붙임2

연구논문/작품 중간보고서

2023학년도 제 2학기

제목	Factors guaranteeing QoS in shared bus scheduling	○ 논문(　　) 작품(v) ※해당란 체크
GitHub URL	https://github.com/jwl317/2020thesis	
평가등급	지도교수 수정보완 사항	팀원 명단
A, B, F중 택1 (지도교수가 부여)	○ ○ ○	이재원 (인 이재원) (학번: 2015314213)

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지도교수 : 정 재 훈 　서명

1. Abstract

A shared bus can serve groups of passengers from different pick-up locations to drop-off locations. Previous research papers tried to provide algorithms for the most efficient and fastest path from the perspective of public transportation with minimum travel time, travel distance and energy cost. Greedy algorithm is one of the known algorithms to solve the Traveling Salesman Problem (TSP) in polynomial time. Meanwhile, the COVID-19 pandemic has changed the travel behavior, for instance, avoiding crowded buses at peak hours. This project will experiment three Quality of Service (QoS) factors that can affect the travelling time of passengers, particularly the number of buses running, the number of passengers taking the bus at once and the number of waiting passengers in bus stops. In this project, the Simulation of Urban Mobility (SUMO) program is used to test the relationship between each QoS factor and the average travelling time of passengers taking buses based on the greedy alrogithm.

2. Introduction

The COVID-19 pandemic has changed the travel behavior of people all around the world. Taking public transportation, including buses, carried the risk of transmitting the virus from passengers to passengers. 53% of survey respondents from [1] agreed that the knowledge of COVID-19 severity affected their decision on riding buses. Furthermore, low ridership and government restrictions led to a reduce in buses running and an increase in bus fares.

As of today, we are living in the post-pendemic world, however, the passenger perception of COVID-19 risk and other viruses still exist. It is natural that the perception affects the ridership of passengers in shared buses.

Shared bus scheduling problem is an evolutionary TSP that solves the most efficient path that serves many passengers from different origins to different destinations. Shared buses are different from existing ride-sharing systems. Notably, shared buses have a centralized system, while exisitng ride-sharing systems like Uber have a distributed system.

Travel time, travel distance and energy cost are main factors in measuring the performance of any proposed scheduling algorithms. Previous research papers have been scaled too much into computational efficiency in perspective of vehicles and possibly ruled out QoS in perspective of the passengers. For example, the QoS factors can include the number of buses running per route, the number of passengers taking the bus at once and the number of waiting passengers in bus stops. Shared bus scheduling is currently an open field. Therefore, it is meaningful to find a relationship between the passenger QoS factors and the passenger travelling time.

In this project, the performance of passenger QoS factors will be tested based on the greedy alrogithm and a simulation program is used to check and record the performance. The Simulation of Urban Mobility program, also known as SUMO, is a program that allows implementation of pedestrain, vehicle and other public transportation activities and experiments via simulations. In this project's simulation, the vehicle is defined as a bus, stopping at different bus stops on a predefined and created bus route. The bus drives on the road network that consists of a round trip 2-lane road in a 2x2 grid. Traffic lights are located on the road, and buses start from the same staring point and visit bus stops according to the bus route. Passengers start walking from the same starting point, for example from a company building, to different bus stops, ride buses and arrive at their destinated bus stops.

3. Related work

In such mobility-on-demand field, solving the shared bus scheduling problem is challenging because it is a NP-hard problem.

Existing strategies usually follow pruning and selecting scheme. For instance, like *Figure 1*, road network space is divided into cells. Buses can be located at any cells and their locations are dynamically recorded. If there is a request for a pick-up, buses nearby cells of source location will be first ones to be examined. In the pruning stage, buses that cannot satisfy the constraints of requests will be filtered out. Then most ideal buses are selected, and requests are added to their path. Xu et al. [5] propose more advanced algorithm GeoPrune that specifically focuses on "finding vehicles that satisfy the service constraints of trip requests rather than any particular optimization goal."

