answered “Others.” This shows that the survey reached the young working group of the current generation.

Thirty-seven percent of the respondents said that they made use of three transportation modes, 25% used two modes, 19% used four modes, 11% used one mode, 6% used five modes, and 3% used more than five transportation modes. Therefore, three modes are used on average. During the first parts of the journeys, the mostly used transportation modes were jeepney, others, bus, foot, and MRT, in descending order. During the later parts of the journeys, the mostly used transportation modes became others, foot, and jeepney.

For “per trip basis,” referring to the whole commuter journey from origin to destination point: the minimum travel time was 5 minutes (travels with only one mode used, usually the jeepney or others, e.g., trike) and the maximum was 258 minutes (travel from Paranaque to Katipunan, which consisted of seven transportation modes: foot, “others,” “others,” LRT1, LRT2, and “others”). The average travel time per trip was 73 minutes. In terms of travel cost, the minimum cost for one travel is 0 (pertaining to a travel that only consists of one mode of travel, by foot) and the maximum travel cost was Php 222 (a trip consisting of two modes: others and then jeepney). Average travel cost per trip is at Php 40.

Aggregating all the different legs (per transportation mode used) of all journeys, we get 771 legs, which comprises the “per mode basis.” The minimum travel time was 1 minute (a trip that used “others” as the transportation mode) and maximum was 150 (travel from Dasmarias Cavite to Ayala Makati using a bus). The average travel time for all modes was 25 minutes. In terms of travel cost, the minimum cost was 0 (for trips that were made by foot) and the maximum travel cost was Php 180 (a trip that used “others” as the transportation mode). The average travel cost for all modes was Php 14.

Of the 771 legs, 31% used Jeepney, 21% used “others,” 16% walked by foot, 12% journeyed by bus, 10% rode the MRT, 7% used the LRT2, and 3% used the LRT1. Focusing on the “others” option, we found that 60% comprised tricycle journeys, 17% vans, 13% FXs, 4% taxis, 4% cars, 1% pedicabs, another 1% by trolleys, and the last 1% by the PNR line. Aggregating these two data sets, we obtain all of the transportation modes used by the respondents, which is also referred to as the “modal split.” The modal split is as follows: jeepneys still get the top position with 31%, foot with 16%, trike with 12%, bus with 12%, MRT with 10%, LRT2 with 7%, van with 4%, LRT1 and FX with 3% each, car and taxi with 1% each, and trolley with almost 0%.
The top transportation modes that took the longest total travel times were jeepney, bus, and others; the top transportation modes that took the longest average travel times were bus, MRT, and LRT1. The transportation modes that garnered the highest aggregate transportation cost were others, bus, and jeepney; the modes that had the highest average transportation costs were others, bus, and LRT1.

The researchers wanted to know if the variables in the questionnaire were correlated. For this purpose, the researchers made use of the Chi-squared independent test. For gender and mode preference, the summation of the Chi-squared values seen is 9.68, and with a degree of freedom of 5, we get the Chi probability value of 8%. Therefore, gender and transportation mode preferences are independent of each other. For age and mode preference, the summation of the Chi-squared value is 2.79, and with a degree of freedom of 25, we get the Chi probability value of 0.10%. Therefore, age and transportation mode preferences are strongly dependent on each other. For occupation and mode preference, the summation of the Chi-squared value is 63.67, and with a degree of freedom of 15, we get the Chi probability value of 0.000006%. Therefore, occupation and transportation mode preferences are strongly dependent on each other.

In general, both genders prefer to use jeepneys to other transportation modes. Men slightly prefer to use the bus and go by foot more than women do; women slightly prefer to use “others” more than men. The older generation, people aged 26 years and over, tend to prefer to use the bus and do not prefer to walk by foot; the younger generation, people younger than 26 years, do not use the bus and prefer to walk by foot. Most employees prefer to travel by bus and the MRT and do not prefer to use the LRT. The complete opposite preference is seen with students who prefer to travel by LRT and do not prefer to use the bus and the MRT.

The researchers observed that most trips were 30 to 55 minutes long (29.92% of the responses) or were 55 to 80 minutes long (24.24% of the responses). Around 50% of the trips were completed in less than 60 minutes, 75% were less than 90 minutes, and 90% were less than 120 minutes. The researchers also observed that most trips cost between 22 to 44 pesos (36.36% of the responses), or cost 0 to 22 pesos (26.89% of the responses). Around 50% of the trips cost less than Php 40, 75% were less than Php 50, and 90% were less than Php 65.

