A Study of Metro Manila's Public Transportation Sector By Implementing A Multimodal Public Transportation Route Planner

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Abstract: Public transportation provides commuters a convenient way to reach their destination faster and cheaper, as compare to using private vehicles. This however is not always the case for Metro Manila as many Filipinos have a negative perception of using public transportation.
This paper would first discuss the researchers' study regarding the travel behavior of Metro Manila commuters and the status of its public transportation sector, as concluded from their "Metro Manila Public Transport Travel Survey." Information from the said study was used to implement a multimodal public transportation route planner for Metro Manila. The said system's goal is to provide commuters actual facts about public transportation, so as to change its negative image and to entice more people to utilize it. Then, the researchers' analysis of the publicly distributed GTFS data provided by the government would be discussed. All these support the researchers' end-goal of upping 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 S.M. Kumari *et al.* (2010) and K. Rehrl *et al.* (2007), having good transportation network is one of every modernized city's initial priorities, as today's modern society needs mobility in every aspect of life. Everyday people have 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 of the world, transportation networks are unceasingly being congested. According to S. Kenyon *et al.* (2003), to solve this problem and to lessen the number of vehicles clogging up the road networks, many governments all over the world have been pushing for the so-called "Modal Shift." That is, enticing citizens to shift away from mainly using private transportation modes to using public transportation vehicles. Based on the National Household Travel Survey (NHTS, 2009), the average vehicle occupancy of private cars is only at 1.55 person; average jeepney occupancy is at 10.6 people and bus occupancy is at 43.4 people based on World Bank's Implementation Completion and Results Report (2011). These statistics illustrate the big difference in number of people transported with almost the same road space used. Harmoniously, 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 supports the long-term sustainability of transportation networks, as each and every 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 has the goal of providing the user a good route from the given origin point to the destination point, prior to the user's journey. Whilst the 1st generation of route planners, handled only monomodal travelling and focused on private vehicle driving, the new generation of route planners faces more problems as they have to take into account multiple modes of transportations and multiple objective functions (cheapest travel cost, fastest travel time, shortest travel distance, etc.) based from F. H. Meng' *et al.* (1999) research. The researchers believe that implementing a multimodal public transportation route planner for the commuters of the Metro poses to be a promising solution in decongesting the main roads of Metro Manila.

This research first aims to share the researchers' findings and analysis regarding the travel ravel behavior of Metro Manila commuters and share 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 our commuters with regards to a route planning system, it also provides an updated study of the current situation of Metro Manila's public transportation and its commuters. Information from the said study were 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, with the help of "OpenTripPlanner," would then be 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 and realization of its goal of providing commuters actual facts about public transportation, so as to change its negative image and to entice more people to utilize it. Lastly, the researchers' careful analysis of the publicly distributed GTFS data provided by the government would be discussed, along with the researchers' recommendations on how to manage transportation data to create a more reliable GTFS data – based from their knowledge and experiences from their attempt to create their own GTFS data. All these support the researchers' end-goal of upping 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 DOTC and raw hard copies of route data from the different public transportation-governing agency. Only a couple of routes were implemented, as it is just a proof of concept of the researchers' suggested standard; completion of a more accurate and reliable GTFS data would be part of the researchers' further study. The tool that was used to create the GTFS data is GTFS-Editor. The map of Metro Manila would be extracted from OSM and kept unedited.

The current Metro Manila GTFS data which is used by the instance of OpenTripPlanner the researchers are hosting online implements the following agencies: MRTC, LRTA (for LRT1 and LRT2), LTFRB (for busses and jeepneys), MARINA and 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 with other additional transportation information. These estimates are based on transportation data acquired from the various public transportation governing agencies. Also, the system would not incorporate the actual schedule of the supported transportation modes; 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 OpenTripPlanner.

1.2 Purpose

This paper aims to explore the effectiveness of the open source multimodal trip planning system OpenTripPlanner 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 of 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 (no public transportation route available, longer travel time as compared to driving, etc.) 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 follow the researcher's goal of providing ways for a more sustainable transportation network in the long run.

