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Conflict resolution measures for connection dispatching

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ABSTRACT

In this paper we present conflict resolution measures in connection dispatching suitable for railway transportation companies without having full access to relevant data. The presented measures do not only cover classical waiting/non-waiting-strategies but also alternative dispatching measures if a distributor train cannot wait. The fact of unknown travel chains and insufficient data availability is respected. Different solutions for a connection conflict are generated depending on travel destinations.

Conflict resolution measures are divided into those that can be applied within the railway system and those that are outside the railway system. Each of the considered measures has been analysed by the use of a formalized procedure to get a structured prospect on background, impact, operability, compatibility and quantifying parameters. The procedure is explained by giving several examples. Finding conflict solutions, the focus is to achieve the highest possible completeness regarding potential solutions. At the same time, to reduce computing time, heuristic approaches are applied. The presented measures enable transportation companies to implement a system which calculates conflict resolution proposals to support the connection dispatching staff. This leads to a more automated, more transparent and more efficient dispatching process which results in more satisfied travellers.

1. Introduction

Connection conflicts are a common conflict situation in public transportation in general and in railway systems in particular. They have a high visibility outside the company due to the high affection of travellers. A connection loss often leads to huge discomfort and delays for the traveller.

So far, no systems exist which solve the connection dispatching problem sufficient and fast enough. Though tools to visualize connection conflicts and to transmit interchange wishes do exist, the task of conflict resolution is still completely under manual control of human dispatchers. They mainly base their decisions on a few input factors and their experience which may imply that important factors are disregarded. Also, dispatching effects on the complex railway system are difficult to predict for a human being. This might lead to non optimal solutions. In connection dispatching an additional problem is the huge amount of conflicts that often cannot be covered by the dispatcher and conflicts might remain undispatched.

The transportation company is responsible for the resolution of connection conflicts (in contrast to the infrastructure company which is maintaining the network). This implies that especially in railway operations not all relevant (infrastructural) data is accessible for the transportation company which hinders to find optimal solutions. Also, connection dispatching

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is an operative dispatching process which strictly limits the available time for solution computation. Therefore, a conflict resolution needs to compute results quickly.

As for a dispatcher of an infrastructural railway company the real-time solution of inter-train conflicts and reducing delays on the physical network is one of the main challenges, for the dispatcher of the transportation company connection conflicts are the main conflict type to be dealt with. In this paper we focus on conflict resolution techniques for connection dispatching as part of a modular dispatching system.

In the next chapter work related to this problem is outlined. The dispatching system is briefly described in Section 3 with a focus on the relevant parts for conflict resolution measures. The general approach of finding potential solutions in the system and the formal procedure to evaluate dispatching measures for connection dispatching is presented in Section 4 with subsections containing examples for applying the procedure to actual measures. In Section 5 a first approach how to select and apply suitable conflict resolution measures is drafted. All other dispatching measures will also be briefly explained here. Section 6 contains a conclusion and an outlook for further work.

2. Related work

The problem of connection dispatching has already been subject to many researchers. Suhl et al. (2001) created the term of *customer oriented dispatching*. The approach here is to optimize the travellers' delay assuming the travel chains are known. This approach is also used in many other publications as in Berger et al. (2011), Kurby (2012) or Schöbel (2001). Schöbel (2011) uses the term *delay management* to describe the problem solution of a waiting decision in connection dispatching using Integer Programming. While this model permits to take decisions under consideration of possible track occupation conflicts, it is limited to wait-depart and priority decisions and does not consider further dispatching measures. Anderegg et al. (2009) present deterministic polynomial-time optimal algorithms for waiting decisions assuming a cyclic schedule. Klemenz (2008), Klemenz and Radtke (2010) describe a method to reduce the overall travel time of passengers by optimizing connections during the planning phase. Infrastructural constraints are taken into consideration. Fay (2000) and Cheng and Yang (2009) use a rule based approach. The rules were derived from questioning dispatching staff. Fuzzy-logic is used to model diffuse or contradictory statements. Fay (1999) implemented a system also including connection dispatching based on the aforementioned approach. However, the system is designed for the infrastructure dispatcher and does not respect the separation of transportation and infrastructure company with their responsibilities for connection dispatching. Bär et al. (2006) and Kurby (2012) present a dispatching system which calculates the impact of a waiting decision on later connections. In their approach empirical data is used to forecast delays based on the current delay situation. The system is focused to solve track occupation conflicts but also decides about connection conflicts using waiting strategies. The connection dispatching part and the network dispatching part interact with each other. The connection dispatching part can be used as basis to calculate a value for a connection. Other representatives for solutions to track occupation conflicts (inter-train conflicts) are Şahin (1999), Törnquist (2007) and Oetting et al. (2013). D'Ariano and Pranzo (2009) present a dispatching system to resolve network conflicts for the infrastructure company. The system is modular. Liebchen et al. (2009) present a very formal and general mathematical way to describe dispatching problems and possible solutions.

The above mentioned dispatching support systems generally apply for the use in infrastructure companies to resolve network conflicts and reduce delays. Only Bär et al. (2006), Kurby (2012) take the transportation company's connection conflicts into account but limit the solution space to waiting strategies. Several of the mentioned approaches address the connection dispatching problem. In these approaches mostly none or only little alternative conflict resolution possibilities for connection conflicts apart from waiting/non-waiting strategies are covered. The solution space consists generally of planned vehicle runs which can be delayed.

In many approaches the travel chains as well as data about the (infrastructural) network are presumed to be known. Practically, the travel chain is generally known only for a part of travellers. Some companies have aggregated information about travel chains which remains fuzzy and therefore does not permit an exact optimization. Transportation companies also often do not have access to infrastructural data. Furthermore, many relevant input data for solution findings is not digitally recorded yet.

In practice the solution space consists of many more alternative conflict resolution possibilities (compared to simple waiting/not-waiting strategies) of which some will solve the conflict only partially. A part of them can be found within the railway system, others can be found outside the system. The different measures need to be combined. The difficulty here is, that the target function of the different conflict resolution measures cannot be summed up as each measure can affect multiple traveller sets which overlap. Furthermore, for many measures more than one applicable solution exist which all need to be examined.

3. Dispatching system

To face the problem of connection dispatching we propose a system which supports the dispatcher to find good solutions in connection dispatching. The system is designed for the transportation company and respects the separation of infrastructure and transport in railways as defined by law in the European Union (The Council of the European Communities, 1991; The European Parliament and the Council of the European Union, 2001; The European Parliament and the Council of the