



Executive Summary

Framework development of a Transit Oriented Rout Planner for the SJMA

by

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Introduction

Originally, this research project was aimed towards conducting a full feasibility study concerning Web-Based Information Systems for Passengers. Along the course of the investigation it became evident that this is a very broad field and many details would be left unattended. This is why the rest of this investigation will be devoted entirely to the development of the framework of a Transit Oriented Route Planner for the San Juan Metropolitan Area, which is the new topic of this investigation. There won't be enough time nor resources to complete the feasibility study, so this would be a good topic to cover on future investigations.

This research project is now being conducted in order to develop the framework of a Transit Oriented Route Planner (TORP) for the San Juan Metropolitan Area (SJMA.) Route planners are interactive web sites in which users enter their current location and the location they want to get to and then the site offers the most efficient path to take based on time, money, distance, and other relevant factors. Most of these sites offer written directions, maps, cost estimates and special information for people with disabilities among other things. In general, TORPs provide time and money savings for passengers, increase ridership, and assist multimodal integration. The ideal scenario for a TORP would be to include it within a full Web-Based Information Systems for Passengers (WISP) in order to provide a complete service to the user. TORPs are also very effective as a marketing tool and various transit agencies are using them already in the United States. The implementation of such a system in Puerto Rico is an issue of great relevance to the "Tren Urbano" project since it's operation has not begun yet and passengers need good orientation.

Having narrowed down the scope of this investigation, greater detail will be examined in order to get into the specifics of most aspects of the TORP. Being that the investigator's (Jaime A. Román) field of study is Civil Engineering, help is being provided by a computer's specialist (Michael J. Santos) in order to configure and maximize the algorithm's capability as well as minimizing the computational time required to do the operations. This is a project that involves the expertise of various professionals and the integration of various fields of study. TORPs are a multidisciplinary issue. Basically, the new goal of this research will be focused on the aspects concerning transportation engineering which is much more specific than the previous goal.

Objectives

The new objectives of this research project are the following:

- To determine the desirable characteristics of an efficient TORP.
- To determine the flaws of a bad TORP.
- To determine what would be the ideal characteristics of a TORP for the proposed Public Transportation System in the SJMA.
- The development of an efficient prototype TORP for the SJMA.

Scope

This research project will definitely involve the full completion of the above mentioned objectives but is not limited to them. Depending on availability of information it might be possible to generate a complete prototype of the proposed TORP. Now, if the databases necessary are not available or not existing this cannot be done and a conceptual scheme or framework of the basic design of an efficient TORP will be provided.

Research Development

Literature Review

For the development of a prototype of a TORP, valuable information has been found. Basically, route planners consist of a database either custom built, or purchased. This database contains the variables and information stored in tables. When a search is done, the output consists of the variables entered and the variables selected for output. In this case a custom database can be created for the SJMA. Based on comparison between leading relational databases available in the market (Oracle8i, IBM DB/2 and Microsoft SQL Server) and due to an existing contract between Microsoft and the Government of Puerto Rico, SQL Server 2000 is the relational database of choice for the implementation of a WISP. Based on this selection the operating system would be by default Windows 2000 Server or Advanced Server, depending on the power needed to run this system. The server on which this system will run must have Windows 2000 Server operating system and SQL Server 2000. It must meet the following **minimum requirements**:

Windows 2000 Server	<ul style="list-style-type: none">• 133 MHz or higher Pentium-compatible CPU.• 256 megabytes (MB) of RAM recommended minimum [128 MB minimum supported; 4 gigabytes (GB) maximum].• 2 GB hard disk with a minimum of 1.0 GB free space. (Additional free hard disk space is required if you are installing over a network.)• Windows 2000 Server supports up to four CPUs on one machine.
Microsoft SQL Server 2000	<ul style="list-style-type: none">• SQL Server 2000 Enterprise Edition and Standard Edition run on Microsoft Windows NT® Server version 4.0 Service Pack 5 (SP5) or later, Microsoft Windows NT Server 4.0 Enterprise Edition with SP5 or later, Microsoft Windows® 2000 Server, Microsoft Windows 2000 Advanced Server, and Microsoft Windows 2000 Datacenter Server operating systems. <p>Memory (RAM)</p> <ul style="list-style-type: none">• Enterprise Edition: 64 megabytes (MB); 128 MB recommended.• Standard Edition: 64 MB.• Developer Edition: 64 MB.• Desktop Engine: 64 MB for Windows 2000; 32 MB for other operating systems. <p>Available Hard-Disk Space</p> <ul style="list-style-type: none">• Enterprise, Standard, Evaluation, Developer and Personal Editions require:<ul style="list-style-type: none">○ 95–270 MB for server; 250 MB for typical installation.