2. PUBLIC TRANSPORTATION ROUTE PLANNERS

2.1 International Context

Zhang and his team implemented Advanced Traveler Information System (ATIS) by using Dijkstra's algorithm and running it with 5 transportation modes in the Eindhoven region (the Netherlands). Although the said algorithm was not fast enough when inputted with a large set of data, the generated routes were in good quality making it a good algorithm for creating paths in a realistic network. Their research concluded with recommendations for improving Dijkstra's algorithm by accelerating it with the help of bi-directional search or heuristic methods like A*. Karl Rehrl and company implemented “the Personal Travel Companion,” in the transportation network of Vienna Australia, 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 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 for good grounds for further researches in the field.

Peng and Kim developed a distributed trip planning system that integrates different trip planning system 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 them in a seamless manner, allowing users to create travel plans that go across different transit system boundaries. Brennan and Meier produced a similar system called "Smart Traveller Information Service" (STIS) that integrates different pre-available transport systems in Dublin Ireland. Their system works functionally well in producing different routes for different transportation mode option. 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. The proposed approach was lab tested with the transportation network of Tehran. However, the current system lacks input of user preference and only takes into consideration travel time. Also, the proposed approach still has to be tested with 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 the multimodal aspect as well as the capacity to take into consideration user preference when computing for routes.

In Hong Kong, an Internet-based comprehensive public transport enquiry system (PTES) was developed by Lilian Pu-Cheng. The system helps commuters know the connection of different forms of transportations and to know how to get to the stops or terminals from boarding place and/or connection points. Its most important features aside from its computation efficiency are its real-time multiple-criterion route search, fare structure computation. More route information and choice of fare type (student, senior citizen, air-conditioned, non-air-conditioned, etc) are included in its further research. As a capstone for their research, Foo Hee Meng and his team developed a system called "Route Advisory System" (RADS) that run the algorithm they created and implemented it with the public transport of Singapore. The system was able to take into consideration user preference in time, fare, and starting time. However, further improvements can be added by providing commuters with dynamic guidance under 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, an international multimodal journey planning and delivery of 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 travellers. 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 re-planning option, concerns for elderly and disabled users, concern for green routes, and mobile application implementation. Also developed in Greece by Zografos and company is ENOSIS, a passenger information and trip planning system that aims to provide both urban and interurban multimodal planning services with real-time travel information. The said system takes into account multiple criteria and incorporates complex scheduling constraints all customized by the user. It also serves as a travel companion throughout the entire travel by providing real-time ordinary and unexpected event alerts. Some other notable route planners include researches of the teams of Zhang, Li, and Jariyasunant all created systems to support

mobile-based advanced traveller information systems in the context of California. 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 city in India. Their system provides a convenient and powerful tool for storage and graphical representation of information; the system also is not limited to road networks but includes comprehensive information about Hyderabad City in general including hospitals, government and private offices, stadiums, and tourist places within the city limits. These systems are the prime multimodal public transport route planners out there and the Philippines, with its ever-worsening traffic condition, has to catch up with these innovations.

2.2 Philippine Context

Google maps, which is perhaps one of the most well known route planning system in the world, has its own version of public transport route planner called Google Transit. Google Transit is able to calculate a number of routes complete with distance to be travelled and travel time. The system however only incorporates buses, MRT, LRT1, and LRT2 routes; jeepneys, which is the main transportation mode used in the Philippines, is not included in the system. Transportation cost is 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 however currently running the transportation network of Cebu city and the Metro Manila routes are not yet fully functioning, as it is only able to return the walking route from the origin to the destination point. Sakay.ph, 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 the researchers' system would be from its inspiration ``Sakay.ph'' would be the GTFS data the system runs with.

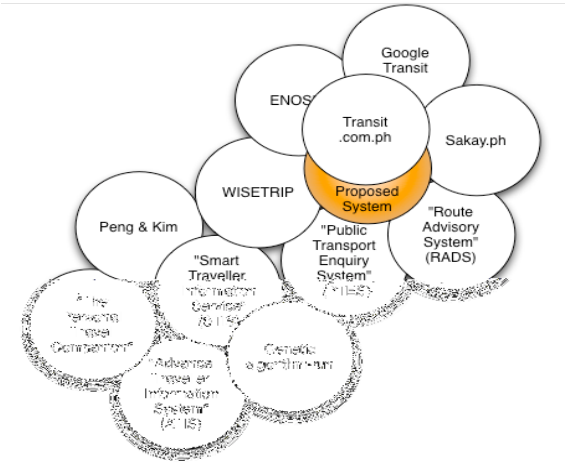


Figure 1. Route Planner Tree Diagram

Figure 1 illustrates the tree diagram representation of notable Public Transport Route Planners. It summarizes the position of known Public Transport Route Planners as compared to 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 the researchers wish to put in their proposed route planner, research behind them 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 take into consideration the shortest travel time, the proposed system would return an array of possible routes so commuters would have a number of options to choose from. 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.

