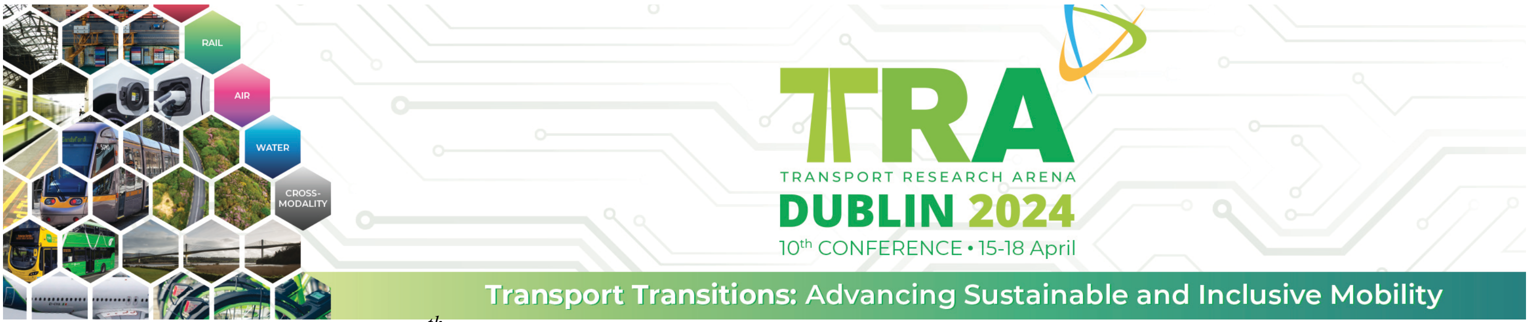


*10th Transport Research Arena, TRA 2024, Dublin, Ireland*

# Reducing Possible Harassment during Taxi Rides by achieving Safety and Stability

Martin Aleksandrov[a]

*[a]Freie Universität Berlin, Arnimallee 7, 14195 Berlin, Germany*
*martin.aleksandrov@fu-berlin.de*

## Introduction

Harassment in public transport occurs quite often. For example, a recent study shows that almost 10% of commuters from other ethnicities across Singapore experience racial discrimination on public transport every second ride [1]. In response, victims may prefer private transport such as taxis. Although taxis are considered safer, there has been an increasing number of harassment cases there as well [2]. This harms the inclusiveness of people for which taxis is the only means of travel such as those with disabilities. So, we ask: *how might we reduce passenger harassment in taxis?*

## Our approach

Without being able to track harassment, we cannot fight it. However, according to the existing approach, taxi companies are unaware of and, therefore, cannot track passenger harassment (Figure 1 (left)). In response, we propose a novel approach, according to which they can do so (Figure 1 (right)).

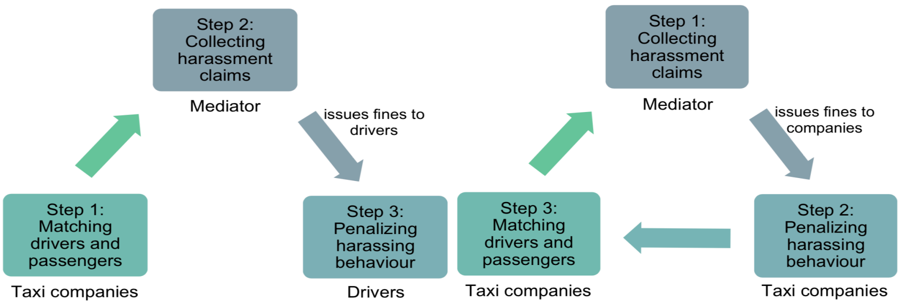


*Figure 1: Existing approach (left) and proposed approach (right) for fighting passenger harassment during taxi rides. Example of a Mediator is the Taxi and Limousine Commission in New York City.*

We have built a two-sided market model where passengers have (1) safety, (2) delay, and (3) type preferences, over drivers (Figure 2 (left)). Safety is based on their past experiences. Delays are based on when they want to depart. Types are based on gender, race, age, culture, etc. Thus, we propose a 2-phase method for reducing possibly the chance of commiting harassment by firstly maximizing their **safety** (Phase 1) and secondly optimizing **stability** (Phase 2) when matching passengers and drivers (Figure 2 (right)).

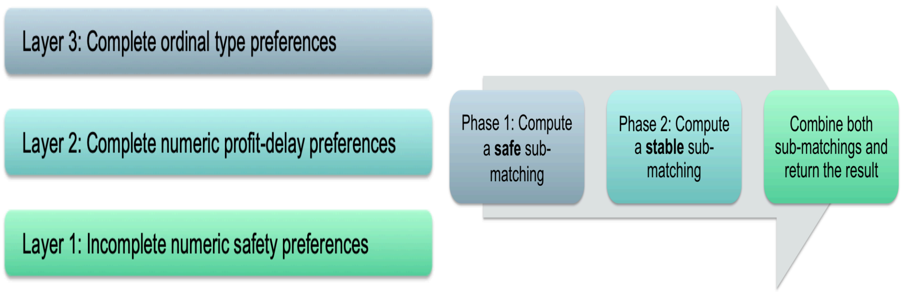


*Figure 2: (left) The proposed model with three preference layers; (right) The proposed two-phase matching method.*

## Our findings

We study achieving safety and stability in combination with profit efficiency (i.e. maximizing the total profit) and delay efficiency (i.e. minimizing the total delay). In Phase 1, we show that matchings that are safe and efficient can be computed by generalizing carefully the popular Hungarian method [3]. However, after Phase 1, some passengers might remain unmatched due to fact that the safety preferences are incomplete.

