Research Brief

Equitable Public Transit Network Reduction

Riccardo Fiorista[1]

Public transit agencies across the globe grappled with voluntary or forced service reductions throughout the COVID-19 pandemic. Now, as we set our sights on the post-pandemic world, many U.S. agencies must anticipate a looming fiscal cliff that could necessitate further reductions in their networks. It is crucial to acknowledge that these Public Transit Network (PTN) reductions can affect various population groups unevenly. The pivotal question becomes: *how can agencies implement such reductions while prioritizing equality of access?*

Our incoming JTL-Transit Lab MST student, Riccardo Fiorista, offers an intriguing solution with his Equitable Public Transport Network Reduction (EPTNR) problem formulation. He has developed a methodology to build an EPTNR problem graph, compute the equality of access to socio-economic opportunities, and identify the most equitable PTN reductions. Notably, his study achieved first place in the *Network Modeling Student Problem Solving Competition* at the Transport Research Board Innovations in Travel Analysis and Planning Conference. His open-source code for generating and optimizing EPTNR problem graphs is readily accessible on [GitHub].

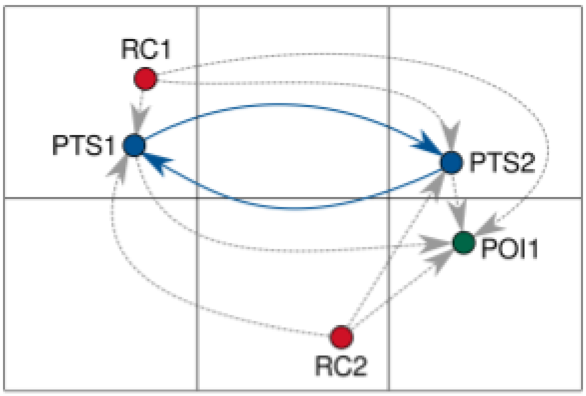

Figure 1: Sample EPTNR problem graph with Residential Centroids (RC), Public Transit Stations (PTS) and socio-economic Points Of Interest (POI). Blue edges represent the public transit network while gray ones represent a walking connection. Per-edge travel times are computed using the transit schedule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

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 divided by race, income level, and other demographic factors.

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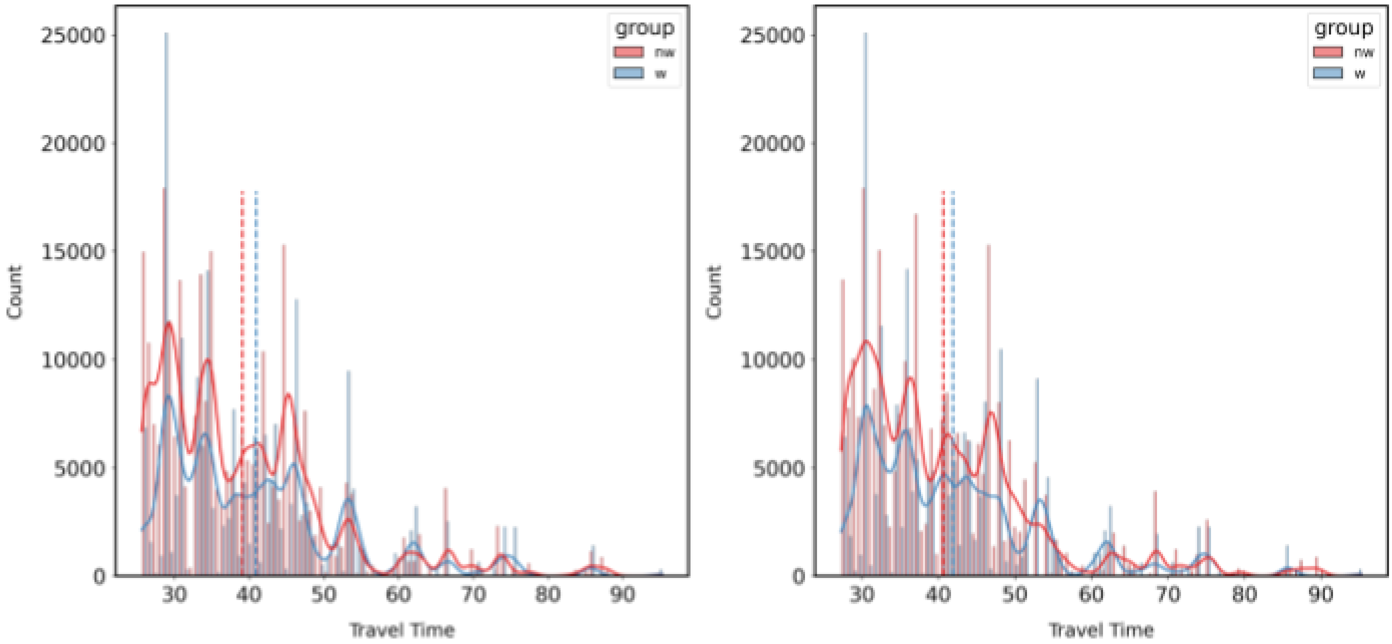

Figure 2: Left: Per-group, average travel time distribution in minutes by foot and public transit of all inhabitants of Atlanta city from their residential centroids to all secondary school facilities in the city. Group nw represents the non-white population while w is the white one. The vertical lines show the group-specific mean of average individual travel times. **Right:** The same distribution but under consideration of an optimally reduced network using an egalitarian approach. Here, the red and golden line connections from Arts Center Station to Lindbergh Station have been removed. Both groups are penalized with higher average travel time. However, the nw group is more so as they were already advantaged by approximately 2 minutes on average.

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.

As a practical application of the EPTNR formalization and search, Riccardo employed it on Atlanta's MARTA PTN, aiming to reduce MARTA's metro network by two edges while simultaneously enhancing access equality to secondary schools for non-white (nw) and white (w) residents. This exercise identified the red and golden line connections between Arts Center Station and Lindbergh Station. Figure 2 illustrates how the resulting network configuration decreases the gap in group-specific average travel time, thereby reducing access inequality.

Riccardo's winning performance has earned him a coveted 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 powerful tool to handle PTN reductions, while ensuring that we navigate the path to equality and accessibility, rather than away from it.