IMPLEMENTATION OF MULTIMODAL PUBLIC TRANSPORTATION ROUTE PLANNER FOR METRO MANILA

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Abstract: The transportation network is continuously being congested. One way governments all over the world have been trying to solve this problem is by urging commuters to shift from using private transportation to public transportation. While many countries have been successful in this, the Philippines is being left behind with its ever-worsening Metro Manila traffic problem. This paper aims to share the researchers' experiences in implementing a public transportation route planner based on OpenTripPlanner for the general reference of commuters in Metro Manila. The said system aims to provide direction to all kinds of commuters on how to go around Metro Manila, equip them with additional important travel information, guide them in transfer points from one transportation mode to another, and produce analytical studies regarding public transportation to relevant offices and organizations. All these follow the researchers' goal of providing ways for a more sustainable transportation network in the long run.

***Key words*:** Route planner, multimodal, public transportation, Metro Manila, OpenTripPlanner

1. INTRODUCTION

Transportation has been a major part of modern life. According to S.M. Kumari *et al.* (2010) and K. Rehrl *et al.* (2007), every modernized city should have a good transportation network, as mobility is one of the most important needs of today's modern society. Unfortunately, because of the ever-growing population of the world, the transportation network is continuously being congested. S. Kenyon *et al.* (2003) said that to solve this problem and to lessen the number of vehicles clogging up the road networks, many governments around the world have been taking steps to entice their 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 show that more people are transported via public transportation with lesser road space used. Congruently, there has also been a shift from monomodal, using only one transportation mode per trip, to multimodal travelling, using more than one transportation mode per trip. This adds to the long-term sustainability of the transportation network since every transportation mode would have its proper role and function; the system would stays in balance and harmony. One way to attract commuters to support this shift is by providing them with the relevant and reliable information as it was researched that lack of public transportation information is one reason why some commuters opt to use private vehicles instead.

This movement gave birth to the popularity of "Public Transport Route Planners." These systems aim to find the best route from an origin point to a destination point prior to the user's journey, given a myriad of different transportation modes available. While its predecessor, the 1st generation of route planners handled monomodal travelling 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 this initiative of providing a public transportation route planner for

commuters poses to be a promising solution in decongesting the main roads of Metro Manila.

In this paper, we aims to share our knowledge in the implementation of the open source multimodal trip planning system OpenTripPlanner with the transportation network of Metro Manila. The system would compute an array of available multimodal public transportation routes from the user's given origin and destination points, not only the shortest path between the two points. The routes suggested would also 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 by the system such as user demographics, previous route queries, usual origin and destination points, etc. The researchers would then be able to produce statistical and analytical studies regarding the public transportation sector of the country. The produced system would be uploaded online for public consumption and realization of the researchers' end goal.

1.1 Scope and Limitations

Given the user's input of origin and destination, as well as the target time of departure or arrival, the system would return the computed multimodal route with other additional transportation information. These estimates are based on transportation data acquired from LTFRB and may not be entirely accurate. 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.

The system would support 5 modes of transportation, namely: MRT, LRT1, LRT2, busses, and jeepneys. Other forms of public transportations like boats, ferries, and pedicabs (cycle rickshaw), tricycles, and FXs would not be included as their data are not readily available.

Although the researchers wish to tackle the traffic problem of as wide an area they can, only Metro Manila would be included in the research due to time and budget constraints. 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.

This research also does not intend to create a new public transportation route planner. It aims to implement the already available open source multimodal trip planning system OpenTripPlanner. The original OpenTripPlanner was modified to contain the local modes of transportation that are operating here in the Philippines to suit the local needs.

1.2 Rationale

This research would first and foremost validate previous researches in the domain of public transportation route planners, especially in the Philippines where it is at its infancy. The researchers also aim to contribute additional knowledge and useful inputs to the OpenTripPlanner community.

The implementation of the system on the other hand would provide regular commuters alternatives from their habitual transportation route and mode preference. One-time and first time commuters would be given now unavailable public transportation information for them to be able to use public transportation without apprehension and anxiety. Commuters' negative perception of using public transportation would be challenged with these newly available data and commuters would then be enticed to make use more of the public transportation modes, decongesting the road networks of too much private vehicles. It also aims to allow Filipinos enjoy the region of Metro Manila more by giving them additional knowledge on how to go about the whole area.

