Available online at www.sciencedirect.com
ScienceDirect
Engineering Applications of Artificial Intelligence 21 (2008) 419–429
Engineering Applications of ARTIFICIAL INTELLIGENCE
www.elsevier.com/locate/engappai

Distributed decision evaluation model in public transportation systems

Imen Boudali[a,*], Inès Ben Jaafar[a], Khaled Ghedira[b]

[a] *Institut Supérieur de Gestion, Cité Bouchoucha, Le Bardo 2000 Tunis, Tunisie*
[b] *ENSI, Campus Universitaire, de Mannouba, 2010 Tunis, Tunisie*

Received 5 November 2006; received in revised form 19 February 2007; accepted 15 May 2007
Available online 20 July 2007

Abstract

Due to several external and internal disturbances affecting public transportation systems, some regulation measures have to be undertaken. In the regulation process, the regulator has to evaluate a number of possible decisions in order to determine best compromise of some regulation criteria. The complexity of this task increases when numerous disturbances appear simultaneously and mainly when regulation criteria are contradictory. For these reasons, we propose in this paper a multi-agent model that deals with decision evaluation step as a multicriteria optimization problem. In this model, the best compromise is determined by means of the following concepts: Pareto optimality, *a*-efficiency and plurality voting. The process of the proposed approach is shown through an illustrative example.

Keywords: Public transportation systems; Traffic regulation; Multicriteria optimization; Multi-agent systems; Pareto optimality; *a*-efficiency; Plurality voting

1. Introduction

These last years, the public transportation sector has become a highly competitive market. This is essentially due on one hand to the increasing density of population in urban areas, and on the other hand to the proliferation of transportation networks. Thus, transportation companies have to improve their service quality in order to remain competitive. For these reasons, many research works aiming to develop efficient techniques and tools have been carried out (Balbo and Pinson, 2005; Crainic and Florian, 2005; Fay, 2000).

The role of these tools is to assist transportation managers in their traffic management tasks. In fact, two great problems are related to the management of transportation systems, traffic planning and traffic regulation.

The traffic planning consists in establishing a theoretical vehicle scheduling on the base of a predictive study of traffic conditions, whereas the traffic regulation consists in a real-time adaptation of theoretical schedules to traffic real conditions through some regulation measures. The objective of traffic regulation is to overcome disturbances that can occur in real time in the network.

The disturbances that could happen, like traffic jams, accidents, vehicle breakdown, are caused by random and complex influences affecting the network.

In order to avoid the deterioration in service quality, these disturbances have to be managed as soon as possible by undertaking efficient operational decisions. However, when the number of possible decisions for a given disturbance is increasing, the choice of an efficient one according to several regulation criteria becomes a hard task that the regulator cannot support in few moments.

The complexity of this task increases when simultaneous disturbances appear and especially, when regulation criteria are contradictory. Consequently, the decision evaluation problem can be considered as a multi-criteria optimization one (Collette and Siarry, 2002; Boudali et al., 2006).

In order to help the regulator in decision evaluation step, we propose in this paper a distributed model based on

*Corresponding author.
E-mail addresses: imen.boudali@isg.rnu.tn (I. Boudali), ines.benjaafar@isg.rnu.tn (I. Ben Jaafar), khaled.ghedira@isg.rnu.tn (K. Ghedira).

0952-1976/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engappai.2007.05.007

multi-agent approach. This model deals with this step as a multi-criteria optimization problem. It consists in determining the best compromise decision for a detected disturbance, given a number of criteria to be optimized. Thus, it offers the regulator the necessary facilities to undertake the best decision as soon as possible. The agents of the proposed model apply cooperatively the concepts of Pareto optimality, a-efficiency and plurality voting in order to ensure determining the best solution among others.

The remainder of this paper is organized as follows. In Section 2, the traffic management framework (traffic planning process, traffic regulation process, regulation criteria, and decision classes) is described in detail on the base of regulator experience in the French transportation company SEMURVAL. Then, in Section 3, we outline some previous works dealing with decision evaluation phase in traffic regulation. Section 4 deals with the proposed multi-agent model. The organizational aspects of this model as well as the associated solving process are presented in this section. Then, the solving process is illustrated through a practical example in Section 5. Finally, we conclude with some remarks and future works.

