

Utilizing Multimodal Public Transportation Route Planners for Long-term Sustainable Transportation Networks

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Abstract

relevant and reliable transportation information. The researchers made the available information in the public by implementing a public open source software Trip Planner. The said system would help Metro Manila has helped commuters all over the world. In addition, the researchers had goal of providing ways for a more long run would be.

Keywords: Route planner, sustainable transportation, public transportation, modal shift, OpenTripPlanner

1. Introduction

As modern life evolves and progresses, there has been a constant need to transport people and products from one point to another. Everyday, people need to go to school, to work, to entertainment places, just to name a few. When it comes to products, raw materials need to be transported to factories and then to warehouses, before being sent to their outlet stores. Mobility has indeed become one of the most important ability today. Transportation has been an integral part of our everyday lives that there is a great need for a good transportation network.¹ But as more people and products need to be transported, the transportation network is continuously being congested. One way to solve this problem is to minimize the number of vehicles on the road. This is why a number of governments from all over the

world have been taking steps to entice their citizens to shift from using private vehicles to using public transportation modes.² The average vehicle occupancy of private cars is only at 1.55 person, based on the National Household Travel Survey (NHTS).³ On the other hand, average jeepney occupancy is at 10.88 people, and bus occupancy is at 45 people based on Ateneo's publication of Philippine Public Transport Survey.⁴ These numbers show the immense difference in number of people transported between public and private transportation modes. In using public transportation, there is an inevitable shift from monomodal, using only one transportation mode per trip, to multimodal travelling, using more than one transportation mode per trip. This is because every transportation mode and franchise has its own role and function in the whole transportation

system. This certainly contributes to the long-term sustainability of the transportation sector. In Kenyon and Lyon's research, it was found out that lack of public transportation information is one of the main reasons why some commuters are anxious of using public transportation. One way to solve this, and to entice commuters to support the modal shift, is to provide commuters with the relevant and reliable information.²

This modal shift measure gave birth to the popularity of "Public Transport Route Planners." System that helps commuters find the best route between a given origin point to any destination point. Since these route planners run on public transportation, it has the responsibility to integrate different modes operating in the area. These route planners are intelligent enough to be able to take into account a lot of factors such as multiple objective functions (cheapest travelling cost, fastest travelling time, shortest travelling distance, just to name a few.).³ The researchers believe that this initiative of implementing a public transport route planner that commuters can use for their travels seems to be a promising solution in decongesting Metro Manila.

The researchers aim to share in this paper their knowledge in implementing the open source multimodal trip planning system OpenTripPlanner⁶ with the transportation network of Metro Manila. The produced system would be uploaded online for public consumption and realization of the researchers' end goal of helping decongest the road networks of Metro Manila. 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 important travel information such as the estimated time of travel, estimated distance to be travelled by foot, and the estimated distance to be travelled. When the system reached a large enough user database, the researchers would then run analytical tests on the data recorded to able to produce statistical and analytical studies regarding the public transportation sector of the country.

1.1 Significance and Originality

There have been a number of researches when it comes to monomodal route planning, as the network in this kind of system is more static with fixed topology and costs, while the public transport

system is more dynamic where travelling cost is time-dependent or randomly varying.¹ Although some researches have started exploring the multimodal public transportation route planning field, there are still a lot of open ended questions including which algorithm is best fit for this kind of system and what system architecture is best for creating these kinds of systems. In the context of the Philippines, researches in route planning are more so in its early stages.

This research would not only validate previous researches about public transportation route planning, but it also aims to aid the decongestion of Metro Manila by helping commuters shift from using private transportation to public transportation. The implementation of the system would not only provide regular commuters alternatives from their habitual transportation route and mode preference, it will also empower one-time and first time commuters to use public transportation without apprehension and anxiety. With the propagation of the now non-readily available public transportation information, commuters' negative perception of using public transportation modes would hopefully be changed. This would then entice commuters to make use of the public transportation modes more - decongesting the road networks of too much private vehicles. Local tourism in the region of Metro Manila would also be boosted, as Filipinos would be given additional knowledge on how to go about the whole area. Lastly, with the data that would be collected from the system's users database, combined with the transportation data collected by the researchers, various analytical studies about Metro Manila's transportation network and commuters can be produced to help provide a better transportation sector to commuters.

