

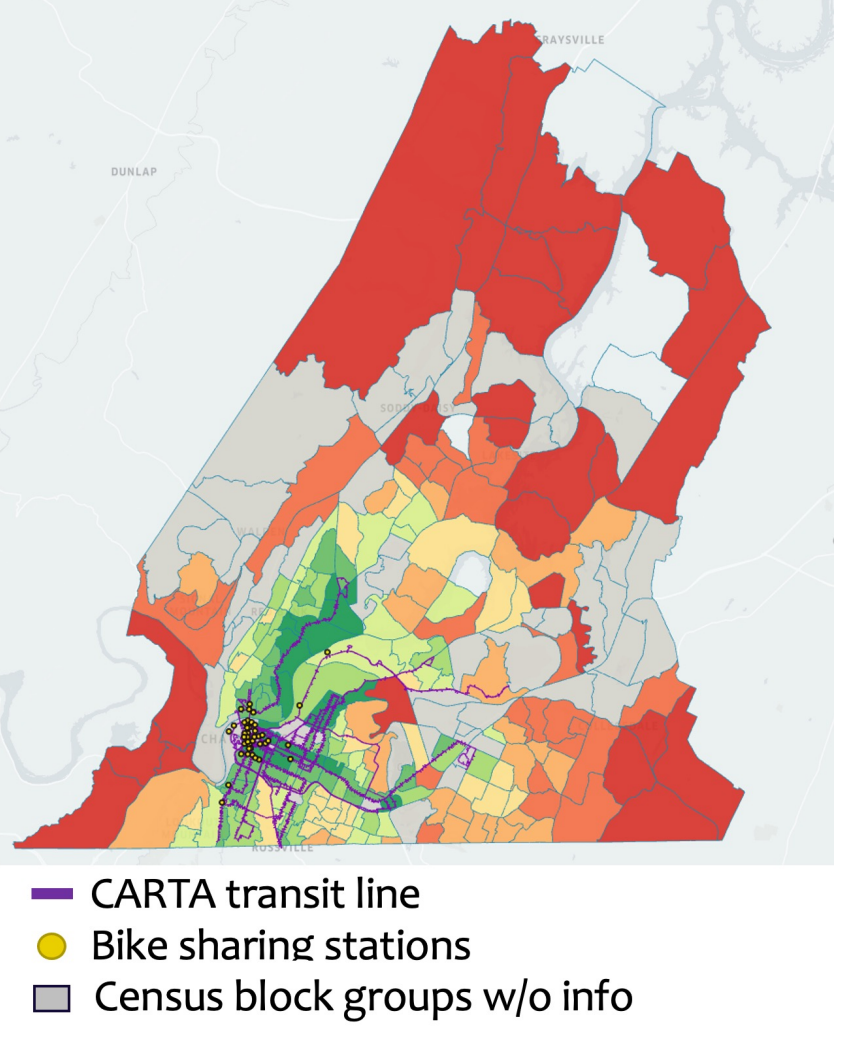
# Mobility for All — Harnessing Emerging Transit Solutions for Underserved Communities

**PIs and Researchers:** Abhishek Dubey (Vanderbilt), Aron Laszka (University of Houston), Paul Speer (Vanderbilt), Chandra Ward (UTC), Mina Sartipi (UTC), Philip Pugliese (CARTA), Dan Freudberg (WeGO), Samitha Samaranayake (Cornell), Himanshu Neema (Vanderbilt), Ayan Mukhopadhyay (Vanderbilt), Lillian Ratliff (UW). **Staff:** Maxime Coursey (Vanderbilt), Savannah Ward (CARTA)

**Students and PostDocs:** Ava Pettet, Dan Calderone, Juan Pablo Talusan, Michael Wilbur, Rishav Sen, Sophie Pavia, Youngseo Kim, Carlos Martinez, Dhanushka Pandithage, Amutheezan Sivagnanam, Afiya Ayman, Taha Egtesad, Omidvar Shadi, Tran Toan, Seyedmehdi Khaleghian

### Challenge: Provide Wide Coverage while Ensuring that the Service is Economical, Efficient, and Equitable

- Available Modes of Transportation in the city are personal cars, personal bikes, bike shares, fixed line buses, and paratransit vehicles.
- We are working to introduce microtransit and integrate it efficiently with the rest of the public transportation systems.
- The challenge is to provide a means of transportation for daily activities to everyone who needs it while prioritizing access to the people who need it most.



