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Simulation and Evaluation of a Public Transport Priority Methodology

Malandraki G.[a]*, Papamichail I.[a], Papageorgiou M.[a], Dinopoulou V.[b]

[a]*Dynamic Systems and Simulation Laboratory, School of Production Engineering and Management, Technical University of Crete, 73100 Chania, Greece*

[b]*Department of Mechanical and Industrial Design Engineering, Technological Education Institute (TEI) of West Macedonia, Koila, Kozani 50100, Greece*

Abstract

The development of methodologies for bus priority at traffic signals is a research field that continues to grow since the need to improve public transport (PT) is nowadays higher compared to the previous decades. Several ways have been used to attract people to use PT means. These attempts can be distinguished in two basic categories: facility-design-based measures and signal-control-based measures. In this paper, a signal-control-based methodology is presented and implemented in a microscopic simulation environment emulating the network of Chania, Greece, with realistic traffic conditions. The control objective is to minimize the average delay time for the buses without creating major disturbances to the rest of the network. For this reason, apart from a fixed-time strategy combined with public transport priority (PTP), the traffic-responsive urban control (TUC) strategy with PTP is implemented in order to reduce the delays also for the private vehicles as well.

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Keywords: signal control; public transport priority; traffic-responsive urban control

1. Introduction

The majority of the urban road networks face serious traffic problems, which are the result of the ever growing population in the cities combined with aged road networks. Since such a development was not expected in many cities during the construction of the network, many factors have not been taken into account, e.g. sufficient parking

* Corresponding name: Malandraki Garyfalia. Tel.: +30-28210-37421
E-mail address: gamalandraki@dssl.tuc.gr

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space or space for exclusive bus lanes. As a consequence, the most serious problems that are noticed are traffic congestion, increased travel time of private and public vehicles and air pollution. One approach that could be used to mitigate, at least up to a level, some of the above problems is the frequent use of public transport (PT) means. However, this calls for an improvement of PT services, since, frequently, the travel time of PT vehicles, and especially of buses, is much longer than the one of private vehicles. The main reason for the high travel times experienced by buses is that they face significant delays at each bus stop, for boarding and alighting. Additionally, buses have to follow indirect routes. Since these factors cannot be controlled, the aim of the researchers is to favour the movement of PT vehicles compared to private cars at signalized junctions.

To achieve this, a series of priority strategies have been developed in the last decades that aim to change the signal plan locally so as to serve a passing PT vehicle as soon as possible. The measures that are used to improve PT vehicle performance are divided into two general categories, the facility-design-based and the signal-control-based measures (Dinopoulou et al., 2013b). The second category includes real time methodologies which are rule-based or optimisation-based and they gain more the interest of the researchers. For vehicles behind schedule, Kim et al. (2005), Li et al. (2005), Liao et al. (2008) and Liao and Davis (2011) proposed rule-based public transport priority (PTP) strategies, which provide priority via green extension or stage recall for late buses, based on their estimated arrival time. Kuang and Xu (2012) and Lin et al. (2013) developed a rule-based PTP strategy aiming to reduce the total passenger waiting time by allowing changes of stage sequence and green extensions. A more detailed literature review is reported by Dinopoulou et al. (2013b).

This paper presents and evaluates a local real-time reactive rule-based PTP methodology (Diakaki et al. 2003). Specifically, PTP is executed in real time to provide priority, if needed, at signalized junctions so that the PT vehicle delays due to the red light are reduced. The priority is given by changing the signal settings locally, but without affecting the rules of road safety. In case of more than one priority requests at the same junction and within the same period, a first-come-first-served policy is applied, unless a subsequent request is served by the same stage, in which case it is prioritised only by green extension. It is also important to verify that the strategy will not create major disturbances to the rest of the network. For this reason, two signal control scenarios are considered and compared: first, the traffic signals are controlled with a fixed-time plan; second, the traffic-responsive urban control (TUC) strategy (Diakaki et al. 2003) with PTP is also implemented in order to assess potential improvements in network capacity and overall delay time.

The methodology is implemented in a microscopic simulation environment emulating the urban network of Chania, Greece, using realistic traffic conditions; only one bus lane is considered, which excludes priority conflicts for buses being served at different stages. The results are evaluated based on three criteria: the average delay, the harmonic speed and the total travel time (TTT). In lack of space for a dedicated bus lane, the PT vehicles are moving in mixed-traffic lanes and the detection of a PT vehicle is done by special bus detectors that are located on the corresponding links, sufficiently upstream of the stop-line, at each signalized junction where priority is considered. The microscopic simulator AIMSUN (TTS, 2013) is used and several scenarios are studied to compare different options and assess the strategy's effectiveness for different cases.

This paper is organized as follows: Section 2 presents the investigated priority methodology and the TUC strategy. Section 3 illustrates the urban network of Chania and reports the different scenarios studied and the results achieved. Finally, conclusions are presented in Section 4.

2. Background

2.1. PTP methodology

The investigated PTP methodology, which is described in more detail by Dinopoulou et al. (2013a), is a real-time, reactive, rule-based priority strategy and includes two priority options:

Option 1: The cycle time of each junction must remain unchanged, and priority is provided by either green extension or red interruption. The stage sequence is not modified and the PT vehicle's green time is extended, if it is necessary, only by reducing the other phases down to the permitted respective minimum times.