On the Right Path

by Stephen Portillo

Background

Transportation is a major pollution source in today's car-dominated cities as commuters' cars emit pollutants such as carbon oxides, sulphur oxides, and nitrous oxides in using their cars. Mass transit use reduces emissions from transport as many people can be served by one vehicle, producing less pollution per commuter. However, commuters often find existing mass transit systems to be slow and inefficient, and thus default to the car as a fast, easy way to go to their destinations.

Municipal government faces a challenge in trying to create and maintain transit systems that are useful for their citizens without exceeding allocated budgets. Transit systems require a lot of infrastructure, so trying to improve these systems can involve major changes that take time and money. Predicting exactly how transit systems will respond to such changes is difficult because of their complexity; planners must account for such things as: commuters' preferences, the city's geography, and the timing of transit routes. Unforeseen side effects of route changes can be disastrous for a transit system, depleting time, money, and public confidence.

If the difficulties with transit planning could be overcome, cities would have more efficient transit systems. These systems would better serve the needs of the people, causing a paradigm shift in the eyes of the public. Transit would no longer be a second rate mode of transportation, and would instead become a reliable, rapid, economical, green way to get around.

Purpose

Information processing by computer can be useful in thi problem, as computers can easily tackle the myriad calculations required to evaluate complex systems like transit routes. Although an algorithm to produce ideal systems would be difficult to create, one that evaluates systems given to it would be much more reasonable to program. The approach I decided to take focused on generating “trip directives” based on the characteristics of the city containing start locations, destinations, and times of day to represent the individual trips commuters take. Then, my program would fulfill these directives using a model of a road/transit network, determining if, where, and when a commuter would opt to use transit, based on which mode of transportation is the fastest.

Planners would be able to feed hypothetical transit systems into this program and receive projected transit usage data for them. This data would allow planners to compare the strengths and weakness of different systems, as a normal day of traffic would be simulated. Where and when commuters chose transit or their cars would be given, and planners would be able to discern why. From simulated traffic changes caused by different systems, planners will be better able to predict how a transit system will react to change, and will thus will be able to make better changes.

Hypothesis

After creating an evaluative program as above, the program was tested using a real life example: the hamlet of Sherwood Park, Alberta. A simplified model of the municipality and its transit system was created, along with a model of an alternate transit system with modified routing. The program was then used to evaluate the two systems, and to judge the usefulness of the program.

The modified routing focused on the large loop feeder routes that characterize Sherwood Park’s system. These routes run through the neighbourhoods of the hamlet, returning to the main transit centres every half an hour. The alternate routing proposed modified these loops to be smaller, allowing buses to transport commuters from their homes to the transit centres more quickly. It is hoped that quick access to the transit centres would sway more commuters to use transit to reach other destinations, as the trip time would be lowered.

Procedure

To simplify the simulation model, Sherwood Park was divided into nodes representing the major neighbourhoods of the hamlet. Each node has population data representing the distribution of homes and workplaces, and is considered connected to other nodes through road networks. The transit networks are defined by which nodes they pass through and when they pass through these nodes.

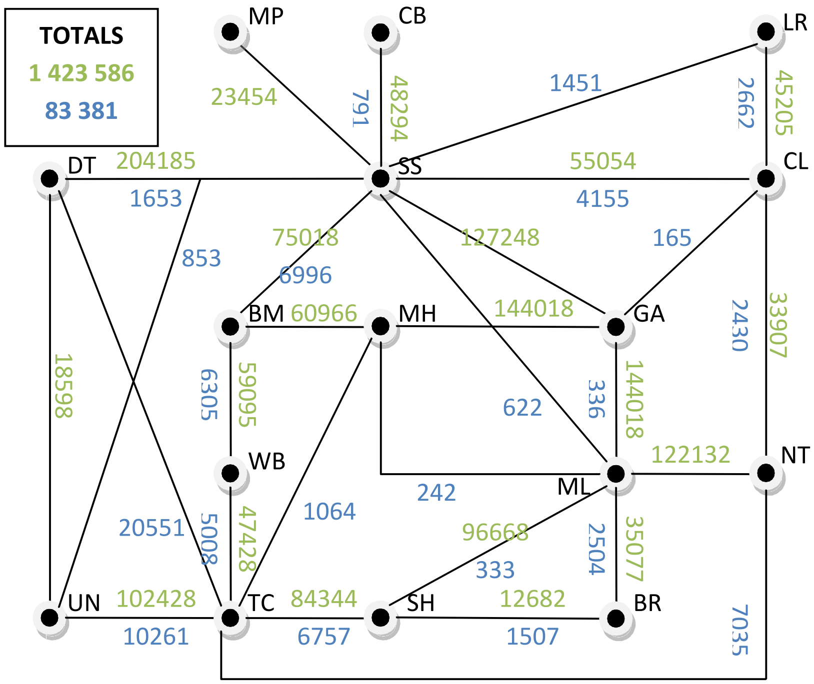
To work on this model of the city and its networks, the TransitBox program was created. The program focuses on the "trip directives" it generates based on the distribution of population. Each directive starts from a node in the city, specifies another node as its destination, and contains a time for departure; in total, all of the directives generated are representative of the commuters of the city. For each trip directive, the program generates a best path for that directive based on the connections possible in the city.