■ CARTA transit line  
● Bike sharing stations  
 Census block groups w/o info

### Design Algorithms

*A few days in advance...*

**1. Booking**

- Clients book microtransit trips over the phone or via an app
- Each request includes an origin, a destination, and a pickup time
- Accepted requests are recorded

*One day in advance...*

**2. Planning**

- Recorded requests are assigned to vehicle runs
- Vehicle runs must satisfy constraints, such as drivers' shifts, travel times between locations, vehicle service time between runs, etc.

*Day of trips*

**3. Service**

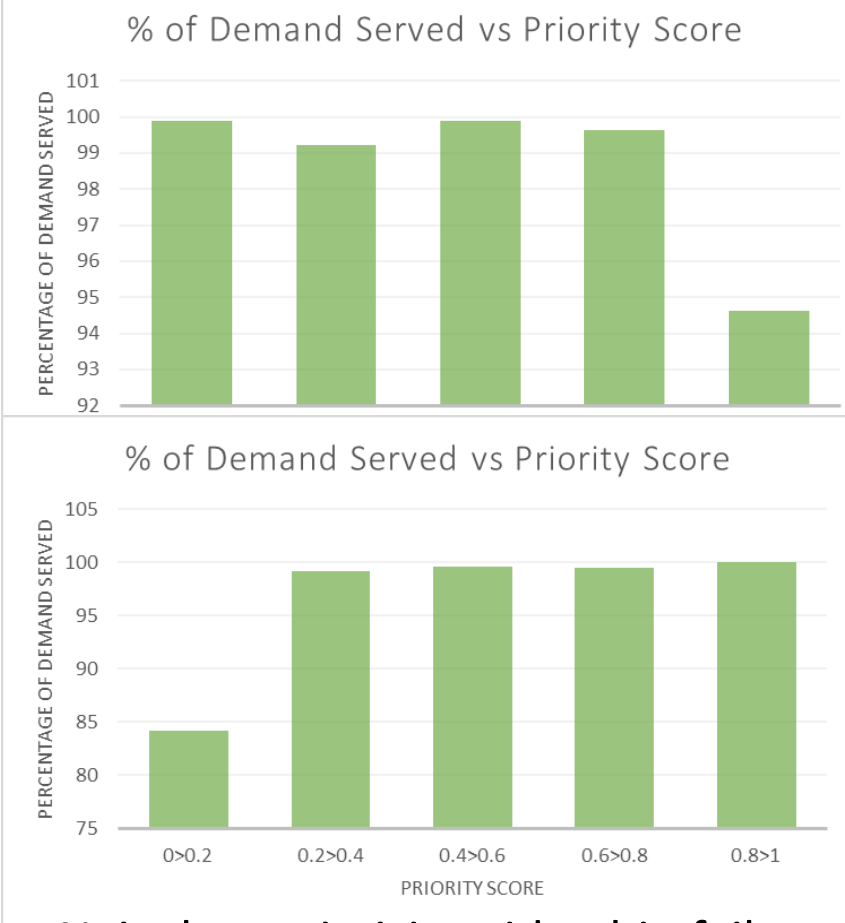
- Vehicles serve the assigned runs
- Clients may request changes to destinations or book same-day trips
- Issues are resolved in real time

The problem of scheduling on-demand transportation options is computationally complex. The goal is to design dynamic routes that ensure all constraints (driver and vehicle availability and quality of service) are met, and the overall utility is maximized.

### Understanding Equity in Transit

**How?**

- A "utilitarian" view of designing transit focuses on maximizing ridership. Augmenting priorities to such an approach can improve equity.
- We are also integrating other notions of fairness such as Nash social welfare and Rawlsian justice.