There are also no updated data about the public transportation sector of the Philippines and its users, thus urging the researchers to create their own using their "Metro Manila Public Transport Travel Survey."

3. FRAMEWORK

As stated in the introduction, the main purpose of this research is to know the effectiveness of implementing a public transportation route planner for the road network of Metro Manila with the use of the open source multimodal trip planning system OpenTripPlanner. This section would discuss 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 from across the world, who are all coordinated by OpenPlans and TriMet; it is a collaborative effort among TriMet, OpenPlans, and the developers of Five Points, OneBusAway, and Graphserver. OpenTripPlanner was, as a matter of fact, identified as the most promising open source multimodal trip planning software system. Not to mention the merit it gets from its big active developer community, as reported by B McHugh. The system would be set up using geographic data from OSM and GTFS data from relevant transit agencies, both discussed in details below.

OpenTripPlanner contains most of the main features desired of in a multimodal public transportation trip planner. It is also important to note that it has an active community that is continuing 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 S. J. Barbeau's technical report.

Also according to S. J. Barbeau's final report, the next step to extend research of the OpenTripPlanner project is to create a public pilot deployment of the said system for a city or a country. A pilot deployment of OpenTripPlanner would be very valuable to researchers as a base 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 travellers for multimodal trips and how best to effectively communicate them, and much more. Congruently, a working example of the system would help stir up interest by other communities, not only in OpenTripPlanner but also in similar trip planning software. The researchers also want to take part in this with their own implementation of OpenTripPlanner 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 geographic information they have 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 from the system can easily be shared and viewed by requesting a download or viewing a simple webpage-based application. Anyone with an interest in providing and using data about any area is free to do so. Also, when someone finds an error in the data, he or she is free to correct it accordingly. It has the ability to gather information from multiple different sources as it makes use of 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. There are a number of open-source software tools that exist to work well with OSM data. Software like these allow communities to collaborate on software projects, providing a robust and stable base for improvements, as also stated in S. J. Barbeau's technical report.

3.2. General Transit Feed Specification (GTFS)

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

3.2.1 GTFS-Editor

One of the most popular open source GTFS formatting tool is GTFS-Editor. The said tool would be able to help researchers and public transportation agencies transform raw public transportation data into GTFS data - the transportation data format accepted by OpenTripPlanner. It 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

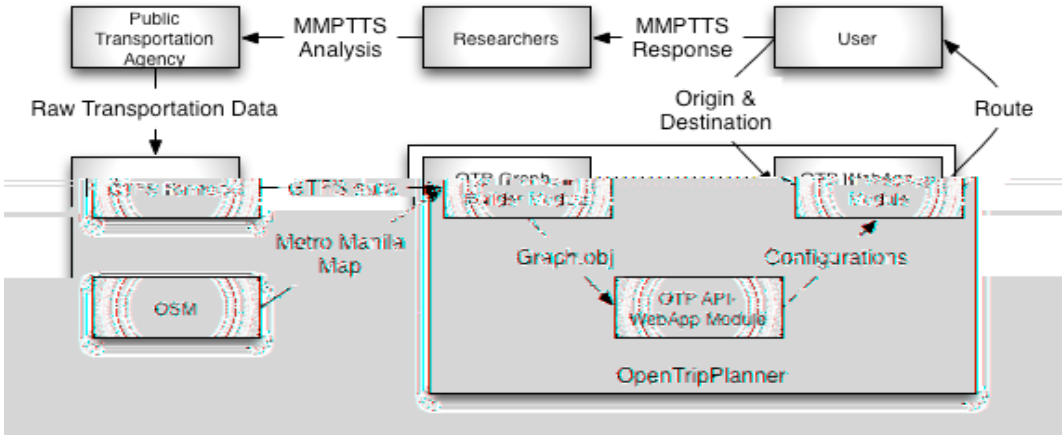


Figure 2. Theoretical Framework

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 standards of General Transit Feed Specification (GTFS) 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 OpenTripPlanner's graph builder module to produce the graph object of Metro Manila. This graph would then be the basis of OpenTripPlanner's web application to produce the computed routes for a given origin and destination points. The target market of the system was assumed to be the same group of people who answered "Metro Manila Public Transport Travel Survey." Their response were analyzed by the researchers to produce their study not the use of the different public transportation agencies, but for other researchers as well.