2. PUBLIC TRANSPORT ROUTE PLANNERS

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

In the Eindhoven region (the Netherlands), J. Zhang *et al.* (2012) implemented a Dijkstra-based Advanced Traveler Information System (ATIS) that ran on five (5) transportation modes. In Vienna Austria, K. Rehrl *et al.* (2005) implemented a small-scaled application called "the Personal Travel Companion." In the US, Z. R. Peng *et al.* (2008) developed a distributed trip planning system that integrates different trip planning system in the country. Another similar system called "Smart Traveller Information Service" (STIS) was produced by S. Brennan *et al.* (2007) in Dublin Ireland. In Tehran, R. Abbaspour *et al.* (2010) created a multimodal public transport route planner based on a genetic algorithm. In Hong Kong, an Internet-based comprehensive public transport enquiry system (PTES) was developed by L. Pu-Cheng (2012). As a capstone for their research, F. H. Meng *et al.* (1999) developed a system called "Route Advisory System" (RADS) that run the algorithm they created and implemented it with the public transport of Singapore. V. Spitadakis *et al.* (2012) implemented WISETRIP in Greece, an international multimodal journey planning and delivery of personalized trip information. Also developed in Greece, by K. Zografos *et al.* (2009) 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. Some other notable route planners include researches of L. Zhang *et al.* (2011), J. Q. Li (2010), and J. Jariyasunant *et al.* (2011) who all created systems to support mobile-based advanced traveller information systems in the context of California. J. M. Su *et al.* (2008) 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. P Kumar *et al.* (2005) developed a GIS-based multimodal transport system for Hyderabad city in India.

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. This system is however currently running the transportation network of Cebu city only; the routes of Metro Manila are not yet presently implemented. Thus, 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.

3. FRAMEWORK

As stated in the introduction, a public transportation route planner for the road network of Metro Manila would be implemented 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 (http://www.opentripplanner.org/) is an open source, multimodal trip planning system collaboratively developed by a team of passionate developers from across the world, coordinated by OpenPlans and TriMet. It is a collaborative effort among TriMet, OpenPlans, and the developers of Five Points, OneBusAway, and Graphserver, and was identified as the most promising open source multimodal trip planning software system with an active developer community, as reported by B McHugh (2011). The system would be set up using biking and walking 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 transport 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 *et al.* (2011) technical report.

Also according to S. J. Barbeau's *et al.* (2011) 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 software.

3.1. OpenStreetMap (OSM)

OpenStreetMap (http://www.openstreetmap.org/) is maintained by the non-profit OpenStreetMap foundation. It is an open sourced and freely available international repository of geographic data that individuals contribute to about their local community. The general public and organizations such as transit agencies with public-domain data add 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 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. Because the system uses crowd sourcing, the ability to gather information from multiple different sources, the general public is able to contribute large amounts of data instead of only one organization being held responsible for creating and updating data. There are a number of open-source software tools that exist to work well with OSM data. Software like them allow communities to collaborate on software projects, providing a robust and stable base for improvements, as also stated in S. J. Barbeau's *et al.* (2011) 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 (https://developers.google.com/transit/gtfs/reference) 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 transport 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 *et al.* (2011) technical report.