1.2 Purpose

This paper aims to explore the effectiveness of the open source multimodal trip planning system OpenTripPlanner with the road networks of Metro Manila. The resulting public transport route planner would then be hosted online for the general reference of Metro Manila commuters. The system aims to:

- 1.) Provide an array of multimodal public transportation route directions to commuters on how to reach their destination from their origin,
- 2.) Equip commuters with additional important travel information (estimated time of travel,

estimated total transportation cost, and the estimated distance to be travelled),

3.) Change the negative 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

4.) Produce analytical studies with the data gathered regarding public transportation to relevant offices and organizations for further improvements and studies regarding the transportation sector of the Philippines

All these follow the researcher's goal of providing ways for a more sustainable transportation network in the long run.

2. Literature Review

A number of public transport route planners were implemented in different transportation networks throughout the world, especially in Asia. Although they follow different frameworks and methodologies, they all meet in their final goal of providing multimodal public transportation routes to entice commuters to use public transportation modes over private vehicles. This section would discuss some distinguished examples of this type of system.

2.1 International Context

In the Eindhoven region, J. Zhang and his team implemented a Dijkstra-based Advanced Traveler Information System (ATIS) that ran on five (5) transportation modes.⁷ In Vienna Austria, K. Rehrl and company implemented a small-scaled application called "the Personal Travel Companion."⁸ In the US, Z. R. Peng and his group developed a distributed trip planning system that integrates different trip planning system in the country.⁹ Another similar system called "Smart Traveller Information Service" (STIS) was produced by the team of S. Brennan in Dublin Ireland.¹⁰ In Tehran, the group of R. Abbaspour created a multimodal public transport route planner based on a genetic algorithm.¹¹ In Hong Kong, an Internet-based comprehensive public transport enquiry system (PTES) was developed by L. Pu-Cheng.¹² As a capstone for their research, 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.¹³ V. Spitadakis and company implemented WISETRIP in Greece, an international multimodal journey planning and delivery of personalized trip information.¹⁴ Also developed in Greece, by the team of K. Zografos 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.¹⁵ Some other notable route planners include researches of L. Zhang,¹⁶ J. Q. Li,¹⁷ and J. Jariyasunant¹⁸ who all created systems to support mobile-based advanced traveller information systems in the context of California. J. M. Su and company developed a multimodal trip planning system for intercity transportation in Taiwan.¹⁹ P Kumar and team developed a GIS-based multimodal transport system for Hyderabad city in India.²⁰

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. 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. 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 for an array of routes for the given origin and destination point, complete with supplementary transportation information. They were also able to incorporate jeepney routes, which was the main shortcoming of Google Transit. However, it has been reported that some of its route suggestions are not the actual routes used by commuters. It is notable that the domain of public transport route planners is helping commuters all around the world - even in the Philippines. There are however almost no studies and no published researches in the said field in the country.

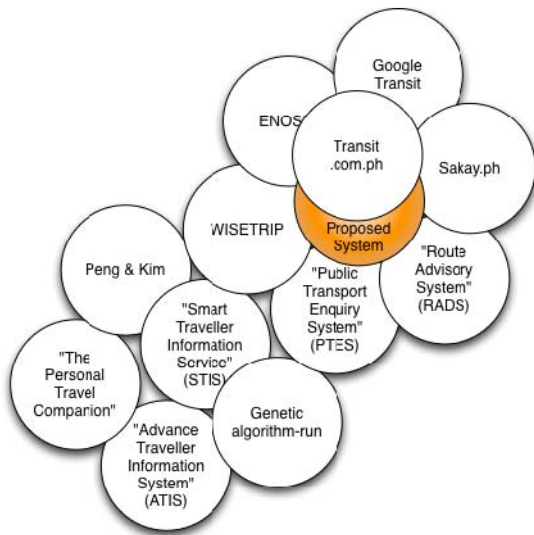


Fig. 1 Public Transport Route Planners Tree Diagram

Fig. 1 is a diagram illustrating 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, none of them fully encapsulate the goals of the researchers. 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 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. Since other systems are in the business for money, they do not keep user information for other purposes, however the proposed system would save all user information and past sessions as one of its end goal is to produce analytical studies for the betterment of the transportation sector in the Philippines.