	<ul style="list-style-type: none"> ○ 50 MB for minimum installation of Analysis Services; 130 MB for typical installation. ○ 80 MB for Microsoft English Query (supported on Windows 2000 operating system but not logo certified). ● Desktop Engine requires 44 MB of available hard-disk space. <p>Disk Drive CD-ROM drive.</p> <p>Monitor VGA or higher-resolution monitor.</p> <p>Internet Requirement Microsoft Internet Explorer version 5.0 or later.</p> <p>Networking Support Microsoft Windows 95, Windows 98, Windows Me, Windows NT 4.0, and Windows 2000 have built-in network software. Additional network software is required if you are using Banyan VINES or AppleTalk ADSP. Novell NetWare IPX/SPX client support is provided by the NWLink protocol of Windows-based networking.</p> <p>Client Support</p> <ul style="list-style-type: none"> ● Windows 95¹, Windows 98, Windows Me, Windows NT Workstation 4.0, and Windows 2000 Professional are supported. ● UNIX, Apple Macintosh, and OS/2 require Open Database Connectivity (ODBC) client software from a third-party vendor. <p>Source: Microsoft Corporation</p>
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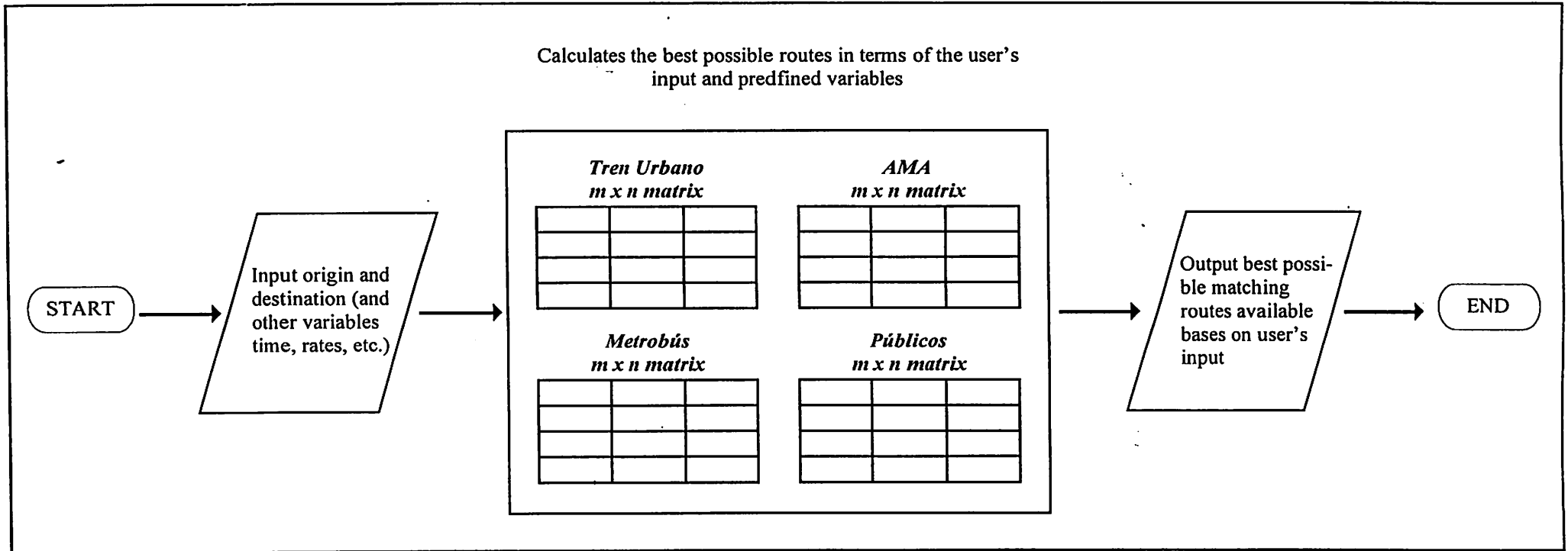
Although with minimum requirements the system can run, exceeding these requirements is **highly recommended**. Since this system will be accessed constantly, improving its hardware resources capacity can significantly speed search process and access time. Connections to this server can also affect sending and retrieving information, but at this moment they will be not taken into consideration. The minimum requirements established only stand for minimal operation conditions, not for performance. Performance can be measured on the number of transactions the server can process simultaneously. For this case, at least a minimum of 10,000 transactions a month can be done smoothly (based on the information provided by a case study done by Microsoft).