**Impact:**

- Our preliminary goal is to understand how each measure of fairness affects ridership and equity of, and accessibility to public transit.
- Our findings will fundamentally transform the design of public transit infrastructure by making it equitable by construction.

Naively maximizing ridership fails to serve residents who "need" transit the most (top). Focusing on priority can change the distribution of accessibility (bottom).

### Our Approach

**Community Engagement**

- Understand the situation and analyze the impact of problems such as gentrification and pandemic
- Community Engagement through Focus Groups
- Conduct Longitudinal Surveys

**Design Algorithms**

- Operate On-demand Transportation
- Integrate On-demand Transportation With Fixed Line Algorithms
- Design fair line planning to update the fixed route service, if required

**Pilot Operations**

- Start with using the slack available in paratransit operations
- Introduce new on-demand service
- Integrate On-demand service with the fixed line operations

**Design evaluation and impact analysis criteria**

- Understand the system equilibrium.
- Design transit accessibility scores and evaluate the performance over time
- Check the potential improvement under simulation

### Bookings Recommendation Engine

1. specify pickup locations and time preferences

**Client (passenger)**

2. enter request

**Operator (CARTA)**

3. latest solution

**Deep reinforcement learning agent**

4. recommended pickup times

**Anytime algorithm**

5. agree on 30-minute pickup window

Cell	Home	Home Address
423-123-1234	423-555-5555	8th Avenue, Chattanooga, TN
First Name	Last Name	Email
Douglas	Smith	Douglas.Smith@gmail.com
ADA/Carta Eligibility	Wheel/Chair / Ambulatory	
ADA Eligible	standard wheelchair	
General Client Notes		
Pickup behind entrance welcome center		

A snapshot of our booking application deployed on Google Cloud

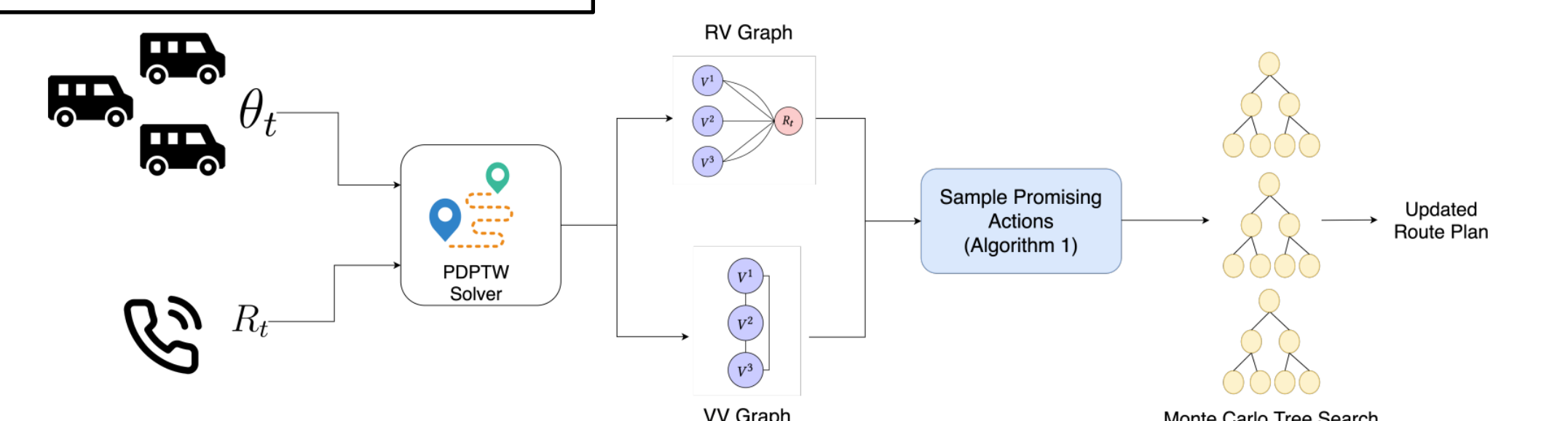
Published in IJCAI 22

### Online Optimization for Robustness

It is important to consider the real-time changes, new bookings, vehicle breakdowns and optimize the trips in real-time, telling the drivers of the change.

