Mobility-On-Demand Transportation: A System for Microtransit and Paratransit Operations

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ABSTRACT

New rideshare and shared-mobility services have transformed urban mobility in recent years. Therefore, transit agencies are looking for ways to adapt to this rapidly changing environment. In this space, ridepooling has the potential to improve efficiency and reduce costs by allowing users to share rides in high-capacity vehicles and vans. Most transit agencies already operate various ridepooling services including microtransit and paratransit. However, the objectives and constraints for implementing these services vary greatly between agencies. This brings multiple challenges. First, off-the-shelf ridepooling formulations must be adapted for real-world conditions and constraints. Second, the lack of modular and reusable software makes it hard to implement and evaluate new ridepooling algorithms and approaches in real-world settings. Therefore, we propose an on-demand transportation scheduling software for microtransit and paratransit services. This software is aimed at transit agencies looking to incorporate state-of-the-art rideshare and ridepooling algorithms in their everyday operations. We provide management software for dispatchers and mobile applications for drivers and users. Lastly, we discuss the challenges in adapting state-of-the-art methods to real-world operations.

KEYWORDS

mobility-on-demand, ridepooling, transit operations, software

1 INTRODUCTION

Large-scale adoption of smart phones and sensing technologies has given rise to new user-centric transportation modes including rideshare and shared-mobility services. We collectively refer to these new transportation modes as mobility-on-demand (MoD). Led by companies such as Uber, Lyft and Via, MoD provides users with reliable point-to-point travel options through smart phone applications. As MoD continues to transform urban mobility, cities are looking for ways to utilize new technologies to improve existing public services and adapt to this new environment.

One domain in which public transit agencies are looking to better utilize is the case of microtransit and paratransit services. These services fit under the umbrella of *ridepooling*, which refers to MoD that utilizes high-capacity vehicles to service trip requests. From the city's perspective, microtransit services are available to all residents and can be thought of as a low-cost extension of their public transit system. They can be used for direct point-to-point travel as well as in hybrid transit systems where the vehicles shuttle passengers to and from fixed-line transit [4]. Similarly, paratransit is a ridepooling service run by a transit agency that provides curb-to-curb service for passengers that are unable to use fixed-route transit (e.g. passengers with disabilities).

Many transit agencies operate both microtransit and paratransit services. However, the objectives and constraints for implementing these services varies greatly between agencies. This means that most agencies have to either design their own software or manually augment their workflows to adapt existing off-the-shelf software. This ad-hoc process makes it hard for researchers to implement new ridepooling algorithms and approaches in real-world settings.

This paper describes our MoD transportation software for microtransit and paratransit operations. The target audience is transit agencies managing these services and was initially designed for an upcoming pilot to test our ridepooling algorithms with our partner agency the Chattanooga Area Regional Transportation Authority (CARTA) in Chattanooga, TN. The software includes three interfaces - an operations manager web application for dispatchers, a vehicle operator (or driver) mobile application and the user mobile application for residents to book requests. Additionally, it includes two modular optimization components - an offline solver for ahead-of-time scheduling and an online solver for same-day trip requests. The optimization components can be replaced with new solvers over time or augmented to handle various constraints specific to each transit agency by implementing programming interfaces we have designed for the offline and online tasks.

2 SOFTWARE OVERVIEW

As shown in Figure 1, we provide an operations manager which is a web application that allows the transit agency to manage clients, take bookings, update schedules and monitor real-time operations. Through the operations manager the agency is provided with what they need to handle both microtransit and paratransit services and is general enough to be used for any centrally managed ridepooling service. Through the real-time component dispatchers can monitor and track active vehicles for more informed decision making. They also have access to optimization components that can automate or recommend trip-to-vehicle assignment as discussed in Section 3.

We also provide two mobile applications that can run on tablet or phone. As shown in Figure 2, the driver application allows vehicle operators (or drivers) to manage their routes for the day. It interacts directly with our backend to get up-to-date routes and communicate

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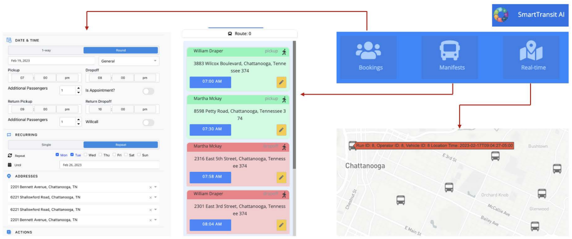
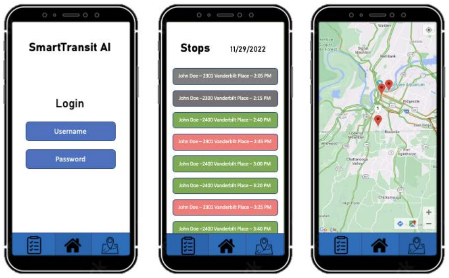