4. METHODOLOGY

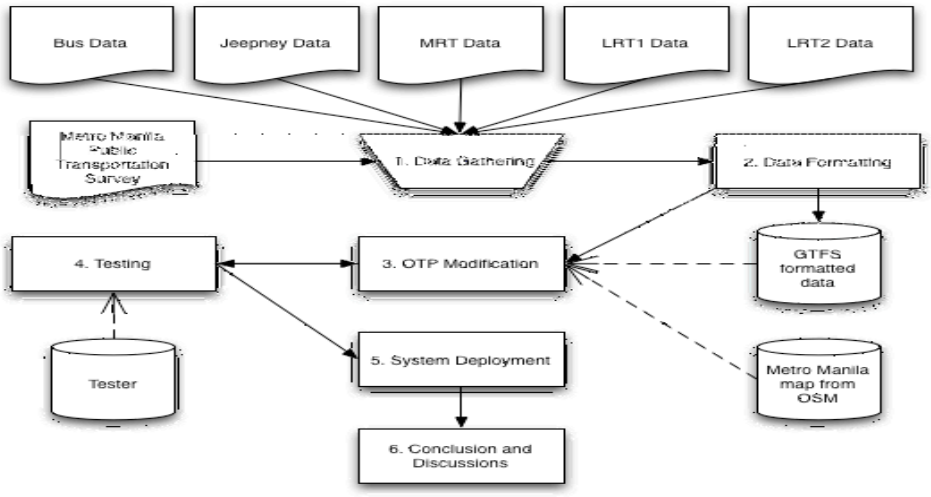


Figure 3. Research Methodology

Figure 3 illustrates the methodology behind the whole 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 about the transportation sector through the "Metro Manila Public Transport Travel Survey." This part would assist in achieving the first sub-objective of "providing an up-to-date analysis of the condition of Metro Manila's public transportation sector and its users, to know if there is a need to implement a multimodal public transportation route planner." The second step, which is the Data Formatting, would aid the researchers in meeting sec on sub-objective 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 OpenTripPlanner web-app, is focused in meeting the main objective of the researchers – "to see the effectivity of OpenTripPlanner as a multimodal public transportation route planner in the context of Metro Manila road networks using OpenTripPlanner." Step four is all about testing and revising the system, before going to step five, which is the System Deployment. After everything has been done, 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

First step in the whole methodology is data gathering, as 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 being housed by different governing bodies. Data gathering is an integral part of the whole process as it will set the foundations of the system and it would also set the scope and limitation of the project.

The survey entitled “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 said 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 done to 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 as the response showed that the respondent only used 1 transportation mode: taxi, which is not considered as a public transportation mode by the researchers. Also, the said 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 reduces our number of valid responses to 264.

Survey data was 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 would be formatted according to the General Transit Format Specification (GTFS) discussed in the previous chapter, as it is the format accepted by the OpenTripPlanner (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 done with the help of instructions from their official GitHub website. Below is the detailed description of the researchers' suggested standard of creating a GTFS feed:

1) Create an Account

create a more true-to-life train schedule than the one uploaded in their website some modifications were done on 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, making it take up around 30 minutes to complete a one-way trip. The servicing time was based on their officially announced one in their home website.

There are two LRT tracks managed by the LRTA, first is LRT1 which runs from Baclaran to Roosevelt and vice-versa, the other one is LRT2 which runs from Recto to Santolan and vice-versa. LRT1 trips would be reflected by yellow color-coded lines in the system, and purple for LRT2 trips. Stops and stations were also acquired from their home website; operating times were also acquired there 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, making 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, taking each one-way trip around 30 minutes. The servicing time was based on their officially announced one in their home website.

The creation of bus and jeepney routes did not follow the usual convention; this is because of the fact that 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 patters, they do not have trip schedule timetables. These and a lot more other reasons made it hard to create realistic transportation data about them. This made the researchers decide to only implement a couple of routes they are personally familiar with, so as to uphold data integrity and accuracy. Their focus was then shifted on 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 OpenTripPlanner. Source code was downloaded from OpenTripPlanner'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 inquired from the official OpenTripPlanner 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 study ``Metro Manila Public Transport Travel Survey" also helped by giving the researchers origin and destination points travelled by actual commuters. The system's computed routes were then compared to the one submitted by the respondent.

