INFORMATION EXCHANGE FOR CONNECTION DISPATCHING

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Summary: Travellers in public transport today expect current, precise and individual information. Existing systems have different approaches to provide this information. Most of them use proprietary exchange formats as existing standardized interfaces do not fulfil all needs. The German standardization project IP-KOM-OeV develops an interface that fulfils today's needs. Information can be provided to the traveller for various services. This paper focuses on a service which allows to inform the traveller about his connections but also to inform the transportation companies about the travellers' planned connections. The latter can have a direct impact on the operations when the connection demands are taken into consideration for the connection dispatching. We will present the results of the standardization project regarding the connection service and show how this service can be used by transportation companies to improve connection dispatching.

1. Introduction

A traveller today expects guided navigation comparable to those of individual (portable) navigation systems but adapted to a travel in public transport. However, passenger information in public transport is still very collective and little standardised. Existing standards do not cover current needs what leads to reduced functionality or proprietary solutions. The German standardisation project IP-KOM-OeV (IP-based communication in public transport), funded by the federal ministry of economy, aims to introduce a common standard for passenger information. Not only information towards the passenger is considered, also feedback possibilities for the traveller are included. Traveller as well as transportation companies can benefit from such an exchange of data.

Subsequently we will give an introduction to the standardisation project in the next chapter and show how to benefit from the standard exemplarily using the standard's connection services. For this we will give a short overview on connection dispatching in chapter 3. In chapter 4 the connection part of the Trias standard is explained more in detail. Possibilities of usage of the Trias connection service and possible benefits are explained in chapter 5.

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2. The Standardisation Project IP-KOM-OeV

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The traveller information today is presented in a collective way. The customer has to search actively for the information needed and he has to choose among the available channels. In contrast to the status quo, a passenger today expects individual, current and precise information. The information should be available before and during a travel. This information can be provided on different channels, the most individual and convenient for the customer is his own device. The German standardisation project IP-KOM-OeV creates a standard called Trias. It faces today's needs and provides interfaces which permit accurate and individual customer information. This standard leads to benefits for travellers, transportation companies and the industry. The latter benefit from a standardised environment as it enables modular architectures and thus allows a specialisation on core competences. Producers can rely on the standard and reduce risks for implementation and tendering. Transportation companies can modularly select products among the producers and reduce their costs for the information systems. Single parts can be replaced. Providers of information systems can use the standardised interfaces to provide information to their clients. Thus the traveller will benefit from better information. [1, 2]

The project consists of working groups with different focuses. The first working group creates a new standard to replace the more than twenty year old IBIS-standard (VDV300) [3, 4]. The new IBIS-IP standard [5] is based on IP-communication. Passenger information and other customer services will be integrated. Migration concepts and possible system architectures using SOA[3] are developed as well. The second working group created personas and analyses the requirements using selected scenarios [6, 7]. Furthermore, an exemplary implementation of a functional architecture for such a service platform is provided. The second working group is closely collaborating with the third working group which is defining services and a possible architecture for a Real-Time Communication and Information Platform (RTCS). The functional requirements for this use case were analysed and integrated into standardised interfaces to enable (third party) applications to gather online information of the current operational situation [8]. In the fourth working group a field test prototype using the Trias interfaces will be implemented to prove the functioning of the developed systems.

One of the developed and standardised services is dealing with connection demands and connection statuses. We will give a brief introduction to connections and connection dispatching in chapter 3 and explain the Trias connection services in chapter 4.

3. Connection Dispatching

As the networks in public transport grow more and more complex and there is a demand for door to door routing, most of the journeys today contain more than one means of transport and imply (intermodal) interchanges. A connection is hereby defined by a feeder train and its arrival station and a distributing train and its

3 Service-oriented architecture

departure station and an interchange time the traveller needs to change from the feeder to the distributor [9]. Unfortunately, due to disturbances in transport operations, often the connection is conflicted, for example by a delayed feeder train. Here, the transport operation centres need to take actions to find a solution that helps the traveller to reach his destination. These actions are summarized under the term connection dispatching. Several parameters have to be taken into consideration by the dispatcher, for example the total delays of the feeder or a possible delay of the distributor if the connection is secured and many more. A very important factor is also the amount of travellers who want to use a connection. If a connection is not commonly used, securing it by delaying the distributor will be a suboptimal solution. A significant amount of passengers in the distributor train have to wait for a few to reach their connection at risk of missing their interchange. This leads to the necessity to transmit the amount of travellers who have an interest in using a specific connection.