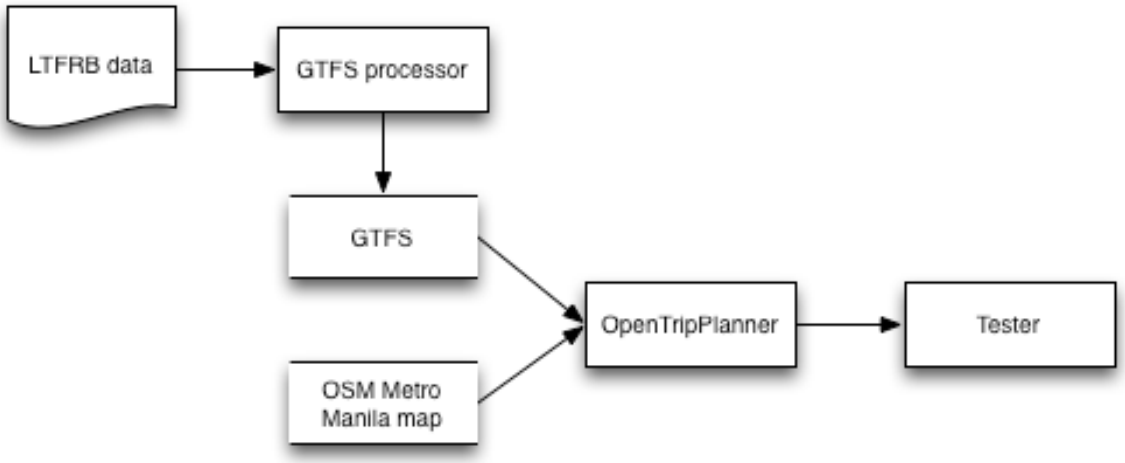

Figure 1. Theoretical Framework

Figure 1 is a diagram summarizing the theoretical framework behind this research. Data was collected from LTFRB and other governing transportation agencies. Separately, DOTC also produced a set of data that is formatted according to the standards of General Transit Feed Specification (GTFS). Aside from being validated through crowd source survey, GTFS data from LTFRB were also personally validated by the researchers. GTFS data along with the extracted Metro Manila map from OSM would be inputted to OpenTripPlanner's graph builder module to produce the graph of Metro Manila. This graph of Metro Manila would be the basis of the system to produce the computed routes for a given origin and destination points. The computed routes would then be subjected to a tester to assess the system's correctness and effectiveness.

4. INITIAL RESULTS

This section would describe the significant details during the initial implementation of 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 on the other hand was obtained from Department of Transportation and Communication's (DOTC) Public Transit Information Service official webpage.

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 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.

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" textboxes. Figures 2, 3, and 4 shows the system's route suggestion given 3 usual routes travelled by the researchers. The different color-coded lines represent the different public transportation modes that would be used in a single route suggested by our system. The system tries to return as many route suggestions as possible; figures 2 and 4 shows that the system suggested 3 different routes to the user.