3. Methodology

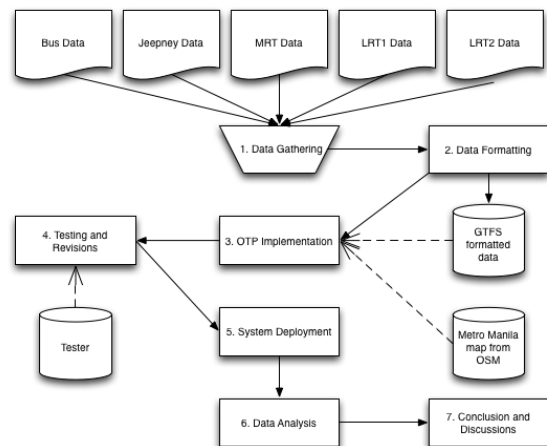


Fig. 2 Research Methodology

Fig. 2 is a diagram illustrating the methodology behind the whole research and system development that would assist the researchers in answering their research questions. The third steps, which is the OTP modification, is focused in meeting the first objective of the researchers, which is to implement a multimodal public transportation route planner in the context of the Metro Manila road networks. The second step, which is the Data Formatting, would aid the researchers in meeting their follow-up objective of proving a good approach in formatting transportation data from LTFRB and various transportation agencies. The last follow-up objective, which is providing a good process to ensure the effectiveness and efficiency of the produced system, would be achieved with the help of the fourth step, Testing and Revisions.

3.1 Data Gathering

First step 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.

MRT capacity and schedule 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 were

downloaded from their official website. All data relating to bus and jeepneys information were directly collected from LTFRB. Data that were collected from the MRTA, LRTA, and LTFRB offices were hard copies. Bus and jeepney data were very raw: around 30 pages of case number, operator name, and route names were collected from the governing offices.

Map data of Metro Manila on the other hand would be extracted from OpenStreetMap. However, since extraction of large amounts of data cannot be directly done through OpenStreetMap's home website, Metro Extracts was used to extract Metro Manila's map.

3.2 Database Formatting

Transportation data would be formatted according to the General Transit Format Specification (GTFS), as it is the data needed by the OpenTripPlanner (OTP) software.

The extracted OSM map of Metro Manila would be kept as is, and no modifications would be done on it.

3.1 OpenTripPlanner Implementation

Complete with the needed data, the researchers would then start the actual implementation of OpenTripPlanner. Source code would be downloaded from OpenTripPlanner's GitHub page; instruction manuals to set up the system would also be obtained from the same page.

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. GTFS data on the other hand was obtained from Department of Transportation and Communication's (DOTC) Public Transit Information Service official webpage.

Once the graph is created, OpenTripPlanner's web API would be 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. But to make the system user-friendlier, some modifications would be employed such as the integration of the geocoder module. This module allows the user to input the origin and destination points' names instead of clicking on the map or providing the points' actual longitude and latitude.

In cases of bugs and errors, the researchers would inquire from the official OpenTripPlanner developer and user community in Google groups. This is the same group the researchers hope to contribute knowledge to.

3.2 Testing and Revision

3.2.1 Alpha Test

The first testing phase would test the system's effectiveness and efficiency. The system would be subjected to 30 route queries with different randomly chosen combination of origin and destination points.

The system would pass the test if 95 percent of the queries return a computed route; it fail of more than 5 percent of the queries return an error message of "No route was found." The 5 percent allowance is given because there are some route queries that are not accessed by transportation modes. When the system fails the test, the researchers would have to do basic debugging test.

3.2.2 Beta Test

Second phase would involve the use of the automated tester application. As discussed in the previous chapter, the automated tester would be inputted with around 10 origin and destination combination along with the usual route actual commuters use for that particular journey. The tester would check if the system is able to return the correct route.