Today the possibility of reporting a connection demand is reduced to proprietary solutions, e.g. for train attendants of Deutsche Bahn. The information on connection demands is of essential character for implementing a good connection dispatching. Regarding other means of transport than far distance trains, the possibility of gathering this information today is low to non-existent. Because of this a standardised service which informs transportation companies about connection needs is highly valuable.

On the other hand it is necessary for the traveller to be informed about the status of his connections as soon as possible. Today the status of a connection which has not been dispatched (yet) is generally unknown and assumed to take place. It is the dispatchers' task to inform travellers about broken or secured connections aside from his general dispatching tasks. Lots of connection statuses are not transmitted to the traveller due to the lack of information systems which performs this task automatically, especially if no manual dispatching action is undertaken. Intermodal connection statuses are rarely transmitted although [9] offers possibilities to transmit information about a secured connection. Still the possibilities of [9] are limited regarding the information about a connection as defined above. The transmission of status information, also negative ones, raises the sense of security especially for inexperienced users in public transport. Therefore, the traveller feels well informed and taken care of.

4. The Trias Interface

In this section we will give a short overview of the Trias interface. More information about the IP-KOM-OeV project and also the Trias standard are available at [10]. The Trias standard includes parts of the well-known Siri standard [11] from the European Committee for Standardization. Siri is a widely adopted standard for the communication between large public transportation information systems or even between different companies. But due to the lack of many features it is not well suited for the communication between public transportation authorities and travellers. The Trias standard closes this gap by providing

- authentication,
- communication techniques for mobile devices,

- trip related information,
- traveller oriented notifications and
- broad filter possibilities to fit the transmitted information to the consumer.

4.1. Architecture

Figure 1 shows a schematic overview of one of the proposed architectures of IP-KOM-OeV. The Intermodal Transport Control System (ITCS) provides information about the current system state for the Real Time Communication and Information System (RTCS). The RTCS itself is connected to the public internet to provide information services for travellers. The Gateway is interfaced to the RTCS via Trias. There is no direct connection between the portable devices and the RTCS. This Gateway has the purpose to abstract from the specific portable device used by the traveller. This layer of abstraction is required because there are many limitations for portable devices in respect to the energy consumption, the connectivity and also the abilities of the operating system. The Gateway can handle all these limitations and specifics. For example the Gateway can use different Push-Services for the different smartphone operating systems. Standardizing those functionalities would not be sufficient because of rapidly changing technologies. The RTCS can be connected to many Gateways. The whole architecture allows provider specific Gateways which can be used to provide additional services for the traveller.

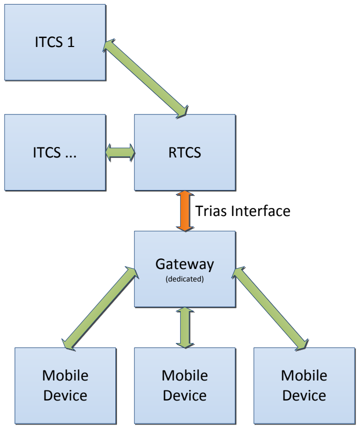

Figure 1: System concept of IP-KOM-OeV

4.2. Connection Services

The Trias interface supports Connection Demand Requests. A potential interchanger could send this kind of message to the RTCS to inform the dispatcher about the interchange request. The dispatcher then can use this knowledge to minimize the number of breaking connections in case of delays. Table 1shows the structure of such a request. Such requests could either be made directly by the mobile device of the traveller or by an attendant or other systems/platforms. If the attendant or system creates this request, there is a possibility to report multiple interchangers at once. The RTCS has also the possibility to inform the traveller about the status of their interchanges, also in case of a broken connection.