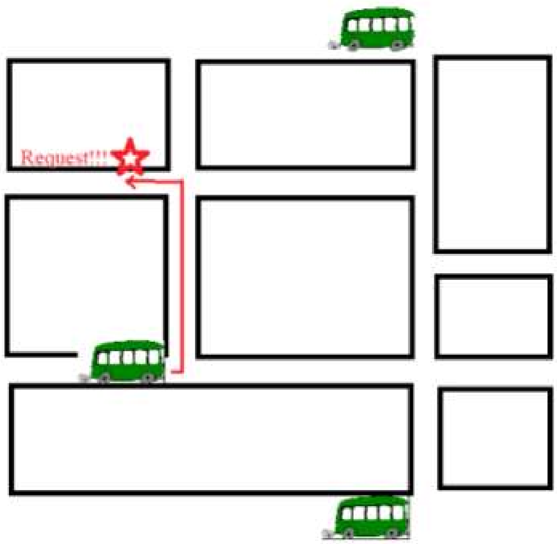

Figure 1. Self-drawn simple illustration showing shared buses driving in a road network space and nearest bus to the request source location being assigned.

Some papers are restricted to high-capacity ride sharing on large road networks. Zuo et al. propose a "clustering-based multi-request matching and route planning algorithm Roo" without computing distances between nodes in advance [7]. In particular, Mahin and Hashem propose an Activity-aware Ridesharing Group Trip Planning (ARGTP) query on large road networks, but multiple point-of-interests (POIs) are pre-defined and used [4]. However, all the above strategies cannot be applied in the real-world scenario where distances and points can be changed in any given time, for instance, due to road repairing.

Less research works focus on QoS. To reduce the total cost, Liu et al. propose Cooperative Intelligent Transport Systems (C-ITS) to minimize the total cost of Public Vehicle (PV) utilization on long distances [3]. C-ITS consists of path generation methods using simple near optimal method and reset near optimal method. C-ITS also involves greedy based path scheduling method. On the other hand, Zhu et al. suggest short waiting time and less detour can be factors that provide high passenger QoS [6]. Additionally, few PVs in a network can save travel distance at traffic peak time, but that means more passengers have to share PVs in limited space. Therefore, the number of PVs in the network can affect the level of passenger QoS.

In summary, majority of heuristic solutions for shared bus scheduling problem are related to greedy algorithm. And they are scaled to reduce the computational complexity and the total cost of bus utilization rather than enhancing passenger QoS. In this project, it is meaningful to investigate the relationship between the passenger QoS factors and their average travelling time, so passengers can make better choice in transportation in post-pandemic era.

4. Project architecture

The simulation in this project manages people that walk to randomly assigned bus stops and arrive at randomly assigned destinations by a single-ride bus. The behavior can be customized by defining the stages in ride and walk. Each person’s total travelling time is recorded by adding walking duration from the starting point to a bus station, waiting duration, boarding duration, and riding duration of the bus to the destinated bus stop. Then, the average travelling time will be calculated.

The simulation runs on SUMO which allows to work on the road network involving passengers who can walk and take a ride on public transport. TraCI, short for Traffic Control Interface, is a python library that allows users to define, retrieve values of objects, like passengers and buses, controltheir behavior dynamically and record the generated logs.

In the simulation, the road network is made of edges, nodes, lanes and bus stops. Each edge is formed by lanes. Edges are connected by nodes. Like *Figure 2* and *Figure 3*, the network is a 2x2 grid shape and each edge is composed of 2 round-trip lanes with a sidewalk on the right outer-most side on each direction. The bus can go straight, turn left and turn right following the traffic light. All nodes have a traffic light.

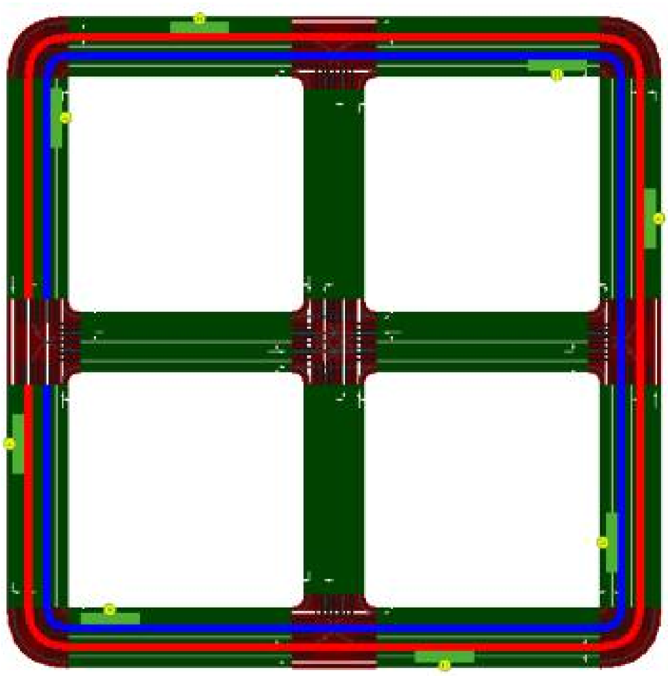

Figure 2. Sample simulation road network in 2x2 grid shape.