In Phase 2, we study computing matchings that are stable for the unmatched passengers on layers two and three. With one type (e.g. ``pink" taxis [4]), we achieve this by greedily selecting an unmatched passenger that delivers the greatest profit to an unmatched driver and letting the passenger select the driver nearest to them. With one depot (e.g. taxi queues), we achieve this by running a version of the well-known Gale-Shapley algorithm [5], where passengers pick drivers according to their preferred types. Table 1 contains these results.

| Case: properties of the computed matching | Phase 1 (Multiple types and multiple depots): safety on layer 1 | Phase 2 (One type and multiple depots): stability on layers 2 and 3 | Phase 2 (Multiple depots and one type): stability on layers 2 and 3 |
|---|---|---|---|
| Time complexity | $O(\max(n,m)^3)$ | $O(\max(n,m).n.m)$ | $O(\max(n,m)^2)$ |

*Table 1: The worst-case running times for computing safe matchings in the general case and stable matchings in two practical cases.*

With more than one (gender) type (e.g. men and women) and more than one depot (e.g. airport and taxi hub), some instances do not admit matchings that are stable on layers two and three [6]. For this reason, we designed two novel algorithms (i.e.RunGS3Count2 and RunGS2Count3) and compared them empirically in terms of efficiency (Figure 3 (left)) and stability (Figure 3 (right)).

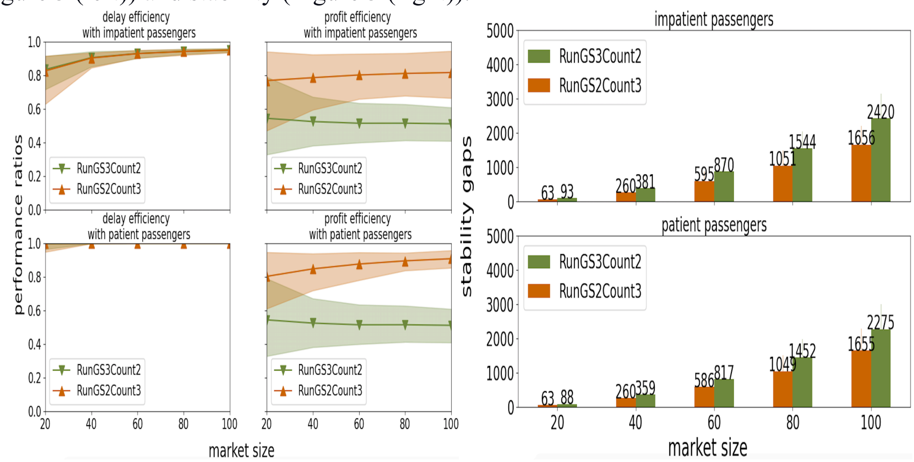


*Figure 3: (left) efficiency of RunGS3Count2 and RunGS2Count3; (right) stability of RunGS3Count2 and RunGS2Count3.*

RunGS2Count3 returns more efficient matching that may be unstable on layer three whereas RunGS3Count2 returns less efficient matching that is guaranteed to be stable on layer three. Essentially, this means that RunGS2Count3 may induce a greater chance of harassment whereas RunGS3Count2 may induce a lower chance of harassment. In the full paper, we will provide all missing details about our contribution.

## References

[1] Share of respondents of other ethnicities who felt racially discriminated against when in public transport in Singapore as of January 2019, URL: https://www.statista.com/statistics/1045504/singapore-discrimination-when-using-public-transport-respondents-other-ethnicities/
[2] Fileborn, B., Cama, E., Young, A.: Perceptions of safety among taxi and rideshare service patrons: Gender, safekeeping, and responsibilization. International Journal for Crime, Justice and Social Democracy 11(4), 40 (2022), URL: https://www.crimejusticejournal.com/article/view/2085
[3] Kuhn, H.W.: The Hungarian Method for the Assignment Problem. Naval Research Logistics Quarterly 2(1–2), 83–97 (March 1955), DOI: https://doi.org/10.1002/nav.3800020109
[4] Dunckel-Graglia, A.: Women-only transportation: How "pink" public transportation changes public perception of women's mobility. Journal of Public Transportation 16(2), 5 (2013), URL: https://digitalcommons.usf.edu/jpt/vol16/iss2/5/
[5] Gale, D., Shapley, L.S.: College admissions and the stability of marriage. The American Math. Mon. 69(1), 9–15 (1962), URL: https://www.jstor.org/stable/2312726
[6] Chen, J., Niedermeier, R., Skowron, P.: Stable marriage with multi-modal preferences. In: Proceedings of the 2018 ACM Conference on Economics and Computation. pp. 269–286. EC '18, Association for Computing Machinery, New York, NY, USA (2018), DOI: https://doi.org/10.1145/3219166.3219168

*Keywords:* Transport safety (1.1); Future workforce and skills (1.2); People-centered and inclusive transport (1.3); Transport policy (1.4).