Table 1: The structure of a Connection Demand Request

<table>
<tr><td colspan="2">RequestId</td><td>The Identifier of the request can be used to change the Connection Demand later on.</td></tr>
<tr><td rowspan="3">alternative</td><td>DatedConnection</td><td>This field references a DatedConnection between two trains.</td></tr>
<tr><td>PickUpLocation</td><td>This field references a PickUpLocation at which the traveler is picked up by the transporting vehicle</td></tr>
<tr><td>SetDownLocation</td><td>This field is the SetDownLocation at which the traveler will leave the transporting vehicle.</td></tr>
<tr><td colspan="2">NumberOfPersons</td><td>The number of persons who want to interchange at the specified Location. Attendants and aggregating systems can report values greater than one.</td></tr>
<tr><td colspan="2">TravelProbability</td><td>The cumulated probability that the specified interchange happens.</td></tr>
<tr><td colspan="2">Extensions</td><td>This field is an extension point. New children could be added here on demand.</td></tr>
</table>

5. Possible Usages of the Connection Service

The first usage for the connection service is, of course, providing information on the number of interchanging travellers to the transportation operator. But the service is also relevant for transportation companies who want to inform their clients about the status of a connection. In the following sections we will explain both possibilities.

5.1. Customer Oriented Connection Demand

The introduction of the connection demand service permits the communication of connection needs or connection wishes – not only (but also) through train attendants and other transportation staff. With this new service, travellers, platforms that gain information from their clients, ticket sales, traffic models and other sources may be used to transfer data about connection needs. This information is gathered by the transportation company and processed such that the dispatcher is able to derive useful information for the dispatching process from it. Especially information which comes directly from the traveller is of a high value and can be considered as quite precise. If the connection demand service is widely implemented and used, an absence of a connection demand message can even lead to a relative certainty for the dispatcher that the conflicted connection will not be used and can be broken.

The service permits to attach different sources to the system. These sources are for example fare sales, traveller prediction models, connection demand requests given by attendants or even connection demands directly sent from the travellers' smartphone.

Those sources are probabilistic, which means that different sources contain most certainly overlapping information as the delivered connection demands are not disjoint. That leads to a necessity of creating a model for processing the gathered connection information. The model needs to represent the transportation company's handling of source, i.e. which source data has which influence to the connection dispatching.

5.2. Creating and Improving a Connection Model

The dispatcher requires precise information about the estimated number of travellers for each connection. This information is helpful whenever a dispatching decision is made to minimize the number of afflicted travellers whose interchanges break because of this decision. Each company will have its own particular sources for connection information and will process it following own principles. Nevertheless we will give an overview about general possibilities of dealing with the gathered information.

At this stage, models that predict passenger flows include information about interchanges of travellers. The newly gathered information about connection demands can be used to improve those models generally and for the interchange behaviour in particular. A model needs to be created which uses the different sources of connection demands to derive new forecasts for interchange behaviours from it. This is done in short term, e.g. to consider effects of broken connections in further locations, as well as in a long term, e.g. to map long term impacts on the planned connection.

Let $s_1, \ldots, s_i, s_{i+1}, \ldots, s_n$ be different sources of connection demands. To simplify the decision process for the dispatcher, these sources must be processed and displayed as a single output. The variable r will be the expected number of interchangers used for dispatching. In the following we present some possibilities of processing:

$$\boldsymbol{r} = \max\{\boldsymbol{s_1}, \ldots, \boldsymbol{s_i}, \boldsymbol{s_{i+1}}, \ldots, \boldsymbol{s_n}\} \quad (1)$$

$$\boldsymbol{r} = \sum_1^n \boldsymbol{a_i}\,\boldsymbol{s_i} \text{ whereas } \boldsymbol{a_i} \text{ is a weight for the corresponding source} \quad (2)$$

$$\boldsymbol{r} := \begin{cases} \boldsymbol{s_i} & \textbf{if } \exists\, \boldsymbol{s_i} \\ \boldsymbol{s_j} & \textbf{if } \exists\, \boldsymbol{s_j} \ldots \end{cases} \text{ (exclusive weighting of a source)} \quad (3)$$

Any combination of (1) to (3) (4)

The result of the chosen processing has to be very close to the real number of interchangers.

