Demand Responsive Transport for Mobile Application based Mass Transit System

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1. Introduction

Transportation sector is at the forefront of disruption. Uber, a name known for disruption in transport sector, was founded in March 2009. Today it stands as a ten (10) billion-dollar company. As we speak, Uber and its clones (Lyft, Didi, Ola, Grab, EasyTaxi, Carma, Sidecar, Car2Go, Hitch-a-ride, Careem, Blablacar, and etc.) are operating across the globe.

Apart from scale, Uberization phenomena also expanded in scope. The service which was initially limited to taxi like service expanded to app-based bus services, food delivery services, healthcare services, cargo, goods and parcel delivery solutions and beyond (Hensher 2017). The reasons for expansion in scope are often related to service needs of the population that original taxi like service providers were unable to fulfil. For example, in many countries uberized taxi service are hailed by small population segment due to its higher costs and limited area coverage (Schechtner and Hanson 2017, Zhao et al. 2018). This has led to a situation where many Uber clones (i.e., Didi, Careem, Citymapper, Swvl, Grab and etc.) are beginning to offer app-based bus or shuttle services in their respective markets to attract the population segment that was not served by the uberized taxi like services (Hensher 2017).

It is intuitive to see the attractiveness of bus or shuttle services as opposed to taxi services. The customer stands to gain from lower prices due to pooling, which is often the case in many developing countries (Schechtner and Hanson 2017). The transportation policy maker stands to gain from reduced traffic congestion and the service provider stands to gain by creating a value proposition for customers and policy makers (Koh et al. 2018, Archetti, Speranza, and Weyland 2018). To this end, the app-based bus services are being provided by Didi in China, Grab in Asia Pacific, Careem and Swvl in Middle East, Africa, and South Asia, Citymapper in UK and many others.

All of these companies utilize traditional fixed line routing concept to provide app-based bus services. Using mobile application, a user can find nearest fixed line bus route and book the ride. While technology in app-based bus services has helped to reduce information asymmetry for the user, the fixed line services still suffer from low customer service, poor capacity utilization and rigidity in reacting to changing demand and traffic conditions issues (Archetti, Speranza, and Weyland 2018, Koh et al. 2018, Speranza 2018).

2. Demand Responsive Transport in Mass Transit

Demand responsive or dynamic or flexible routing concept, where a bus route can be adjusted based on customer request was explored by Archetti, Speranza, and Weyland (2018) for public transportation context. The authors note significant improvement in customer journey times (i.e. door to door journey times) and capacity utilization of transportation infrastructure in their simulation study. More recently, Singapore Land Transport Authority explored the concept of utilizing dynamic or demand responsive routes for bus services in one pilot study for public transportation services in the city of Singapore (Koh et al. 2018). The results indicate that dynamic routing of bus routes in reaction to demand offers several benefits over its fixed line counterpart. Some of these benefits include:

- Ability to accommodate changing customer demand and traffic conditions,
- Seamless customer travel experience and reduced wait time,
- Rationalization of low demand routes while maintaining customer travel times,
- Improved capacity utilization levels for the service provider,
- and reduced traffic congestion since greater customer demand can be served using smaller vehicle fleet sizes.

The pilot study by Singapore Land Authority focused on segregating high demand density neighbourhoods from low demand density neighbourhoods and offering dynamic routing services for the latter neighbourhoods only. While the former were proposed to be continually served using fixed routes. This is a major limitation due to the temporal nature of customer mobility demand where a locality typically experiences high and low demand periods during various times of the day. Both studies focus on public transportation which is significantly different than the context of app-based services. Moreover the framework proposed by Koh et al. (2018) in Singapore Land Authority pilot study lacks key system-wide cost considerations that we address in our work.

In this research, we aim to explore and expand the concept of demand responsive or flexible service or door-to-door service for app-based on-demand bus services, where a bus route is adjusted based on each incoming customer request. In the section 3, we discuss the overall framework and architecture that an app based bus or shuttle transport company may deploy to provide demand responsive services.

3. An Architecture for Demand Responsive Bus or Shuttle Transport

We now discuss overall architecture that can be used to provide demand responsive transport in mass transit format. Figure 1 depicts the schematic of the overall architecture and its various components. One can observe similarities in our proposed framework and one presented by Koh et al. (2018). Both systems use foretasted demand input, available bus route and current seat capacity information to narrow down the choices for re-routing. After creating re-routes for the selected options, the goal is to pick the most appropriate one.

