Agent-based Simulation of the Railway Connection from and to the Vienna International Airport

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Abstract. This agent-based simulation deals with the railway connection of the Vienna International Airport and was created using the simulation program AnyLogic. With this program a transportation company should be able to estimate easily which timetable allows to transport a maximum of passengers without the use of too many trains.

Introduction

The Vienna International Airport is located in the centre of Europe. This makes the airport an important platform for international air travelling especially in Central and Eastern Europe. In 2013 around 22 million passengers were transported. There are more than 15 million people who need to be transported to the airport. Additionally the airport staff uses the different transportation possibilities as well [1].

This simulation investigates and simulates the railway connection of the airport using the Java-based simulation program AnyLogic.

Depending on various parameters that mostly can be changed by the user, this model offers a simplified presentation of a passenger movement at the airport between gates and railway station. Moreover the trains of the Viennese S-Bahn and the City Airport Train (CAT) are simulated. These trains are created according to the original timetable, but the amount of trains can be increased by the user, which leads to a shorter time interval of the trains during rush hours. Furthermore the expenses, income and profit of the railway companies are calculated as well.

1 The Model

There are nine types of agents representing different types of passengers and different types of trains:

- Incoming economy/business travelers
- Outgoing economy/business travelers
- Passengers who do not use a train for airport transportation
- Incoming S-Bahn/CAT trains
- Outgoing S-Bahn/CAT trains

This amount of different agents is necessary because all of them have different goals and features. They will be described in later on in much more detail.

The parameters that are variable are:

- Percentage of train travelling passengers
- Percentage of S-Bahn travelling passengers
- Percentage of passengers who only have hand luggage
- Walking speed of passengers
- Capacity of the trains
- Ticket price
- Working expenses

Passenger parameters are separated into economy and business, train parameters into S-Bahn and CAT. There is also the possibility to add an arbitrary amount of additional trains for each train provider during a time interval which can be inserted too.

The environment in which the agents act and interact is a simplified illustration of the airport including its railway station and rails, check-in, baggage claim area and the main exit as shown in Figure 1. The passenger representing agents are moving in this environment. The other agents, who represent the trains are moving along the railways that are attached to the railway station.

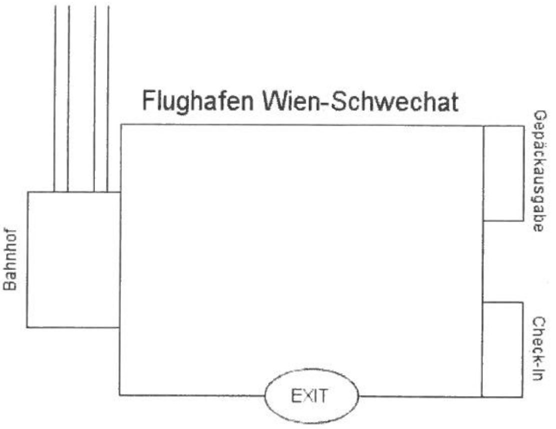

Figure 1: Simplified model of the Vienna International Airport used in the simulation. 'Bahnhof' stands for railway station and 'Gepäckausgabe' means baggage claim area.

In addition there are two graphics that illustrate the expenses, income and profit of the railway companies. Another diagram illustrates proportionately how passengers arrive at or leave from the airport.

2 The Agents

To illustrate the decision making and rules of the agents, their possible activities are illustrated in the following.

2.1 Incoming passengers

In Figure 2 the process of an incoming passenger is shown. An incoming agent is created at the baggage claim area of the model according to the actual flight plan. Afterwards it is decided probabilistically (according to the modulations the user made before the simulation started) if he is travelling only with hand luggage, if the passenger plans to take the train and in that case, if he is heading to the S-Bahn or the CAT.

Depending on these parameters the passenger is either waiting for his luggage at the baggage claim area, which would take half an hour on average, or is heading to the airport right away. If the passenger does not intend to go by train he/she is leaving the airport trough the EXIT. If the agent wants to use the S-Bahn, the simulation calculates his arrival time at the railway station and checks if there is a train connection. In that case the passenger starts to walk to the railway station.