4.5 System Deployment

After the system passed the testing stage, it was hosted online for the consumption of Metro Manila commuters through Ateneo's server. To urge people to use the system, the researchers along with colleagues would promote the web application through various social networking

sites. The researchers would also try to give away flyers to commuters in strategic locations like main MRT and LRT stations, as well as major bus terminals.

4.6 Conclusion and Discussions

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

5. RESULTS AND ANALYSIS

5.1 Metro Manila Public Transport Travel Survey

Of the 264 valid responses the survey garnered, 53% were male and 47% were female. 59% of the respondents were aged 18 to 25, 20% were 26 to 33 of years, 6% were 34 to 41, another 6% were 42 to 49, 5% were 50 to 60 years old, and the last 4% were below 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 it is their generation that is easily reached by the Internet. 70% 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.

37% of the respondents said that they made use of 3 transportation modes, 25% used 2 modes, 19% used 4 modes, 11% used 1 mode, 6% used 5 modes, and 3% used more than 5 transportation modes. Average number of modes used therefore becomes 3. During the first parts of the journeys, the mostly used transportation modes were the Jeep, Others, Bus, Foot, MRT, in descending order. During the later parts of the journeys, the mostly used transportation modes became the Others, Foot, and Jeep.

For "Per Trip Basis" meaning the whole journey of the commuter from origin to destination point: minimum travel time was 5 minutes (travels with only 1 mode used, usually the jeepney or others - trike) and maximum was 258 minutes (a travel from Paranaque to Katipunan consisting of 7 transportation modes: Foot, "Others," "Others," LRT1, LRT2, "Others"). Average travel time per trip was 73 minutes. In terms of travel cost, the minimum cost for 1 travel is 0 (pertaining to a travel that only consists of 1 mode of travel: by foot) and maximum travel cost was Php 222 (a trip consisting of 2 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." Minimum travel time was 1 minute (a trip that used "Others" as the transportation mode) and maximum was 150 (a travel from Dasmarinas Cavite to Ayala Makati using a bus). Average travel time for all modes was 25 minutes. In terms of travel cost, the minimum was 0 (for trips that were made by foot) and maximum travel cost was Php 180 (a trip that used "Others" as the transportation mode). Average travel cost for all modes is at Php 14.

Of the 771 legs, 31% of them were travelled using Jeepney, 21% used "Others," 16% walked by foot, 12% journeyed by bus, 10% was by riding the MRT, 7% by the LRT2 and 3% by the LRT1. Focusing on the "Others" option, it was found out that 60% of this was comprised of Tricycle journeys, 17% by Vans, 13% by FXs, 4% by Taxis, 4% by Cars, 1% by Pedicabs, another 1% by Trollys, and the last 1% by the PNR line. Aggregating these two

data, we get all of the transportation modes used by the respondents, 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, Trolly with almost 0%.

The top transportation modes that took the longest total travel times were Jeep, Bus, Others; the top transportation modes that took the longest average travel times were Bus, MRT, LRT1. The transportation modes that garnered the highest aggregate transportation cost were Others, Bus, Jeep; the modes that got the highest average transportation costs were Others, Bus, LRT1.