Although with minimum requirements the system can run, exceeding these requirements is **highly recommended**. Since this system will be accessed constantly improving its hardware resources capacity can significantly speed search process and access time. Minimum requirements only stand for minimal operation conditions, not for performance. Performance can be measured on the number of transactions this information can do simultaneously, where at least a minimum of 10,000 transactions a month can be done smoothly. In this case, a transaction means a request or search process for the best possible route.

As we continue getting answers from the emails sent to the webmasters of different TORPs, a clearer view of secondary software needed to complete the implementation of a prototype will be available. Secondary software can be referred to GIS and maps that the user can view after a route plan has been developed. There are several software manufacturers that can provide this such as: Rand McNally, MapQuest, MapBlast! among others.

Algorithm Analysis:

A simple algorithm of the TORP is available in the next page.



Proposed Algorithm for the TORP.

Methodology of Transportation Planning:

The process of route planning occurs as a result of the four step traffic planning process. This process is generally referred to as the UTPS (Urban Transit Planning System.) This has been the most widely used practice since the 1980's. Various methods have been developed in order to go through each one of the four steps. Before conducting the study the area is to be examined and divided into zones. There are also various specific methodologies that have been developed to identify these zones. After the zones are well defined and all the necessary information of the zones is gathered the study can be started. Generally a Census is very useful in this step of the process. This process consists of:

- Step 1: Trip Generation

This is the total number of trips generated and attracted by households and employers in a zone, these trips could be home based or non-home based. A home based trip is a trip where either the home of the trip maker is the origin or destination of the journey. Conversely, a non-home based trip is one where neither end of the trip is the home of the traveler. Some of the methods available to accomplish this process are: Multiple linear regression, Trip-Rate Analysis Technique, and Category Analysis.

- Step 2: Trip Distribution

This procedure determines where the trips produced in each zone will go and how will they be divided among all other zones in the area of study. There are several methods of trip distribution such as the Fratar Method, the intervening opportunity model, and the Gravity Model. Of these, the Fratar Model is the most powerful and the most widely used. Generally a trip matrix is generated as a two dimensional array of cells where rows and columns represent each of the z zones in the study area. The sum of trips in a row should equal the total number of trips emanating from that zone. The sum of trips in a column should equal the total number of trips attracted from that zone.

- Step 3: Modal Split

On this phase the choice of the mode or combination of modes to complete the journey is made. There are many methods and variables that have been identified in order to predict common decisions taken by the general public. Some of these variables are: car availability/ownership, possession of a driver's license, household structure (young couple, couple with children, retired, single, elderly, etc.), income, residential density, trip purpose, time of day when the trip is made, relative travel time, relative monetary costs, availability and cost of parking, comfort and convenience, reliability and regularity, protection, and security.

- Step 4: Traffic Assignment

This is where route planners vary greatly. Having estimated the amount of trips generated by a zone, how these trips are distributed throughout the area, and the modes and routes of transportation available to make these trips possible a decision has to be made to answer the big question: Which route should I take? This is where traffic assignment comes in. Basically, this is the science that studies human trends in decision making when a trip is to be made. Engineers have battled this uncertainty for decades trying to find patterns and to identify variables that influence the voyager's decision making. Some of the variables that can be taken into consideration in this process are: time, distance, monetary cost, congestion, queues, types of maneuvers required, type of road, scenery, signposting, road works, reliability of travel time and habit. Of all these, the most popularly analyzed by professionals are time, distance, monetary cost and congestion; being the first two the most popular of all.