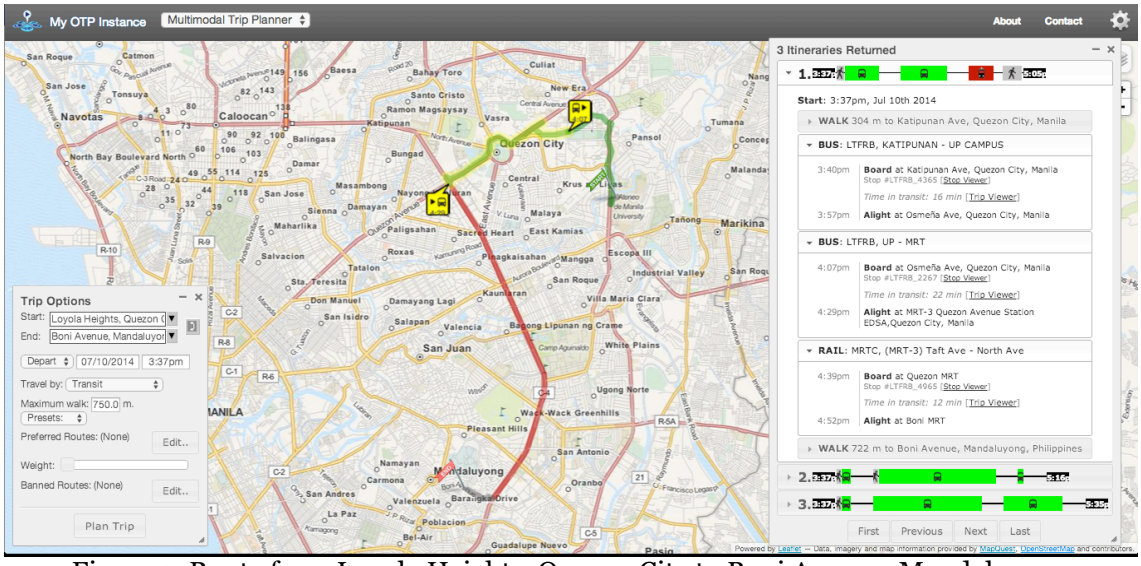

Figure 2. Route from Loyola Heights, Quezon City to Boni Avenue, Mandaluyong

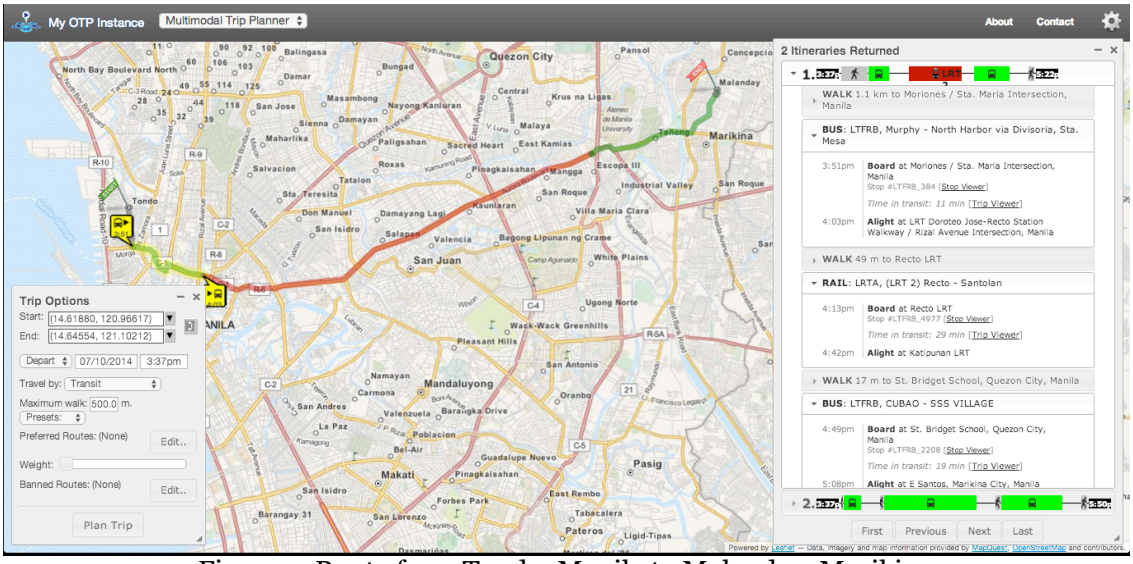

Figure 3. Route from Tondo, Manila to Malanday, Marikina

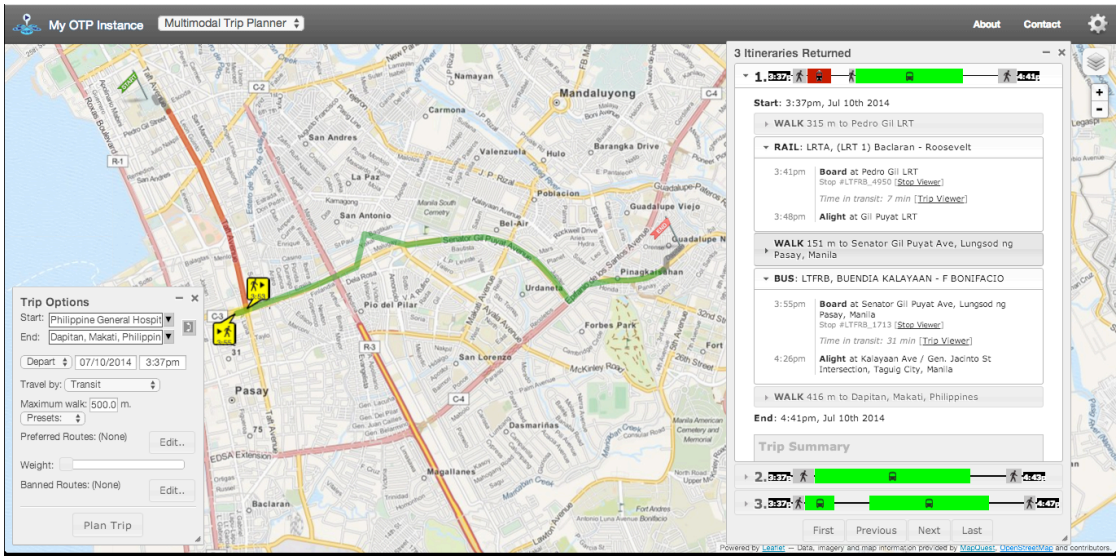

Figure 4. Route from Philippine General Hospital, Manila to Dapitan, Makati

5. ANALYSIS

The base configuration of OpenTripPlanner is always able to compute for at least one (1) multimodal public transportation 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.

Transportation data used by the system needs further cleaning and formatting to allow for better and easier route readability for users. Currently, the system is having a hard time to differentiate bus routes from jeepney routes and returns "bus" routes in the computed route. Although the system's computation of travel time is a rough estimate, it appears to be an exaggerated one that needs further revision. Another additional improvement that the researchers would focus on next is the addition of travel fare.

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.

6. CONCLUSIONS

The researchers have implemented a public transportation route planner with the road network of Metro Manila based on the open source software OpenTripPlanner.

The system was run with the latest GTFS data published by LTFRB. However, this data is continuously being completed and updated by the government. The system should always be updated every time a latest GTFS data is published.

