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Procedia Computer Science 83 (2016) 163 – 170

Procedia Computer Science

The 7th International Conference on Ambient Systems, Networks and Technologies (ANT 2016)

Taxi dispatching and stable marriage

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Abstract

This study explores the challenge of the dynamic dispatching of taxis to the immediate passenger booking requests. In particular, the study leverages on a stable marriage assignment algorithm and applies it for dispatching taxis to passengers. The stable marriage algorithm was developed initially for matching men and women according to their preferences in polynomial time. The results of the custom built simulation model show that the taxi dispatching strategy based on the stable marriage matching improves the taxi operation performance in all observed indicators (taxi profit, number of served passengers, not-occupied and total taxi mileage and passenger waiting time) as compared to the standard first-come, first-served strategy.

Peer-review under responsibility of the Conference Program Chairs

Keywords: Real-time taxi dispatching; Stable marriage assignment algorithm; Taxi; Vehicle routing; Simulation model

1. Introduction

This study focuses on the challenge of dispatching taxis to immediate passengers booking requests. Traditionally, new booking requests are assigned to taxis sequentially on a first-come, first-served (FCFS) principle, with the nearest available taxi dispatched in response to each new passenger booking request. This vis-à-vis assignment is straightforward and easy to implement but may produce unsatisfactory assignment of taxis to passengers, as illustrated in Fig. 1 as follows.

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Peer-review under responsibility of the Conference Program Chairs
doi:10.1016/j.procs.2016.04.112

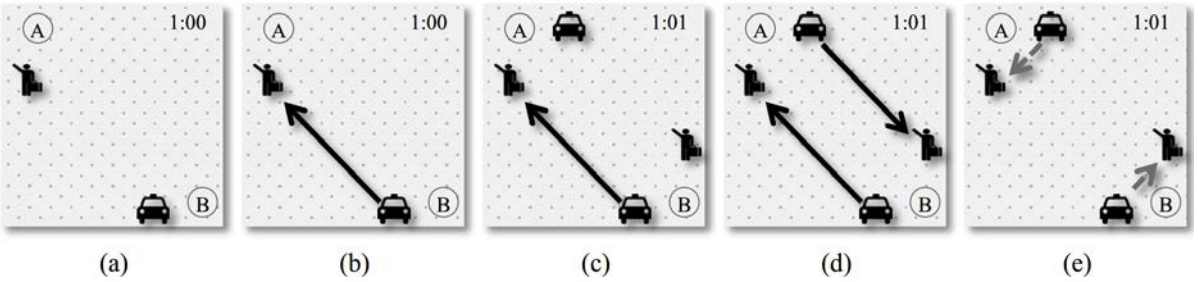

Fig. 1. (a-e) Illustration of sequential dispatching strategy drawback and improvement potential by simultaneous assignment of requests.

Supposing that a passenger at position A requests a taxi (Fig. 1.a), the nearest available taxi is at position B and is assigned to pick up the passenger (Fig. 1.b). A second passenger requests a taxi to transport him from position B (Fig. 1.c). Now the nearest available taxi is at position A. Consequently, both taxis have long drives - in the opposite direction along the same route - to pick up their passengers (Fig. 1.d) and both passengers wait longer than necessary. They would benefit from exchanging their assignments (Fig. 1.e).

This study investigates the application of a promising matching strategy based on stable marriage algorithm for taxi dispatching and discusses trade-offs of this dispatching strategy for taxi fleet operations. The following considerations are used to formalize this problem.

2. Problem formalization and assumptions

The taxi dispatching problem can be considered as an extended form of a Vehicle Routing Problem (VRP). The classical VRP by Dantzig and Ramser asks "What is the optimal set of routes for a fleet of vehicles to traverse in order to deliver to a given set of customers?"[1] The classical problem assumes that customers, fleet size and vehicle capacities are known upfront. Further, it requires the vehicles to begin and end in a central depot, to fulfil all the customer demands, not to violate vehicle capacity constraints and predetermined maximal route length. The overall objective is to minimize the total cost of the routes.

The taxi dispatching problem asks: “Which taxi should be dispatched to which passenger booking request?” The taxi operator either accepts or rejects booking requests if there are not enough taxis available. Once confirmed, the booked trip must be served. This is how the dispatching problem differs from the classical vehicle routing problem.

Furthermore, it is assumed that passengers desire to be transported from origin to destination as soon as possible from the time they make a booking request. Therefore, the requests are immediate and the degree of dynamism equals one.[2] The requests cannot be postponed, unlike for example in the study by Angelelli et al.[3] Moreover, passengers are not willing to share a taxi with anyone else and are only willing to wait for taxis for a limited amount of time. Taxis do not originate and end in one depot, but are geographically distributed at locations where shifts begin. Thus, the dispatching problem could be called: MDMVCDVRPPDTWDCR - Multi Depot Multiple Vehicle Capacitated Dynamic Vehicle Routing Problem with Pickup and Delivery Time Windows and Deniable Customer Requests.

The taxi dispatching problem has been studied from two major viewpoints in the taxi research literature: Rule-based sequential taxi dispatching (first-come, first-served, one-by-one) and simultaneous taxi dispatching (concurrent assignment of taxis to passenger booking requests.

Most of the initial research focused on the rule-based dispatching rules. In one of the first studies, Bailey and Clark[4] investigated efficiency of basic taxi dispatch rules: (1) closest free taxi, (2) closest occupied taxi or (3) the taxi that is free the longest. Following research investigated details of these rule based first-come, first-served assignments such as: whether it is more suitable to assign the geographically nearest taxi Jianxin et al.[5], Chang & Wu[6] and Grau et al.[7] or the taxi which can reach the passenger the fastest Lee & Wu[8], whether to consider real time traffic[9] or whether to use fuzzy logic[10] or alter the rule based strategies if there are more requests than taxis or vice versa[11].