Be it the information obtained from the first three steps does not change with the mode of transport this data can be acquired from any traffic projection done in recent years. The fourth step of the process: Traffic Assignment is the one that varies with the mode of transportation selected. If you are prone to private transportation your traffic assignment will give an output of the sequence of roadways to be taken in order to complete the journey from the Origin (O_i) to the Destination (D_j) using the highway network and a private vehicle. If you are prone to public transportation your traffic assignment will give an output of the sequence of transfers to be taken in order to complete the journey from the Origin (O_i) to the Destination (D_j) using the public transportation system, be it rail, busses, jitneys, walking or a combination of them.

There are several methods to acquire traffic assignment. Some of these methods are: Minimum-Path Techniques, Minimum Path with Capacity Restraints, Transport Networks with a Demand Function, All or Nothing, Stochastic Methods, Simulation-Based Methods (e.g. Monte Carlo), Proportional Stochastic Methods, Congested Assignment (e.g. Wardrop's Equilibrium, Incremental Assignment, Method of Successive Averages) and Public Transport Assignment. One of the most complex of these methods, is the Public Transport Assignment because it takes into consideration many variables and all the lines of the public transport system. The thing is that for public transport, methods are usually very complex be it they have so many variables and are subject to many changes. In the case of private transportation things become much easier because cars move almost freely over the network. In this case there are very simple methods such as the All or Nothing Method which makes several assumptions which ease up the process. Provided this information, including a comparison with private transportation on the prototype TORP shouldn't be that hard as long as a simple method such as All or Nothing Method is used. Nevertheless it can be forecasted that programming the Trip Assignment Method for Public Transport will be hard.

Implementation of the models in a TORP:

As you can see, the models necessary to implement the route planner have been very well defined but there isn't a wide variety of methods available for mass transit. Another issue of great importance is that the input that is necessary to use those models is not available at this moment. In the study made by Barton-Aschman Associates, Inc. regarding the San Juan Regional Transportation Plan Highway Network Development in 1992 the same information was needed. The models were used on a computer program named EMME/2. The database that was generated by Barton-Aschman Associates, Inc. was based on the year 1990 Census and other factors of that time.

Currently Cambridge Systematics is doing a revision of this database and updating it so that it will take into consideration part of the information from the year 2000 Census and current details of the SJMA. This revision has not been concluded yet, so the fully revised database is not available. Nevertheless, Gabriel Rodriguez, who is a planning expert that works for the "Departamento de Transportación y Obras Públicas" (DTOP) has offered himself to contact certain people in Cambridge Systematics and see if he can get hold of this information in order to contribute to this project. This information is crucial for the rest of the research project to be completed so continuous follow-ups will be given regarding this matter until it is obtained. It is also necessary to locate where is the computer program EMME/2 in the Civil Engineering Department. This has been kind of a problem to find it. Some of the professors know it has been used in the department so we know it is there but no one knows where it is... Sooner or later it will appear, it's just a matter of time. Hopefully the program will be found in these days and practice runs will be made with temporary data in order to get acquainted with the software.

Once the database is obtained it has to be run on the program EMME/2 in the Civil Engineering Department and studied in order to determine which factors within this database are relevant for TORPs and which are not. It is also necessary to investigate if there is any possibility of converting this static database into a dynamic database to implement it on a system that runs at Real Time. At this moment there are still many things to be figured out but they need the database in order to be cleared up.

Preliminary Results

The TORP that should be implemented in the SJMA should have state of the art features. Throughout the investigation, some features that have been found to be very important and need to be incorporated in the ideal TROP lie within the following three categories:

➤ The TORP should have the ability to:

- Incorporate changes in the metropolitan area in terms of zones, nodes, population, etc.
- Take into consideration special events such as concerts, baseball games, etc.
- Use as an input: departure time or arrival time, whichever the user wants to specify.
- Minimize either transfers, walking time, costs or distance.
- Maximize comfort and/or security.
- Work on a "Real Time" basis with a dynamic database.
- Run on any web browser, be it on a PC, Cellular Phone or Handheld PC among others.

➤ The TORP should provide:

- Detailed, clear, and straight-forward written directions.
- Alternate routes, not just one "ideal" route.
- Distance, costs and time estimates.
- Maps that show the route on a highlighted line so that users get acquainted.
- Trustworthy directions and have little or no errors in terms of impossible routes, false estimates, etc.

➤ The TORP should also:

- Allow the user select the units in which he would like the results to be displayed.
- Be very user friendly.
- Contain plenty of Graphical User Interfaces (GUIs.)
- Be used for free.