**Problem:** Action space is computationally intractable.

**Solution:** use cheap heuristics to select  $k$  most promising actions



**RV-graph:** there is an edge between a request and a vehicle for every feasible route plan in which a vehicle can service the new request.

**VV-graph:** edges represent swaps with highest utility.

**Feasible actions:** any independent set of edges from RV U VV that includes only one edge from RV.

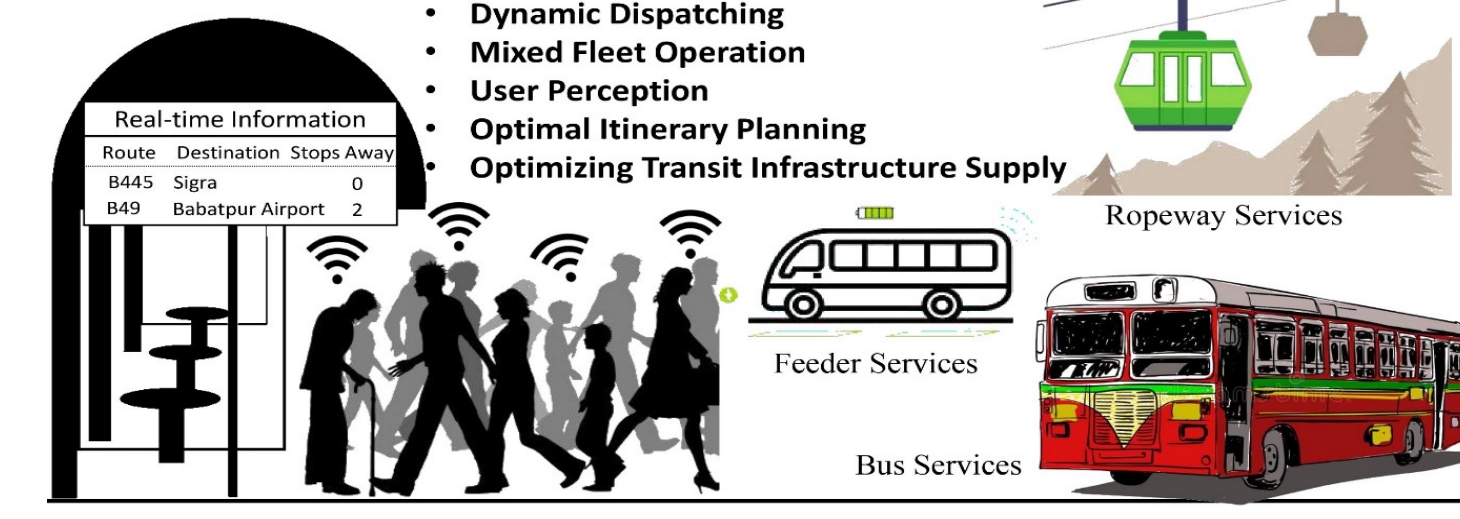
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### Going beyond local communities

- We extended our approaches in collaboration with Google Research and HelpMum, a non-profit organization based in Nigeria to optimize the allocation of health interventions in Ibadan, Nigeria.
- We are also working with Varanasi, India to test the generalization of the results and improve public transportation there.

**Multi-modal routing algorithms for Integrated Fixed-Line, On-Demand, and Feeder Services**

- Dynamic Dispatching
- Mixed Fleet Operation
- User Perception
- Optimal Itinerary Planning
- Optimizing Transit Infrastructure Supply