5.2 OpenTripPlanner

Before being able to implement the actual system, the graph of the subjected area should be created first by OTP’s graph builder module. This module requires two inputs to create the graph: the OSM and GTFS data of the region. Since large amounts of OSM data cannot be directly extracted from its home website, a third-party website was used to download Metro Manila’s OSM data (http://metro.teczno.com/). GTFS data from the LTFRB was entered into the system because it was readily available.

Once the graph was created, OTP’s web API was configured to run the web application. The basic set-up of the system is already able to produce multimodal public transport routes when the user selects the origin and destination point using the provided map. To make the system user-friendlier, some modifications were employed, such as the activation of the “To” and “From” text boxes. This module allows the user to input the origin and destination points’ longitude and latitude instead of clicking on the map.
Once the system was up, the researchers tested it with a number of randomly selected origin and destination points by either arbitrarily clicking on the map or typing in the provided “To” and “From” text boxes. Figure 4 shows the system’s route calculation from Boni Mandaluyong to Katipunan Quezon City.

The base configuration of OTP is always able to compute for at least one (1) multimodal public transport route between the selected origin and destination points, as proved by the random test the researchers carried out. When one selected point (either the origin or destination point) is beyond the boundaries of Metro Manila, the system returns a route with an endpoint nearest the point outside the boundary and adds supplementary walking route to the actual selected point. However, when both the origin and destination points selected are outside the boundary box, the system is not able to compute for a route. The system returns an error message stating, “Trip is not possible. You might be trying to plan a trip outside the map data boundary.” Route suggestions changes depending on the arrival or departure time inputted by the user since different transportation modes have different service times. Some transportation modes are not available during specific times and days of the week.

The current implementation of OTP with the GTFS data from DOTC implements the map of Metro Manila and neighboring major cities such as Antipolo, Bulacan, and Cavite. It implements the majority of the transportation modes used by regular Metro Manila commuters (63% of the modal shift), which was previously discussed above.

The promotion of the system is of utmost importance because as more people use and trust the system, more commuters would be guided into using a better transportation system. Presenting consumers with currently unavailable data regarding public transportation would change their negative perceptions because they will now be able to compare the cost and time of using a private vehicle with using public transportation.

5.3 General Transit Feed Specification

While implementing OTP with the GTFS data from DOTC, the researchers were able to closely examine and explore the GTFS data, which includes eight unique text files, agency.txt, calendar.txt, frequency.txt, shapes.txt, stop_times.txt, stops.txt, trips.txt, which
are the basic files needed to run OTP. However, the researchers saw several errors and inaccuracies. There was more room for improvement.

First, the coordinates for the stops are not always accurate. The longitude and latitude values are not exact to the map, and therefore point to the wrong geographic location. Second, some origin or destination points or stops were misspelled. The researchers also observed that the government’s GTFS data puts bus and jeepney routes under one route type, which should not be the case because this causes confusion for the system and the users. That was the reason behind adding the “jeepney” localized vehicle, differentiating it from the “bus” type vehicle in the GTFS data of LTFRB.

Several adjustments should be performed on data from the different public transportation governing agencies to create a more true-to-life scenario of the transportation sector. For one, the speed of the LRT and MRT trains should be adjusted from their publicly announced travelling speed to create a more realistic train schedule for LRT1, LRT2, and MRT. MRTC publicly announces that their trains run at 40 kilometer per hour, but it is more faithful to say that the trains only run at 30 kilometers per hour because it takes around 30 minutes to reach the end station from the other, not around 22 minutes. LRTA says that their the LRT1 trains run at 40 kilometers per hour, but it is more truthful to say that they run at around 20 kilometers per hour because it takes about 48 minutes to reach the end station from the first station, not 30 minutes. They also said that LRT2 runs at an average of 70 kilometers per hour, but it is also more realistic to say that they run at 30 kilometers per hour because it takes about 29 minutes to reach the end station, not 15 minutes.