The paths are calculated by the program using the A* pathfinding algorithm, which will find the most cost-efficient path when given an underestimating heuristic. The heuristic used, or cost-estimating algorithm, estimates commute times by using the straight-line distance between locations. The main cost considered by the algorithm is the commute time, however, the attitude of commuters is also considered. Based on data from the city model, each directive has a bias either for or against using transit, with all directives falling into a normal distribution. This bias modifies the cost considered by the A* algorithm, and thus influences whether transit or car routes will be taken.

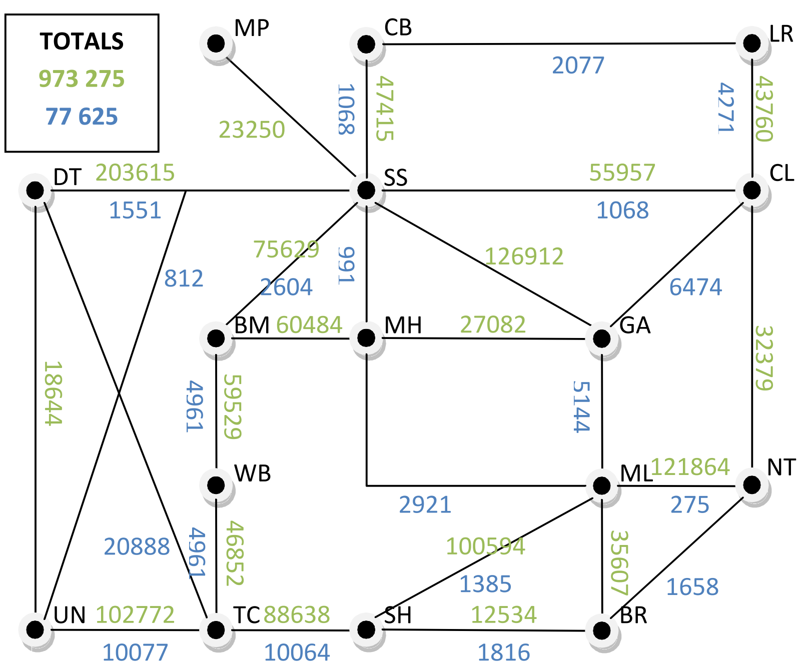
After generating and running through a representative set of directives, the paths taken to fulfill these directives are assembled by TransitBox. The paths are broken down into their constituent steps from node to node. The program generates a file containing a list of all the steps taken for all directives, including the start, destination, and time of day for each step. This data can be analyzed in many ways to yield insights into the behaviour of the transit system.

Results

Traffic Data for Sherwood Park's Original System



Traffic Data for the Proposed System



Legend

- Node
- BM Broadmoor
- BR Brentwood
- CB Clover Bar
- CL Clarkdale
- DT Downtown
- GA Glen Allen
- LR Lakeland Ridge
- MH Mills Haven
- ML Mall
- MP Millenium Place
- NT Nottingham
- SH Sherwood Heights
- SS Strathcona Station
- TC Transit Centre
- UN University
- WB Westboro

Car users
Bus riders
Connection

568450 trips generated, representing 10 days

Conclusions

The results of the experiment are significant, as the new system seemed to increase transit usage: 8.0% in the new system, compared to 5.9% in the old system, of node-to-node steps used transit instead of cars. Interestingly, the number of overall trip steps went down under the new system while the number of trips stayed the same, showing that on average, trips went through fewer nodes.

The strength of the new system seems to be in the Central part of Sherwood Park with significantly higher numbers of riders around Glen Allen, Clarkdale, Mills Haven, and the Mall. Car usage between Mills Haven and Glen Allen decreased, perhaps because of commuters opting to take the bus from Mills Haven to the Mall instead of driving through Glen Allen. Total ridership in the North and South sides of the city remained fairly constant, although usage patterns shifted. The commuter routes into Downtown and the University also showed very little change. The program was successful at identifying the strengths and weaknesses of the proposed system, and so has demonstrated its potential usefulness in transit planning.

Acknowledgements

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References

- "Amit's A* Pages" (http://theory.stanford.edu/~amitp/GameProgramming/) were very useful in my efforts to implement the A* algorithm in my program.
- Models of Sherwood Park and its transit system were based on transit schedules and population data from the municipality's official website (http://www.strathcona.ab.ca/).

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