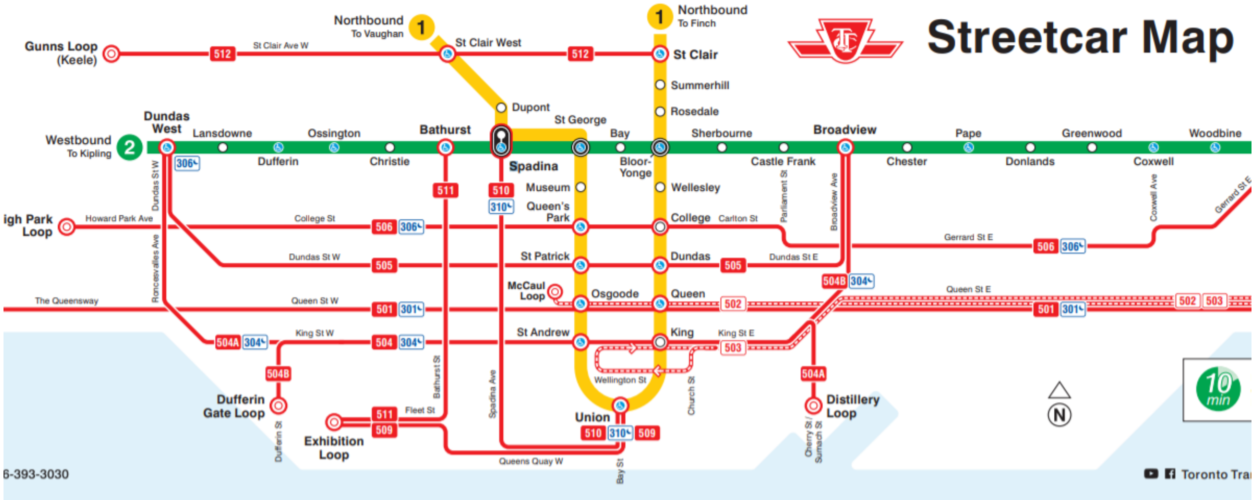

Optimized Design For GTA Metro System

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Team #19

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Introduction

Metro transit, also widely known as subway, is a high-capacity public transport in urban areas. It has several advantages, such as “reduce reliance on cars, mitigate sprawl, and provide residents with access to affordable transportation”[1]. In recent research, the subway could also “have an economically insignificant effect on urban population growth” and help to expand the city[2]. Since the metro system is important to a city, its design should be carefully chosen and decided.

The main topic of our project is to redesign the metro system in Toronto so that this new system is able to satisfy as many passengers as possible with a lowest building cost. Prior to our work, we assume that the only transportation method in Toronto is the subway. Our analysis has three major steps: In the first step, we will choose and decide the geometry location for the subway stations. Secondly, we will find those unsafe factors for running our subway system by doing research, in order to add constraints on the following station connection. Finally, among all the stations and constraints we get, we will compute and choose a subway system that connects each station with minimum building cost by building a complex net flow optimizer algorithm. During the process, we will first build the subway system in Downtown Toronto, in order that we can compare and evaluate our system with the real Toronto subway transit system. Once the comparison result shows our system is feasible, we are able to apply our designing method outside Downtown Toronto and redesign a new subway transit system in GTA.

Station Design

The first step for the subway network design is to determine where to allocate subway stations. In order to satisfy as many passengers as possible, we decide to allocate stations based on the number of potential passengers in each area.

Firstly, we are going to separate the GTA (Great Toronto Area) area into hundreds of small pieces based on the population density map. However, since the population density map only shows the population living in each area, we also need to collect the floating population in order to get maximum possible numbers of potential passengers in each area. For example:

- Largest daily tourists in the Eaton Center, Square One Shopping Centre
- Number of audience in Rogers Centre, museums and galleries
- Number of students studying in University of Toronto

After we have collected enough data and rebuild a new population density map based on the maximum number of potential passengers, we are going to calculate the subway stations demands for each area. To do this, we decided to learn from the subway system in DownTown Toronto in real life. Comparing the existing subway stations with our passenger density map in the DownTown area, we can calculate the suitable number of subway stations for different sizes of potential passengers. Moving on, by normalizing other areas in our passenger density map outside DownTown Toronto, we can figure out how many subway stations needed for each area in GTA.

Furthermore, in order to specify the location of each subway station of its respective area, we would calculate the maximum distance that passengers are willing to walk. By using this measure to optimally locate the subway stations, the maximum number of passengers will be able to enjoy the transit service.

Line Planning

When we connect each station, we need to avoid all the unsafe factors while trying to maximize customer's riding satisfaction. Firstly, we need to make sure that we avoid all the highways and tunnels. Secondly, power stations, water pipes, air pipes and wiring tubes are all needed to be avoided. Thirdly, we also need to avoid public facilities while constructing the subway. At the meantime, we also want to make sure that we avoid foundations under the resident buildings. After avoiding all the unsafe factors, we want to provide the customers best riding experience. We will estimate the longest time customers are willing to wait and walk and make the subway line satisfy their needs.

Cost Measurement

The cost we will consider in our project contains multiple aspects. Firstly, we will find and get the average financial to construct underground subway per mile as part of the cost. Secondly, we will estimate the time and workload to construct a one-mile underground subway and get the human resources costs with the average salary for one worker. Thirdly, the construction costs for different geology areas will be considered.

Algorithm Development

Once we have successfully collected all the data for station design, line planning and cost measurement, we would develop a net flow optimizer algorithm to solve our model. The objective function for the algorithm will minimize the total cost for building the metro system, with several constraints based on our line planning. In the end, the output for this algorithm will be a connected undirected simple graph with vertices are metro stations and edges are metro lines.

Reference

[1]. Richard Florida, June 2, 2016, *The Relationship Between Subways and Urban Growth*, Citylab, https://www.citylab.com/transportation/2016/06/the-relationship-between-subways-and-urban-growth/485006/

[2]. Marco Gonzalez-Navarro, Matthew A. Turner, May 30 2016, *Subways and Urban Growth: Evidence from Earth*, Journal of Urban Economics, vol 108, pp 85-106, DOI: 10.3386/w24996