Research Brief

Equitable Public Transit Network Reduction

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INDIANAPOLIS, IN (June 2023): At the recent TRB Innovations in Travel Analysis and Planning Conference, Riccardo Fiorista, an incoming student of the MIT JTL-Transit Lab, won first place in the Network Modeling Student Problem Solving Competition with his "Equitable Public Transport Network Reduction (EPTNR)" problem formulation. This method is meant to address the issue of voluntary or forced service reductions faced by public transit agencies worldwide, particularly throughout the COVID-19 pandemic and the looming fiscal cliff of U.S. agencies. Such Public Transit Network (PTN) reductions can affect various population groups unevenly. Thus, the pivotal question becomes: *How can agencies implement such reductions while prioritizing equality of access?*

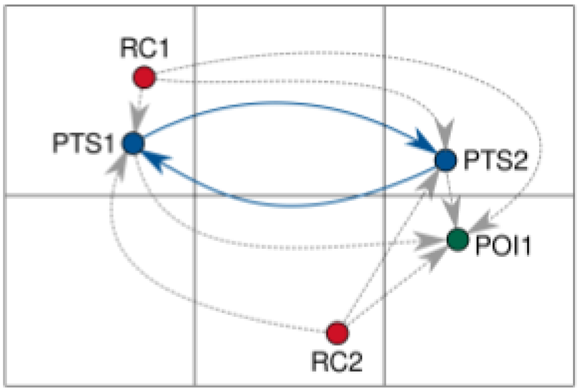

Figure 1: Sample EPTNR problem graph with Residential Centroids (RC), Public Transit Stations (PTS) and socio-economic Points Of Interest (POI). Blue edges represent the public transit network while gray ones represent a walking connection. Per-edge travel times are computed using the transit schedule and Open Street Maps pedestrian routing.

Riccardo offers an intriguing solution with his EPTNR problem formulation. He has developed a methodology to build an EPTNR problem graph, compute the equality of access to socio-economic opportunities between different population groups, and identify the most equitable PTN reductions. His open-source code for generating and optimizing EPTNR problem graphs is readily accessible on GitHub.

In Riccardo's innovative approach, the street and PTN shrink so that each trip originates from a census block's areal centroid, or **Residential Centroid (RC)**, and concludes at socio-economic **Points Of Interest (POIs)**, such as health care or educational providers. All travels, the study assumes, happens by foot and public transit. Figure 1 illustrates an example of this graph.

The study's methodology provides a nuanced understanding of socio-economic equality of access. For each resident, the methodology calculates the average travel time of the shortest paths to all POIs. The result is a comprehensive city-wide dataset that includes information on individual average travel times grouped by ethnicity, income level, and other demographic factors.

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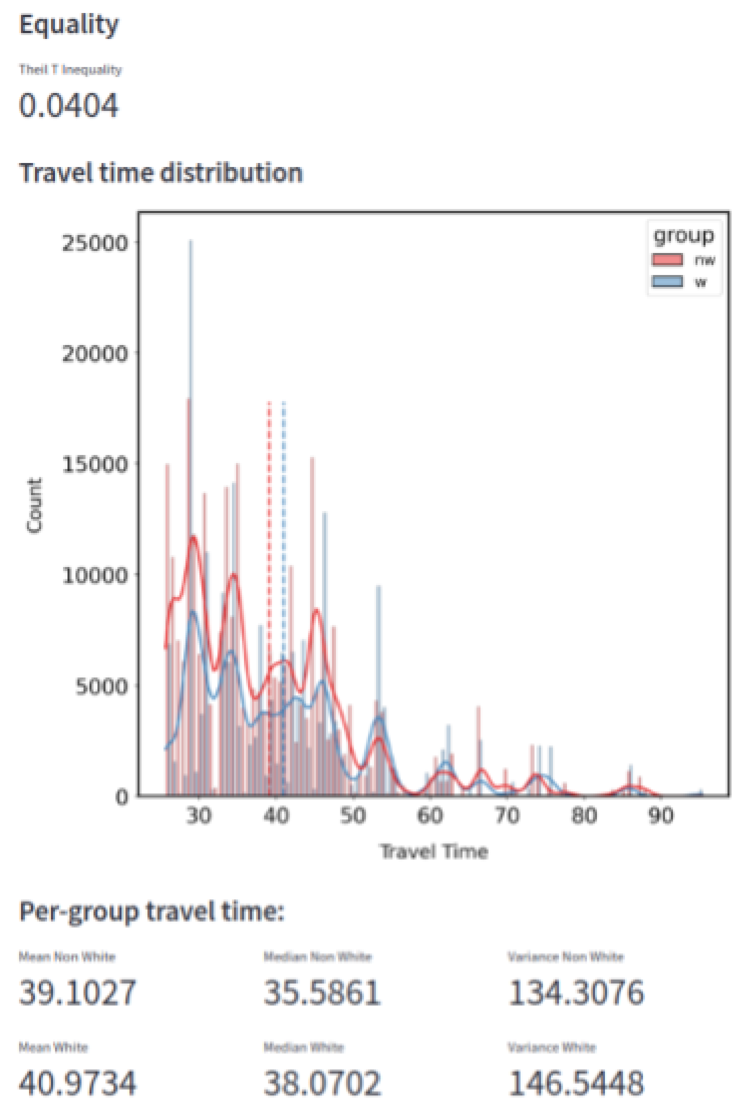

Figure 2: Partial output of the WebUI for the Atlanta MARTA network. Here, Theil T index value at the top, travel time distribution of the non-white (nw) and white (w) population to secondary schools in the middle, and per-group travel time metrics such as mean, median, and variance at the bottom.

All data required to build the EPTNR problem graph is open-source, and most cities worldwide have access to it. Open Street Maps supplies the pedestrian street network data, open General Transit Feed Specification (GTFS) data provides the PTN, and census data the demographic information. Riccardo's study includes a detailed data pipeline.

Once the average travel time dataset is available, the study presents an egalitarian method to compute the city-wide access equality. This calculation involves the Theil index of inequality, which then informs the search for the most equitable PTN reduction.

The study embarks on a full search examining all possible PTN configurations within a predetermined budget for edge removal. For each configuration, the average travel time dataset is rebuilt, and the Theil index recalculated. The algorithm then favors the configuration boasting the lowest Theil value, or the most equal setting, for suggesting PTN reductions. This process leads to a more balanced distribution of average travel times among the groups studied.

Adding another layer of practicality, Riccardo's study introduces a WebUI to interact with the EPTNR framework (partially illustrated in Figure 2). This platform empowers decision-makers to upload an EPNTR problem graph for their PTN and explore both current and future travel time and equality distributions among different population groups. It also presents the equity-optimal reductions identified by the search algorithm and provides an opportunity for users to experiment with manual PTN reductions.

Riccardo's performance has earned him an invitation as an honorary guest speaker at the TRB Conference in January 2024. He continues to refine the EPTNR problem definition and is exploring the potential of reinforcement learning to resolve this set of problems more efficiently. His approach offers transit agencies a new tool to handle PTN reductions, while ensuring that we navigate the path to equality and accessibility, rather than away from it.