SmartTransit AI
Bookings
Manifests
Real-time
DATE & TIME
1-way
Round
Feb 19, 2023
General
Pickup
Dropoff
Additional Passengers
Is Appointment?
Return Pickup
Return Dropoff
Willcall
RECURRING
Single
Repeat
Until
Feb 26, 2023
ADDRESSES
2201 Bennett Avenue, Chattanooga, TN
6221 Shallowford Road, Chattanooga, TN
ACTIONS
Route: 0
William Draper
pickup
3883 Wilcox Boulevard, Chattanooga, Tennessee 374
07:00 AM
Martha Mckay
8598 Petty Road, Chattanooga, Tennessee 374
07:30 AM
dropoff
2316 East 5th Street, Chattanooga, Tennessee 374
07:58 AM
2301 East 3rd Street, Chattanooga, Tennessee 374
08:04 AM
Run ID: 8, Operator ID: 8, Vehicle ID: 8 Location Time: 2023-02-17T09:04:27-05:00
Chattanooga

Figure 1: Operations manager web application: allows the transit agency to manage clients, take bookings, update route manifests and monitor real-time operations and dispatching.


SmartTransit AI
Login
Username
Password
Stops
11/29/2022
John Doe – 2301 Vanderbilt Place – 2:05 PM
John Doe –2300 Vanderbilt Place – 2:15 PM
John Doe –2400 Vanderbilt Place – 2:40 PM
John Doe – 2301 Vanderbilt Place – 2:45 PM
John Doe –2400 Vanderbilt Place – 3:00 PM
John Doe –2400 Vanderbilt Place – 3:20 PM
John Doe – 2301 Vanderbilt Place – 3:25 PM
John Doe –2400 Vanderbilt Place – 3:40 PM

Home page/login Stops Map

Figure 2: Vehicle operator mobile application: allows driver to manage their route for the day.

with the dispatchers as drivers service their schedules. We also provide a mobile application for users to schedule trips through their smart phone. Users can also call to request trips over the phone which is then booked through the operations manager interface.

The interfaces utilize APIs to manage the various automated processes. Travel times are calculated from a customized Open Source Routing Machine (OSRM) deployment and Mapbox for real-time routing. We use Google Maps APIs to help enter addresses in the UI and for geo-encoding addresses. The primary data store is MongoDB and we utilize Google Pub-Sub for pushing updates to users and drivers and processing real-time vehicle locations. The software is deployed on Google Cloud Platform (GCP).

3 RIDEPOOLING ALGORITHMS

A key problem for transit agencies that manage ridepooling services is designing algorithms to assign requests to vehicles. In microtransit and paratransit, requests can be for some day in the future, which we refer to as ahead-of-time requests, or can be for the same day. Therefore, we need two optimization components. An offline solver is run ahead of time and bulk assigns trip requests to vehicle routes for the upcoming day. Then when a new same-day request arrives, an online solver assigns the request to a vehicle that can accommodate the trip.

Trip-to-vehicle assignment is fundamentally a vehicle routing problem (VRP). Most research focuses on a set of common VRP formulations that can be classified by the types of constraints applied to the system including vehicle capacities, pickups and dropoffs, and time-related restrictions (time windows) [3]. However, in real-world scenarios the constraints and objectives vary between setting (microtransit vs paratransit) as well as between agencies. This makes it hard to use off-the-shelf algorithms from the research community. Therefore, our offline and online solvers are modular. We defined structured interfaces for both solvers so that the implementation details of the solver are decoupled from the software itself. In this way, new solvers can be added or constraints can be adapted to fit different transit agency requirements. The solvers are made available by a REST API which means for a new solver to be incorporated the solver endpoint needs to be changed in a configuration file.

We provide two offline solver implementations included with the software. First is a heuristic solver implemented with Google OR-Tools that was customized to CARTA’s paratransit requirements. The second solver is based on our recent work using temporal decomposition which we had to adapt for the real-world constraints of our partner agencies [2]. Additionally, we provide a greedy online solver as well as a state-of-the-art non-myopic online solver for the paratransit setting based on recent work of ours [6]. For the microtransit setting we are currently working on implementing a highly scalable batch solver based on shareability graphs [1].

4 CONCLUSION AND OUTLOOK

In this work, we presented our MoD software for micro transit and paratransit operations. Going forward we would like to extend this work to make it easier to adapt existing optimization components to real-world settings by providing a way to adjust objectives and constraints directly through model-integrated computing [5].

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