The difficulty lies in data gathering, formatting, and continuous updating, as well as the promotion of the system's use by the general public, which will be our future research direction.

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REFERENCES

Abbaspour, R. A. and Samadzadegan, F. (2010) An evolutionary solution for multimodal shortest path problem in metropolises. **Computer Science and Information Systems**, 7(4):789–811.

Barbeau, S. J., and Hillsman, E. L. (2011) Enabling cost-effective multimodal trip planners through open transit data. **Technical report, University of South Florida (USF) National Center for Transit Research**, May 2011.

Brennan, S., and Meier, R. (2007) STIS: Smart travel planning across multi- ple modes of

transportation. In **Intelligent Transportation Systems Conference, 2007. ITSC 2007. IEEE**, pages 666–671. IEEE.

DOTC Transit web site: http://www.dotc.gov.ph/index.php?option=com_k2&view=item&id=569:philippine-transit-information-service

Jariyasunant, J., Kerkez, B., Sengupta, R., Glaser, S., and Bayen, A. (2011) Mobile transit trip planning with real-time data.

Kenyon, S. and Lyons, G. (2003) The value of integrated multimodal traeller information and its potential contribution to modal change. **Transportation Research Part F: Traffic Psychology and Behaviour**, 6(1):1–21.

Kumari, S. M. and Geethanjali, N. (2010) A survey on shortest path routing algorithms for public transport travel. **Global Journal of Computer Science and Technology,** 9(5):73–75.

Kumar, P., Singh, V., and Reddy, D. (2005) Advanced traveler information system for hyderabad city. **Intelligent Transportation Systems, IEEE Transactions**, 6(1):26–37.

Li, J. Q., Zhou, K., Zhang, L., and Zhang, W. B. (2010) A multimodal trip planning system incorporating the park-and-ride mode and real-time traffic/transit information. In Proceedings ITS World Congress, volume 25, pages 65–76.

McHugh, B. (2011) The opentripplanner. Metro 2009-2011 regional travel operations grant final report, TriMet, August 2011.

Meng, F. H., Lao, Y., Wai, L. H., and Chuin, L. H. (1999) A multi- criteria, multi-modal passenger route advisory system. National Science and Technology Board (NSTB) Singapore.

Peng, Z. R., and Kim, E. (2008) A standard-based integration framework for distributed transit trip planning systems. **Journal of Intelligent Transportation Systems**, 12(1):13–28.

Pun-Cheng, L. (2012) An interactive web-based public transport enquiry system with realtime optimal route computation. **Intelligent Transportation Systems, IEEE Transactions**, 13(2):983–988.

Rehrl, K., Goll, N., Leitinger, S., and Bruntsch, S. (2005) Combined in- door/outdoor smartphone navigation for public transport travellers. In **Proceedings of the 3rd Symposium on LBS & TeleCartography**, volume 2005, pages 235– 239.

Rehrl, K., Stefan Bruntsch, S. and Mentz, H.J. (2007) Assisting multimodal travelers: Design and prototypical implementation of a personal travel companion. **Intelligent Transportation Systems, IEEE Transactions,** 8(1):31–42.

Spitadakis, V., and Fostieri, M. (2012) Wisetrip-international multimodal journey planning and delivery of personalized trip information. **Procedia-Social and Behavioral Sciences**, 48:1294–1303.

Su, J. M., Chang, C. H., and Ho, W. C., (2008) Developmentoftripplanning systems on public transit in taiwan. In **Networking, Sensing and Control, 2008. ICNSC 2008. IEEE International Conference**, pages 791–795. IEEE.Zhang, J., Arentze, J. A., and Timmermans, H. (2012) A multimodal transport network model for advanced traveler information system. **JUSPN**, 4(1):21–27.

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.

Zhang, J., Arentze, Theo A., and Timmermans, Harry JP. A multi- modal transport network model for advanced traveler information system. **JUSPN**, 4(1):21–27, 2012.

Zhang, L., Li, J. Q., Zhou, K., Gupta, S. D., Li, M., Zhang, W.B., Miller, M. A., and Misener, J. A. (2011) Traveler information tool with integrated real-time transit information and multimodal trip planning. **Transportation Research Record: Journal of the Transportation Research Board**, 2215(1):1–10.

Zografos, K. G., Androutsopoulos, K. N., and Vassilis Spitadakis. (2009) Design and assessment of an online passenger information system for integrated multimodal trip planning. **Intelligent Transportation Systems, IEEE Transactions**, 10(2):311–323.