The system would pass if 100 percent of the queries return the correct route. Although in reality, there are a lot of routes from the origin to the destination point, the researchers want the system to reflect the actual route most commuters take. If the system fails the query tests, the researchers would have to do basic debugging tests just as the Alpha test.

3.5 System Deployment

Once the system passes the testing stage, it would then be hosted online for the consumption of Metro Manila commuters. To urge people to use the

system, the researchers along with colleagues would promote the web application through various social networking sites. The researchers also plan to give away flyers to commuters in strategic locations such as main MRT and LRT stations, as well as major bus terminals.

3.6 Data Analysis

Once the system has been deployed, data collected with the use of the system would be used to create analytical studies as stated in the previous chapter. The researchers hope that these studies would help provide a better transportation sector to the commuters of Metro Manila.

4. Results and Analysis

4.1 Results

This section would describe the significant details during our implementation of OpenTripPlanner.

Once the system was up, the researchers tested it with a number of randomly selected origin and destination points by arbitrarily clicking on the map and typing in the provided "To" and "From" textboxes. Fig. 3 shows the system's route suggestion given a usual route travelled by the researchers. Different color codes lines represent the multimodal route suggested by our system.

The system is always able to suggest at least one multimodal public transport route between user's inputted origin and destination points. This was proven with the random test the researchers carried out. If either the origin or destination point is beyond the boundaries of Metro Manila, the system returns a route with an endpoint nearest the point, which is outside the boundary. Supplementary walking route are added from the calculated endpoint to the actual selected point of the user. The system is not able to compute for any route at all when both the origin and destination points selected are outside the boundary box of the system. The system pops up an error message saying, "Trip is not possible. You might be trying to plan a trip outside the map data boundary."

When the inputted "to" and "from" points are popular or well-known transportation hubs or usual destination points, the system usually returns 3 multimodal public transportation routes. However, when the two provided points are uncommon places, only one route is suggested.

The system's route suggestions changes depending on the "arrival time" or "departure time" inputted by the user. This is due to the fact that different transportation modes have different service times. Some transportation modes may not available during the specific times inputted.