Figure 2 shows a block diagram of a possible system to process traveller flows. The system gets estimations about the number of interchanging passengers for each connection from various sources. The system gets real time events and updates its estimations continuously. This allows a provisioning of up-to-date information about interchanging passengers for the dispatcher. As visibly in the picture, there are different sources of connection demands available. Those sources are aggregated with a particular aggregation function and then combined with the output from the traveller prediction model. The resulting number of interchangers for each connection is provided to the dispatcher. The combination of the traveller prediction and the primary data sources, again, might follow functions as shown in (1) to (4). With the help of this number the dispatcher can come to a well-funded disposition decision, which minimizes the number of travellers afflicted by a breaking interchange.

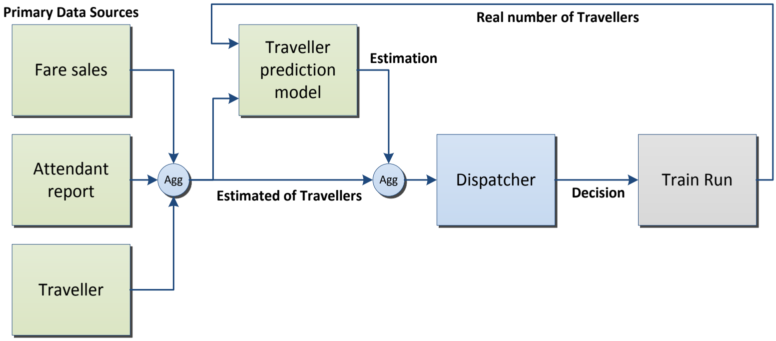

Figure 2: Block Diagram showing a system to process traveller flows

5.3. Determining new demands

A major advantage of the connection demand service is its ability to discover new connection demands. During the planning process, the schedule planners might not foresee all connection demands. Especially people who travel with commutation tickets cannot be covered by analysing, e.g. historical fare sales. Also, the planners might over- or underestimate changing times in a station. With the connection demand service, a transportation company can determine very precisely the needs for new or existing interchanges. Also, changing and waiting times can be reconsidered. Connection demands for pairs of vehicles whose interchange time were considered to be too short show that this connection is usable. The corresponding changing time can be reduced and a waiting time can be introduced to make to (newly detected connection) more secure. Analysing the interchange wishes, which are transmitted directly from the traveller using the connection demand, will deliver new information about interchange needs.

5.4. Connections from or to locations

Apart from interchanges between vehicles, the Trias Connection Service also permits to notify about hop on/hop off wishes. This functionality is very useful in a rural environment, where traffic on demand is used. Today, it is generally necessary to place a call or register manually otherwise. For the first time, a traveller can request a journey solely with the use of his application, using the standardised interface. The application will send a connection demand message to register the hop on/off wish of the passenger. As soon as the wish is dispatched a corresponding status can be sent to the traveller (chapter 5.5).

5.5. Connection Status

The Trias Interface contains the service Connection Status to inform the traveller about connections. With the use of the connection status, a traveller or system can be informed about the status of a connection.

For the traveller this gives a certainty concerning their on-going or soon commencing travel, especially in case of a hop on/off request. In contrast to existing interfaces as [9] Trias allows a more precise information on the connection status, also for broken connections. Furthermore it offers possibilities to inform the customer about alternatives apart from rerouting, like bus/taxi orders or helpdesks.

Systems can use the connection status information for other services. For example a trip planning system can reroute travellers or offer different routes in the planning phase. The data could also be used for statistics, e.g. to improve the connection planning. A connection which breaks frequently can be reconsidered to make it less likely to break.

6. Discussion and Conclusion

Currently, only fare sales, attendant reports and traveller prediction models are available as sources for connection demands. The possibly best source for this information – the traveller himself – has no ability to report his connection demands. This lack of information complicates disposition decisions. The new Trias Interface provides, among other things, a Connection Demand service. This service can be used by the traveller to report his interchange wishes to the transportation company. This could, together with the other sources, increase the precision of the estimated number of travellers for a connection. It also allows an optimization of the interchange times for existing connections.

Today's travellers expect current, precise, freely available and individual information. Currently available, proprietary systems cannot respond to all of these demands. To bridge this gap, novel information systems with standardized interfaces are required. The Trias interface offers broad possibilities for new services in traveller information systems. It provides possibilities to inform more accurate and more precise. The interfaces permit new services and their combination such that also future needs are covered.

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