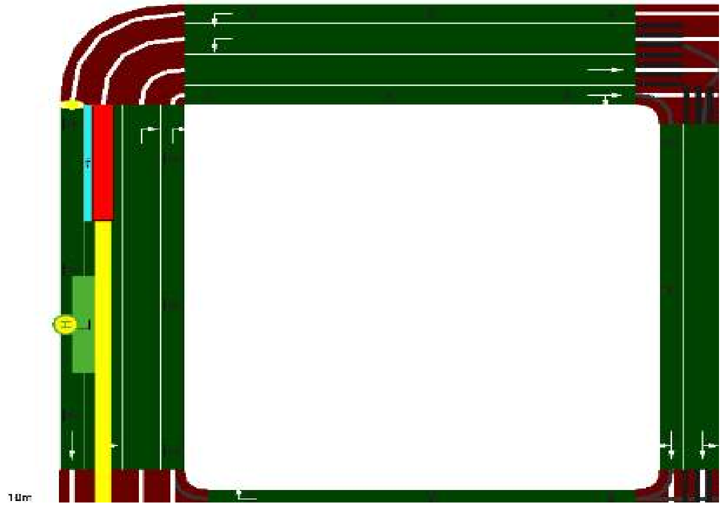

Figure 3. Creating personFlow and vehicleFlow using Netedit. Person will walk to the bus stop and ride on the bus.

5. Experiment hypothesis

Firstly, if more buses are running on the same route at a time, the passenger's average travelling time will decrease because the passengers will ride on the bus after short waiting time. Thus, it supports the increase in passenger's QoS level. Secondly, if maximum passenger capacity in each bus increases, then more passengers will get to ride the bus at once with lesser waiting time at the bus stops. Therefore. it supports the increase in passenger's QoS level, too. Last but not least, if more and more passengers arrive at the bus stop and wait for the bus, then both waiting time and average travelling time will eventually increase because of limited passenger capacity allowed to take the bus. For this reason, passenger's QoS level will decrease.

6. Comment and Future Work

The setup for experiment is still on-going. It is still a challenging issue to implement how to randomly assign source and destinations of different stages, like walk and ride, for each person using TraCI. The road network will be further developed into a 4x4 grid shape and possibly with multiple bus routes in the future.

7. References

[1] Amin, S., & Adah, J. U. (2022). COVID-19 influence on commuters' attitude towards riding public buses for essential trips. *Cities*, *131*, 103890.

[2] Kwon, J., & Jeong, J. (2022, October). A Parcel Delivery Scheduling Scheme in Road Networks. In *2022 13th International Conference on Information and Communication Technology Convergence (ICTC)* (pp. 1750-1755). IEEE.

[3] Liu, Ji, et al. "Two-Phase Scheduling for Efficient Vehicle Sharing." *IEEE Transactions on Intelligent Transportation Systems* (2020).

[4] Mahin, Mehnaz Tabassum, and Tanzima Hashem. "Activity-aware Ridesharing Group Trip Planning Queries for Flexible POIs." *ACM Transactions on Spatial Algorithms and Systems (TSAS)* 5.3 (2019): 1-41.

[5] Xu, Yixin, et al. "GeoPrune: Efficiently Matching Trips in Ride-sharing Through Geometric Properties." *32nd International Conference on Scientific and Statistical Database Management.* 2020

[6] Zhu, Ming, Xiao-Yang Liu, and Xiaodong Wang. "An online ride-sharing pathplanning strategy for public vehicle systems." *IEEE Transactions on Intelligent Transportation Systems* 20.2 (2018): 616-627.

[7] Zuo, H., Cao, B., Zhao, Y., Shen, B., Zheng, W., & Huang, Y. (2021). High-capacity ride-sharing via shortest path clustering on large road networks. *The Journal of Supercomputing*, *77*(4), 4081-4106.