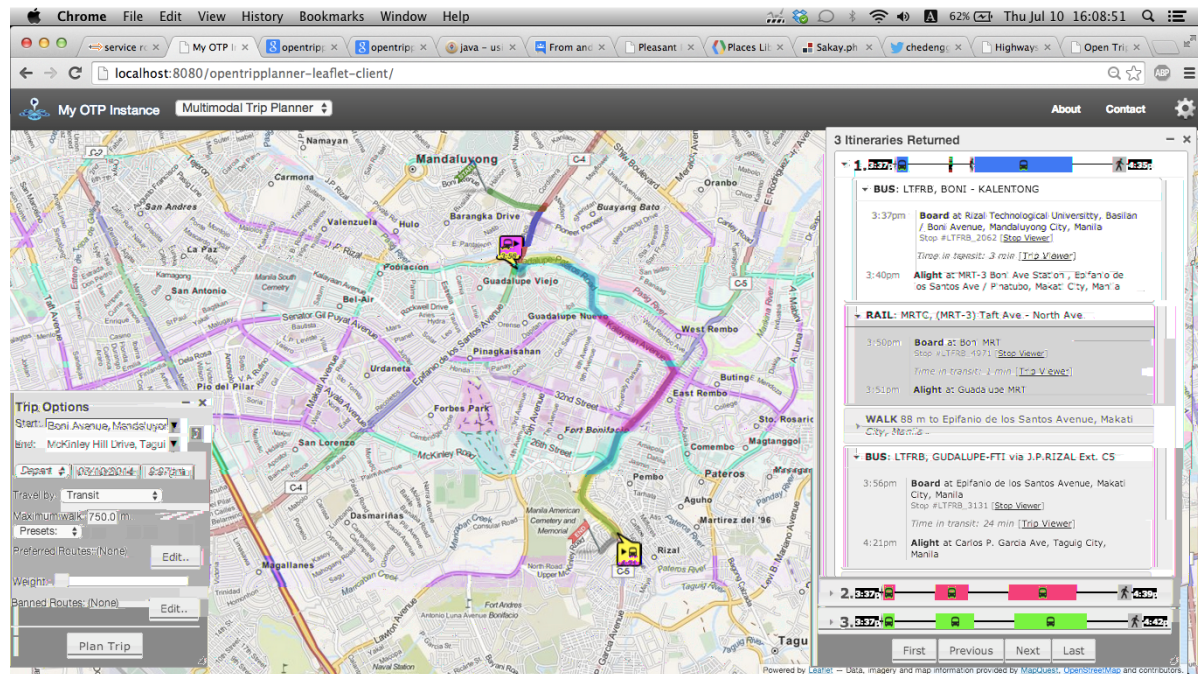


Fig. 3 Sample Route Query from Boni Avenue, Mandaluyong city to McKinley Hill Drive, Taguig

4.2 Analysis

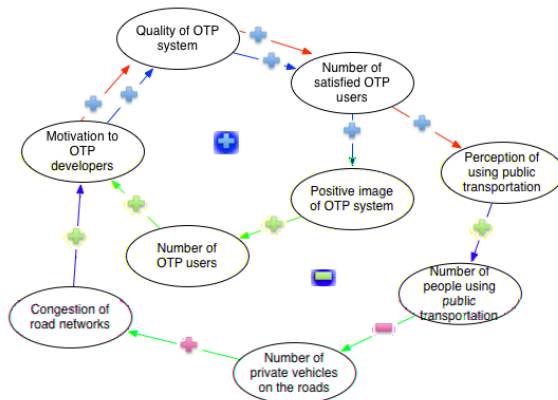


Fig. 4 Causal Loop Diagram

Fig. 4 illustrates the causal loop diagram behind this research. As the quality of the implemented OpenTripPlanner system increases, so too does the number of its satisfied users. A growing number of satisfied users would up the image of the OpenTripPlanner system and would encourage more people to use it. As more people uses the system, the developers and researchers would be motivated further to continually improve their system. This loop creates the inner blue positive flow. When one component increases, all others follow, vice-versa. Positive feedback loops, following System Dynamic technique suggested by Jay Forrester of MIT,²¹ tends to grow exponentially. The inner loop is the internal drive of the system.

Congruently, the outer feedback loop has negative sign. As the number of satisfied OpenTripPlanner users increase, many would start to have a positive perception of using public transportation. With the negative perception of using public transportation going down, more commuters would start to use public transportation and the number of private vehicles on the roads would be lessen. When the number of private vehicles on the road compared to the number of public transportation modes lessen, the road networks of Metro Manila would be little by little decongested. When the researchers see their end goal being realized, their motivation to improve their system more would continually increase. Combining these two feedback loops creates the feedback loops that helps stabilize the whole system so it will not grow exponentially out of hand.

5. Discussions and Conclusion

5.1 Discussion

Although the current transportation data the system is running on is adequate in suggesting transportation routes, it needs further cleaning and formatting to allow for better and easier route readability. Presently, the system is wrongfully reading jeepney routes as bus routes; it is having a hard time differencing jeepney routes. The estimated travel time also needs further revision for a more realistic estimate. Addition of travel fare is also a useful improvement the researchers need to work on next.

As discussed in the previous section, to achieve the researchers' end goal of decongesting the road networks of Metro Manila, the number of commuters using the system should continually grow. This therefore pushes the researchers to give high importance to the system's promotion. This is essential for the researchers to be able to guide commuters into a better transportation system.

5.2 Conclusion

A multimodal public transportation route planner was implemented with the transportation network and data of Metro Manila. OpenTripPlanner was the basis for this system as it is a trusted software implemented in various countries worldwide. It also has a big developer and user community always working on improving it.

The system is currently running LTFRB's latest publication of their GTFS data. This data is however continuously being updated since it is still not complete and finalized. Should LTFRB release a new version, the system should be updated with the new one.

In the implementation of the public transportation route planner, the main impediments lie in data gathering, formatting and updating. Once the system is implemented, the main focus should be in the promotion of the system. This is the research's future direction.

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