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

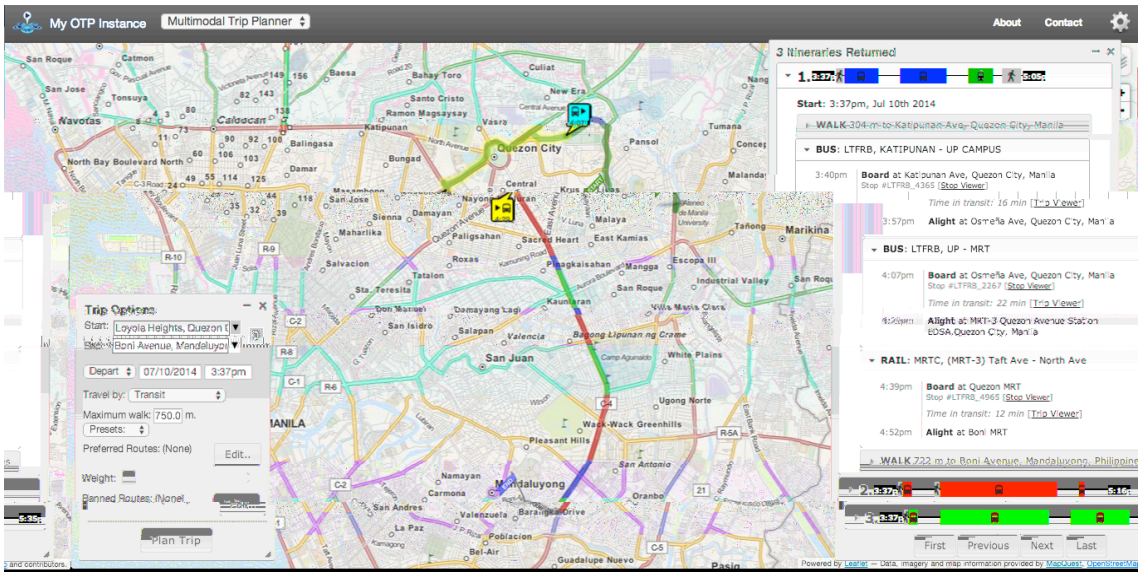
In general, both genders prefer to use jeepneys over other transportation modes. Males slightly prefer to use the bus and by foot more than the females; females slightly prefer to use "Others" more than the males. The older generation, people aged 26 and above, tend to prefer to use the bus and do not prefer to walk by foot; younger generation, people aged below 26 years of age, 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 of 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 traveled 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 OpenTripPlanner's graph builder module. This module requires two inputs to create the graph: first is the OSM data of the region, and second is the GTFS data of the area. 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 inputted in the system, as it was readily available.

Once the graph was created, OpenTripPlanner's web API was configured to run the web application. The base set up of the system is already able to produce multimodal public transport routes when the user selects the origin and destination point with the use of 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 OpenTripPlanner 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 time" 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 OpenTripPlanner with the GTFS data from DOTC implements the map of Metro Manila and neighboring major cities such as Antipolo, Bulacan, and Cavite. It implements majority of the transportation modes used by regular Metro Manila commuters - 63 percent of the modal shift, which was previously discussed above.

The system's promotion is utmost importance because as more people use and trust the system, the more commuters would be guided into a better transportation system. Presenting currently unavailable data regarding public transportation would change the negative perception of commuters. 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 OpenTripPlanner with the GTFS data from DOTC, the researchers were able to closely examine and explore the said data. It includes the 8 unique text files: agency.txt, calendar.txt, frequency.txt, shapes.txt, stop_times.txt, stops.txt, trips.txt that are

the basic files needed to run OpenTripPlanner. They however saw a lot of errors and inaccuracies; there was more room for improvement.

First of all, the coordinates for the stops are not always accurate - meaning, the longitude and latitude values are not exact to the map, thus pointing to the wrong geographic location. Secondly, 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 as 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.

There are a lot of adjustments to be done on data from the different public transportation governing agencies so as 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 as 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 as it takes about 48 minutes to reach the end station from the starting one, and not 30 minutes; they also said that LRT2 runs at an average of 70 kilometers per hour, but it is also more lifelike to say that they run at 30 kilometers per hour as it takes about 29 minutes to reach the end station, and not 15 minutes.

Figure 5. Transportation Data From LTFRB

The creation of realistic transportation data for buses and jeepneys was near impossible as they are treated as "special cases" in the country. For one, they have no specific stops and stations, they stop wherever they see a possible passenger or when a commuters needs to alight the vehicle so long as it is along their designated route. Aside from that, data from LTFRB only shows only major stops, retracing their actual path is almost impossible if you are not familiar with the said route. Figure 5 shows the bus and jeepney route data the researchers gathered from LTFRB. Second, they sometimes do not follow their designated trip patters, some randomly decides to change their route or stop their route journey when they do not get the number of passengers they desire - this is especially true with jeepneys. Third is that they do not have trip schedule timetables, they would arrive along their

designated route anytime of the day; it is also hard to create their schedule based on the frequency of their service since they follow no schedule and the government is not even sure

time a latest GTFS data is published.

In general, with the researchers' examination of the current GTFS data, it appears that different people collated it. Hence 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). Data is a hodgepodge of information; there is a need for a more updated, consistent, uniform, and reliable GTFS data. With these information, the researchers saw a need for a more updated, consistent, uniform, and reliable GTFS data. The researchers suggested for a standard to be followed by the government. This standard is needed as GTFS data needs continuous editing and updating since the transportation sector in the Philippines is always ever 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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