Konstantinos Gkiotsalitis

Public Transport Optimization

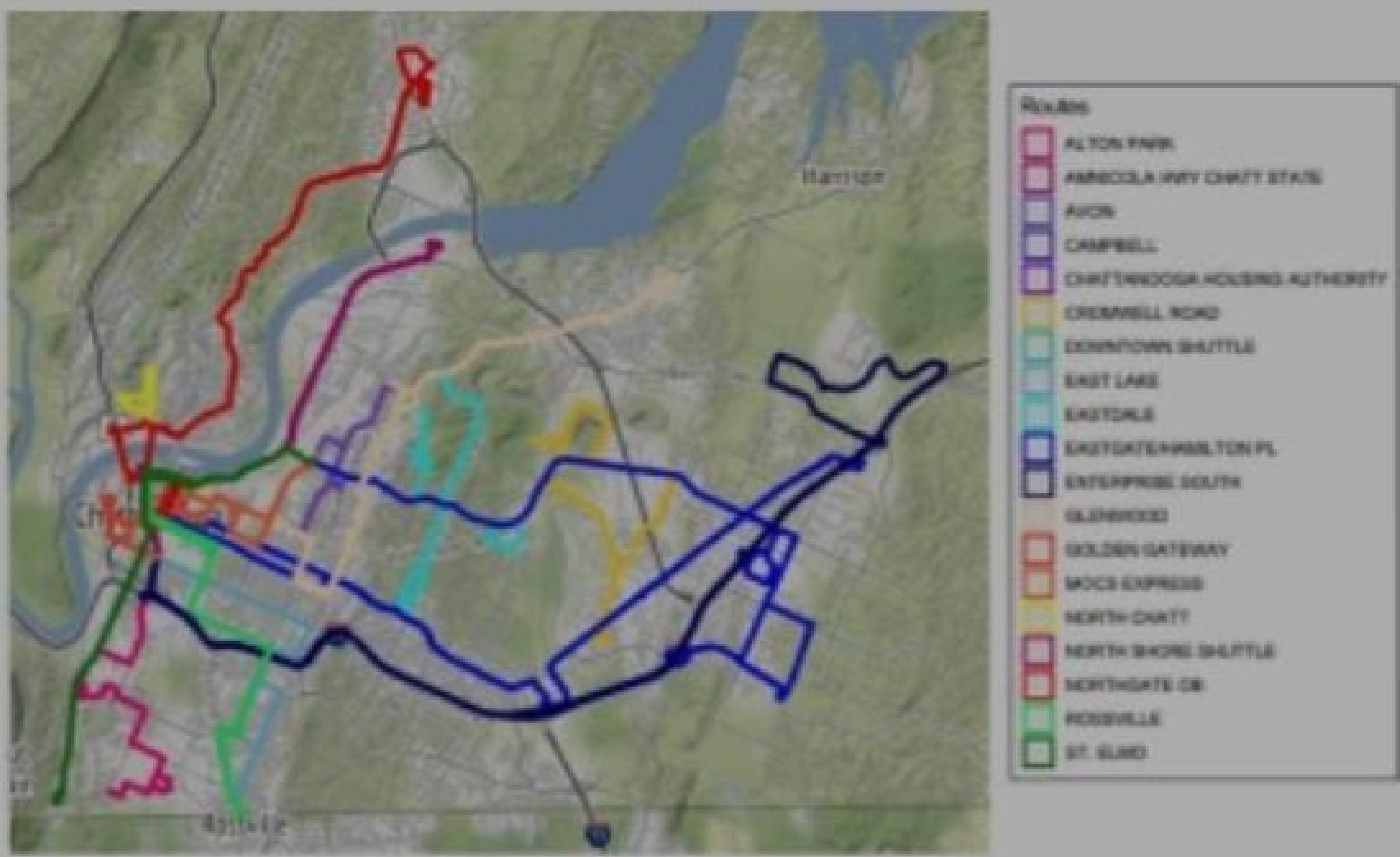
Problems in public transportation, as problems in many other sectors, change rapidly from year to year. The introduction of in-vehicle sensors and smart payment systems, the introduction of electric and autonomous vehicles, the use of demand-responsive services, and the integration of shared modes in public transport services have rapidly changed the sector over the past years. Undoubtedly, many revolutionary changes lie ahead in the years to come. This requires from a public transport modeler to be equipped with knowledge on how to translate new problem requirements into comprehensive mathematical programs that can be analyzed and solved to provide decision support to the relevant stakeholders. Problems ranging from optimally scheduling the trips of a fleet of electric vehicles to selecting the stations of a public transit network with autonomous vehicles are examples of future-looking problems that require knowledge in mathematical modeling to be able to formulate and solve them.

The first part of this handbook focuses on equipping the reader with the required knowledge in mathematical programming, linear algebra, numerical optimization methods, and complexity theory. After completing the first part of the handbook, the reader is expected to be able to do the following:

1. Translate problem descriptions of potential future problems into mathematical formulations that can be analyzed and solved to provide decision support to the relevant stakeholders.
2. Analyze the complexity of the developed mathematical formulations, propose efficient reformulations, and develop or select the appropriate solution methods to solve these formulations in a computer machine.
3. Understand the space and time complexities of solution methods used to solve mathematical programs.