The creation of realistic transportation data for buses and jeepneys was near impossible because they are treated as special cases in the Philippines. For one, they have no specific stops and stations, they stop wherever they see a possible passenger or when a commuter needs to alight the vehicle as long as it is following their designated route. Aside from that, data from LTFRB only shows only major stops; therefore, retracing their actual path is almost impossible if you are not familiar with the route. Figure 5 shows the bus and jeepney route data that the researchers gathered from LTFRB. Second, they sometimes do not follow their designated trip patterns; some randomly decide to change their route or stop their route journey when they do not obtain the required number of passengers. This is especially true with jeepneys. Third, they do not have trip schedule timetables and arrive
along their designated route at any time of the day. It is also hard to create their schedule based on the frequency of their service because since they follow no schedule and the government is not even sure of the number of officially registered vehicles. These unregistered vehicles are called “cholorum.”

6. CONCLUSIONS

The current situation of Metro Manila’s public transportation sector is disorganized. Although the LTFRB provided specific stops for buses and jeepneys, they do not follow them and stop anytime a passenger wishes to board or alight the vehicle. This habit of loading and unloading anywhere has been one of the top reasons for road network congestion, especially in the main networks, including EDSA. The government should implement traffic rules more strictly to correct this unconstructive behavior by motorists and commuters.

• The following can be concluded from the Metro Manila Public Transport Travel Survey:
  • The target market of the survey and of the system are students in Quezon City and young working employees in Makati, the Fort, and Boni.
  • The average number of modes used is three modes per trip (37%, 3 modes; 25%, 2 modes; 19%, 4 modes), maximum is seven modes.
  • The top transportation modes used are jeepney, “others,” foot, bus, MRT, LRT2, and LRT1.
  • The “others” transportation modes used are tricycle, van, FX, taxi, car, pedicab, trolley, and PNR.
  • Modal split, in decreasing order, was jeepney, foot, trike, bus, MRT, LRT2, van, LRT1, FX, car, taxi, trolley, motorcycle, pedicab, and PNR.
  • The transportation modes that had the shortest mean travel time were foot, LRT2, “others,” jeepney, LRT1, MRT, and bus.
  • The most expensive transportation modes to use were bus, “others,” LRT1, LRT2, MRT, jeepney, and foot.
  • Shortest travel time per trip was 5 minutes, longest was 258 minutes, and the average is 73 minutes.
  • Cheapest travel cost per trip was Php 0, most expensive was Php 222, and the average is Php 41.
  • Gender and preferred transportation mode were independent of each other. Age and preferred transportation mode were strongly dependent on each other; occupation and preferred transportation mode were strongly dependent on each other.

With this information, we can see that there is a need to implement a public transportation route planner. First and foremost, our public transportation system supports and promotes multimodal travelling; commuters make use of an average of three transportation modes per trip. People still opt to use private vehicles in their daily commute; this includes cars, taxis, and motorcycles. The researchers also saw that public transportation data is not readily available to the public; however, those that are readily available do not accurately reflect real-life situations.

This research proved the effectiveness of implementing a multimodal public transportation route planner for Metro Manila with the help of OTP because it is always able to compute for at least one multimodal public transportation route from the given origin to the destination, accompanied by additional useful travel information. The implementation of this system was smooth and easy as long as the user follows the instructions found in the official GitHub website of OTP. In cases of errors, the developer
and user Google group of OTP is always willing to help and answer queries and inquiries. It is important to note that the system should always be updated every time a latest GTFS data set is published.

In general, with the researchers’ examination of the current GTFS data, it appears that different people collated the data. Thus, they used different abbreviation or acronyms for the same streets (e.g., EDSA and Epifanio Delos Santos Avenue), different parameters for deciding on distances between stops (e.g., stops for every 1 kilometer vs. stops for every 100 meters), different names of street due to legislation (e.g., Buendia was changed to Gil Puyat). The data is a hodgepodge of information; therefore, the researchers saw a need for a more updated, consistent, uniform, and reliable GTFS data. The researchers suggested that the government should follow a standard, which is needed because GTFS data needs continuous editing and updating as the transportation sector in the Philippines is always changing. This will be further discussed in the next chapter.

Given these information, the researchers hope that commuters’ negative perception of using public transportation would be challenged. Now that they have a way to know details about using public transportation, they would hopefully become less fearful of using it and would entice more people to use public vehicles.

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REFERENCES


World Bank (2011). Implementation Completion and Results Report on a Loan in the Amount of $60.0 Million and a Global Environmental Facility Grant in the Amount of SDR 1.0 Million (US $ 1.3 Equivalent) to the Republic of the Philippines for the Metro Manila Urban Transport Integration Project, June 2011.