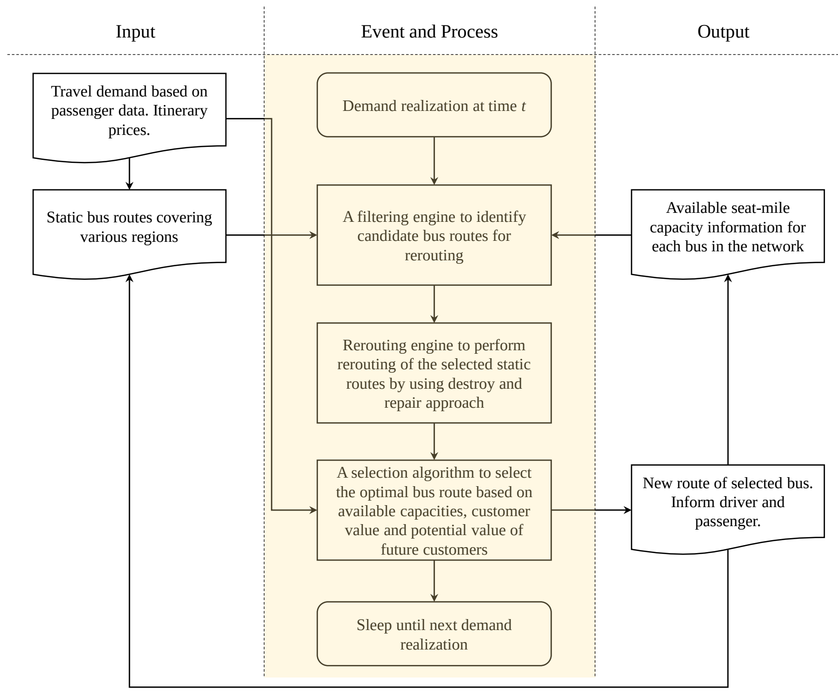

Figure 1 **An Architecture for Demand Responsive Bus Transport**

Koh et al. (2018) utilize a simple choice function by modelling decision maker as a localized agent. The focus is to find re-route option based on minimum costs of re-routing the existing route. Our approach is more comprehensive for a variety of reasons. First, due to the profitability focus, we model trip prices and revenues in our approach. Second, we not only focus on profits of accommodating currently realized demand, but all potential future demand realizations and capacity situations. Thirdly, due to public service nature, rejecting a demand realization is not an option for Koh et al. (2018). We on the other hand make no such restriction and expand our choice set to the cases that we may be reject serving a customer, if it is not yielding high on current and future profits.

The choice decision is performed in the selection algorithm module of the overall architecture (see Figure 1). Here, we borrow concepts from yield management literature. Yield management concepts are often used by airlines and hospitality industries to react to the changing customer demand and environmental conditions (Talluri and Van Ryzin 2006). Mass passenger transportation, airline and hospitality industries, all have similar traits of expensive initial fixed capacity and lower variable costs. Whereas the airline and hospitality industries use decision lever of price discrimination in order to match available capacity with demand, our intention is to utilize appropriate bus selection and dynamic routing of appropriate bus for the similar outcome while keeping the customer journey costs stable.

4. Conclusions, Contributions and Future Work

In this paper, we present the overall architecture for providing demand responsive mass transit services that are being provided by an app based company. The idea is itself novel. In our simulation experiments, we have improvements similar to the one observed by Archetti, Speranza, and Weyland (2018) and Koh et al. (2018) for the context of mobile application based mass transit system. This research is supported by a major transportation services provider in Middle East, Africa and Asia region that is providing transport and logistics solutions by mobile applications.

References

Archetti C, Speranza MG, Weyland D, 2018 *A simulation study of an on-demand transportation system. International Transactions in Operational Research* 25(4):1137–1161, URL `http://dx.doi.org/10.1111/itor.12476`.

Hensher DA, 2017 *Future bus transport contracts under a mobility as a service (maas) regime in the digital age: Are they likely to change? Transportation Research Part A: Policy and Practice* 98:86–96, URL `http://dx.doi.org/10.1016/j.tra.2017.02.006`.

Koh K, Ng C, Pan D, Mak KS, 2018 *Dynamic bus routing: A study on the viability of on-demand high-capacity ridesharing as an alternative to fixed-route buses in singapore. 2018 21st International Conference on Intelligent Transportation Systems (ITSC)*, 34–40, URL `http://dx.doi.org/10.1109/ITSC.2018.8569834`.

Schechtner K, Hanson M, 2017 *Shared Mobility in Asian Megacities: The Rise of the Apps*, 77–88 (Cham: Springer International Publishing), ISBN 978-3-319-51602-8, URL `http://dx.doi.org/10.1007/978-3-319-51602-8_5`.

Speranza MG, 2018 *Trends in transportation and logistics. European Journal of Operational Research* 264(3):830–836, URL `http://dx.doi.org/10.1016/j.ejor.2016.08.032`.

Talluri KT, Van Ryzin GJ, 2006 *The theory and practice of revenue management*, volume 68 (Springer Science & Business Media), ISBN 0387273913.

Zhao M, Yin J, An S, Wang J, Feng D, 2018 *Ridesharing problem with flexible pickup and delivery locations for app-based transportation service: Mathematical modeling and decomposition methods. Journal of Advanced Transportation* 2018.