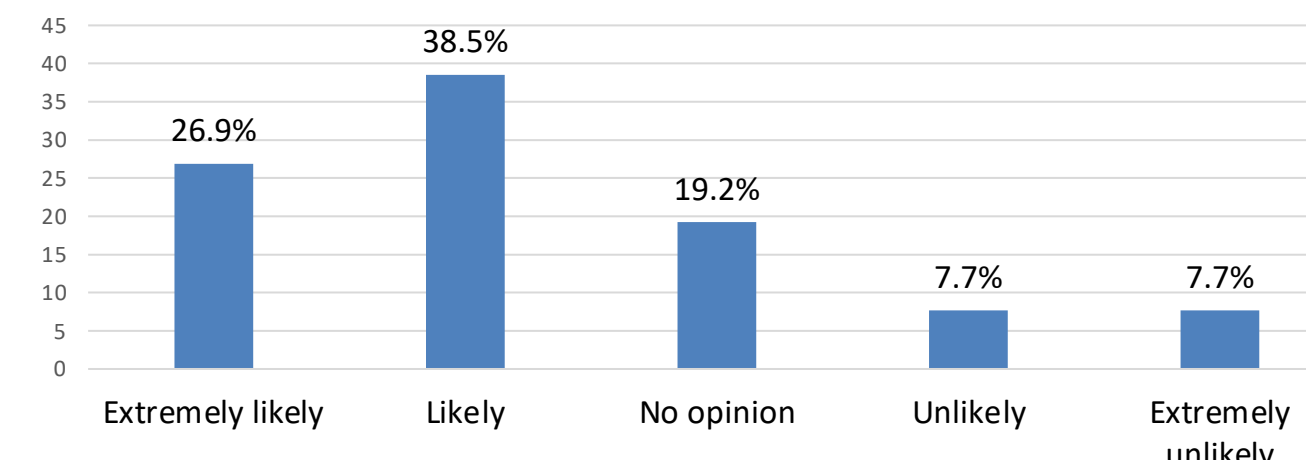


IJCAI 22 Best Paper Award

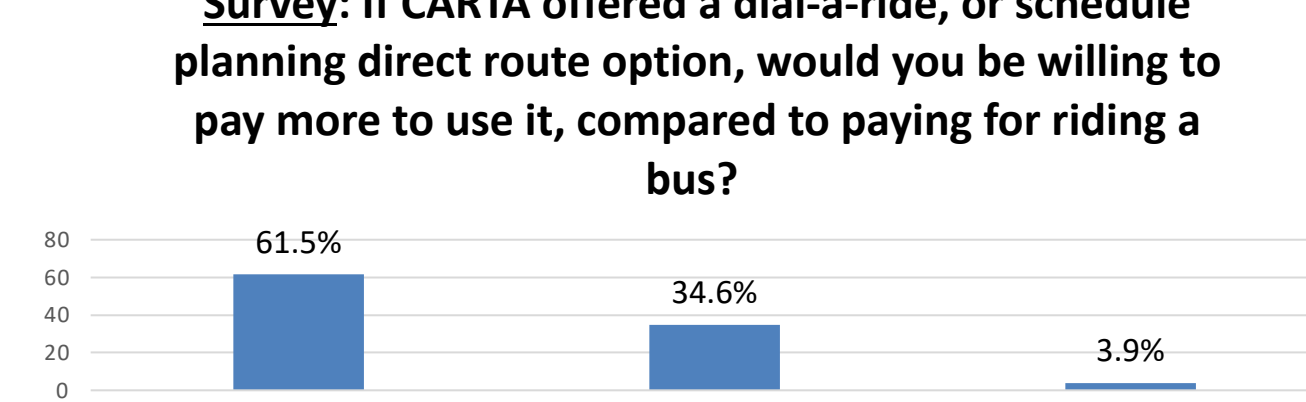
### Understanding Community Needs is Critical

- We conducted six focus groups followed by surveys.
- In-person collection at key transit stops and downtown corridors. QR code survey link posted at bus shelters and on all buses
- Participants were residents of Chattanooga, and some lived outside of the city of Chattanooga.

**Survey:** If CARTA offered a dial-a-ride, or schedule planning direct route option, how likely is it that you would use it?



**Survey:** If CARTA offered a dial-a-ride, or schedule planning direct route option, would you be willing to pay more to use it, compared to paying for riding a bus?



### Pilot Operations and Next Steps



- App-based demand responsive service launched in the expanded service zone on August 22, 2022, using commercial software as a service to provide baseline data.
- We plan to Deploy the application and algorithms developed by the team within paratransit service to a larger service area.
- We seek to continue community outreach and evaluation of existing services.