2. Traffic management

Two great problems are related to the management of public transportation systems which are traffic planning and traffic regulation. In this section, we firstly present the planning process. Then, we discuss the necessity of regulation process in real time. The regulation criteria and decision classes considered in the regulation process are also presented in this section. Let us notice that our study is based on regulator experience in the SEMURVAL Company.

2.1. Traffic planning process

The traffic planning consists in establishing a theoretical vehicle scheduling on the base of a predictive study of traffic conditions, transport demand, travel times and resources availability (human resources and vehicle availability) (Crainic and Florian, 2005; Deb and Chakroborty, 1998; Isaai and Singh, 2000; Mellouli and Suhl, 1999).

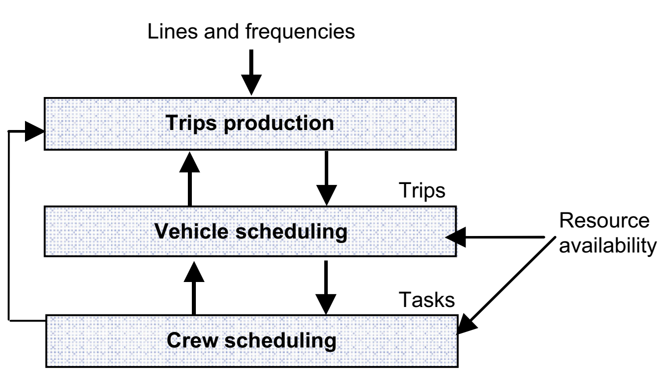

Fig. 1. Steps of the planning process.

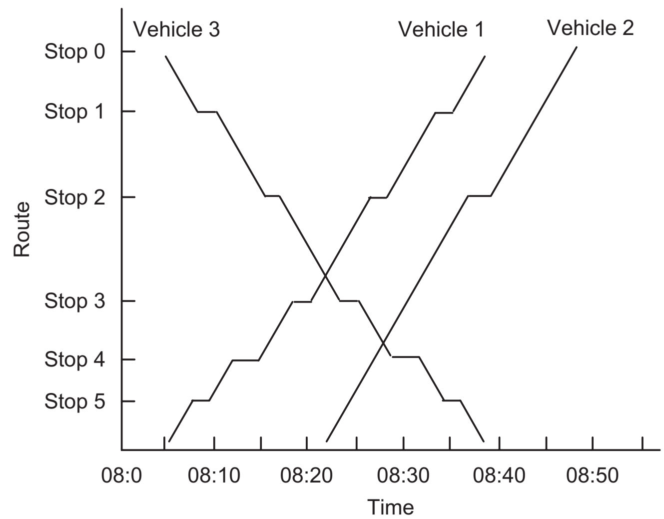

Fig. 2. Vehicle schedules graph.

This process is defined mainly by three steps as shown in Fig. 1.

In the first one, a number of trips are generated given the set of lines in the network and the necessary frequencies. In the second step, the resulting trips are then transformed into blocks and assigned to vehicles.

Finally, a crew scheduling is performed given human resources available in the company.

At the end of this process, we obtain a set of timetables describing vehicle trips according to lines, frequencies, transport demand and travel times in the network.

These timetables are named theoretical or predictive timetables. Another set resulting from this process is the set of service lists defined for the staff.

The timetables related to vehicles are usually represented by a time-route graph as illustrated in Fig. 2.

This process shows the complexity of planning task, essentially in multi-modal network characterized by the presence of more than one transportation mode.

2.2. Traffic regulation process

In the daily activity of public transportation systems, travel times and transport demand are not fixed due to random internal and external influences that may affect the traffic and cause some disturbances (traffic jams, accidents, strikes, etc).

So, in real conditions, with the dynamic character of transport environment, it is difficult to respect exactly theoretical timetables resulting from the planning process. These disturbances result either in a delay or in an advance of schedules of the concerned vehicles.

Hence, punctuality of vehicles, regularity of time interval between two successive passages of vehicles and especially connections are affected. In order to reduce the effect of disturbances, a reactive scheduling of vehicles through a regulation process is immediately required.