Current operating TORP evaluation:

During this period of time, an effort has been made to contact TORP experts and webmasters with little luck, but some information has been collected anyway. E-mails were sent to all the sites with impressive TORPs and so far only one has responded. Nevertheless e-mails are sent weekly and other sites and contacts are being located in order to widen the study. So far the following information has been acquired:

Attribute	Public		Private			
	WMATA	MTA	MapQuest	Expedia	PR Wow	Avis
How flexible is the model to incorporate new information such as new zones, new nodes, population, etc.	+++++	+++++	+++++	+++++	+++++	+++++
Does the WISP use a previously generated database or was its own database created?	+++++	New	+++++	+++++	+++++	+++++
Are special events taken into consideration within the model used? (i.e. concerts, baseball games, etc.)	+++++	+++++	+++++	+++++	+++++	+++++
Is information or departure time or arrival time queried?	Y	Y	No	No	No	No
Are there any options provided to assign priority to time, cost, walking distance, scenery or transfers?	t,d,tr,w	No	No	t,d,s	No	t,d
Are alternate routes provided or only one route?	5 alt	2 alt	1 alt	1 alt	No	1 alt
Are distance estimates provided?	Y	No	Y	Y	No	Y
Are time estimates provided?	Y	Y	Y	Y	No	Y
Does it work on a "Real Time" basis?	+++++	No	+++++	+++++	+++++	+++++
Does the system have a static or a dynamic database?	+++++	+++++	+++++	+++++	+++++	+++++
Are there any comparisons provided between public and private transport?	No	No	No	No	No	No
What programs were used in order to generate the WISP and operate it?	+++++	PI/1 - Visual Basic	+++++	+++++	+++++	+++++
On what Operating System does the WISP operate?	+++++	Win NT	+++++	+++++	+++++	+++++
Are there graphical aids to assist the user?	Y	No	No	No	No	No
Are maps provided?	No	Y	Y	Y	Y	Y
Are detailed written directions provided?	Y	Y	Y	Y	No	Y
In what units are results offered?	\$, hh:mm, mi	\$, hh:mm	hh:mm, mi(km)	hh:mm, mi	N/A	\$, hh:mm
Are there any options provided to select the units? (for example km or mi, etc)	No	No	No	Y	N/A	No
Does the site provide information concerning the elderly, students, persons with disabilities, etc?	Y	Y	No	No	No	No
Are there strategic links located within the site to aid navigation?	Y	Y	Y	Y	Y	Y
Is it easy to use?	Y	not that easy	Y	Y	Y	Y
Are the directions provided trustworthy or are there mistakes constantly made?	Y	Y	Mostly	Mostly	Y	Mostly
Is connection with the server a problem?	+++++	+++++	+++++	+++++	+++++	+++++
How do they monitor the system's effectiveness? A) Receiving phone calls, e-mails, recommendations, criticism, etc. B) Doing Surveys...	+++++	A	+++++	+++++	+++++	+++++
Is it free?	Y	Y	Y	Y	Y	Y
Cost of implementing the system. (U.S. \$)	+++++	+++++	+++++	+++++	+++++	+++++
How did they determine that the WISP was feasible? Requests (strong demand), etc..	+++++	Requests	+++++	+++++	+++++	+++++
How many hits does the site receive on weekdays?	+++++	12k - 14k	+++++	+++++	+++++	+++++
How many hits does the site receive on weekends?	+++++	6k	+++++	+++++	+++++	+++++

Comments
* Los Angeles County Metropolitan Transportation Authority = MTA
* The Washington Metropolitan Area Transit Authority = WMATA
* ++++++ = Indicates that the information has not been gathered yet
* The WISP provided by AVIS limits itself to provide directions to and from airports.
* The only WISPs dedicated to public transport are WMATA y MTA, the rest are oriented in order to aid private transportation.
* PR Wow is not a Route Planner

Preliminary Conclusions

Things are running along just fine. A complete study of the Traffic Assignment methods is almost complete and a very good notion of the most important aspects a TORP should have has been developed. As soon as the database is acquired, lots of doors will be opened and the next phase of the research project will begin. Certainly the design process will be done combining the researcher's transportation expertise with the assistance of the computer specialist technical insight. The result will be a complete list of guidelines for creating the ideal TORP in the SJMA and a functional prototype of it.

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