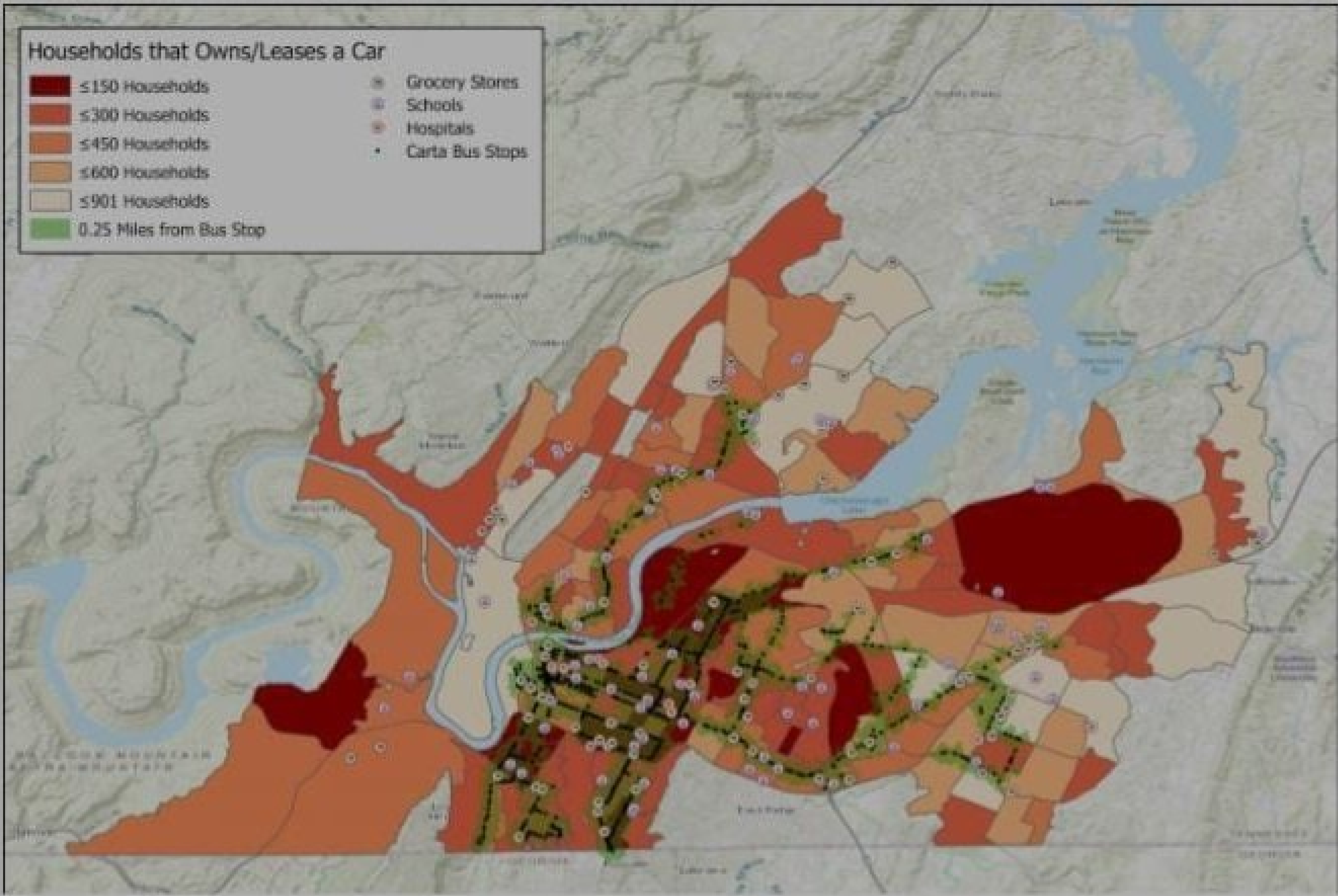
Importantly, there is a detailed description of open-source optimization tools that can be used to solve mathematically formulated problems with a computer machine. After finishing this part of the handbook, the reader will be aware of which tools are suitable depending on the formulation of the problem and will be able to apply them to practical problems. Problems covered are continuous and discrete optimization problems of convex and non-convex origin.

Bus routes that adequately serve citizens are crucial for proper urban mobility. The CUIP is currently studying CARTA bus routes so that we can 1) increase ridership and 2) increase accessibility. See the current bus routes in the image below.



Accessibility and need are key factors for determining high-priority areas. Accessibility to buses is determined by proximity to route. Low-income households are most likely to not own a vehicle, therefore needing access to public transportation the most. Below, you will see accessibility and need plotted with the CARTA routes.

Darker colors represent a higher level of household income, and the blue represents areas with bus stops within 15 minutes of walking.



Vehicles and Walkability

There are specific areas with less income, no access to CARTA, a high rate of unemployment and fewer households that own/lease vehicles.

Future Work

- Analyze OD matrix
- Run simulations to determine best possible new routes
- Learning ride rates and passenger totals