As soon as an S-Bahn representing agent arrives at the railway station the passenger gets the message that he is now able to enter the S-Bahn, which he is doing in the following as long as there is still place for the passenger inside the train. Otherwise he has to wait for the next S-Bahn. If there is no train connection, the passenger has to look for another way of transportation and is heading for the EXIT. Afterwards the agent is removed from the model.

CAT travelling passengers follow the same rules except that for them the CAT timetable is checked for a connection and they are waiting for an CAT train.

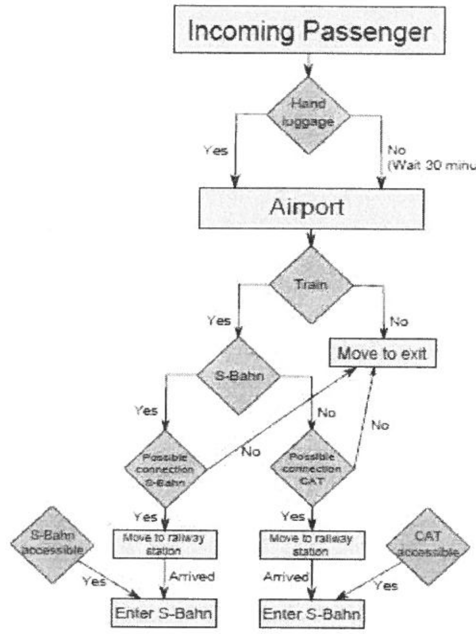

Figure 2: Decision making of a passenger who just exited the plane.

2.2 Outgoing Passengers

For an outgoing agent it is assumed that he is going by train. Otherwise he would have been constructed as a passenger who does not use a train for airport transportation in the first place. So an agent of the type outgoing passenger is either coming by S-Bahn or CAT, as shown in Figure 3. He is created at the railway station as soon as the best possible connection of his transportation type to get his flight reaches it.

Once the agent left the train he enters the airport right away and gets the order to move to the check-in area. As soon as he arrived there he is waiting for his flight to take off and then is removed.

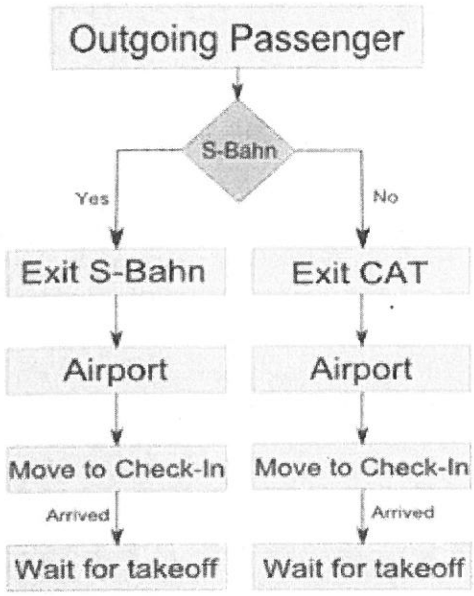

Figure 3: Decision making of a passenger who heads to the airport using train.

2.3 Passengers who do not use a train for airport transportation

This class is representing travelers who are not using the railway system and have therefore no direct input on the transportation companies profits. They are used to complete the amount of airplane users.

Therefore the decision making of these agent is very simple. They are created at the main exit and afterwards sent to the check-in area, where they are waiting for their flight to takeoff to be removed from the simulation afterwards.So this agent type is more or less a simplification of the outgoing passenger classes.

2.4 Incoming trains

Every incoming train is created, according to the (eventually modified) timetable [2] & [3], at the upper end of the rails in the model. Then the agent gets the order to move along the rails straight to the airports railway station, as shown in Figure 4. Once he arrived, two functions calculate for which outgoing passengers (economy and business) this train is the ideal connection to reach their plane.

All these passengers are now created and behave as described in chapter 2.2 as long as the capacity of the train is not exceeded. Afterwards the train is removed from the simulation.

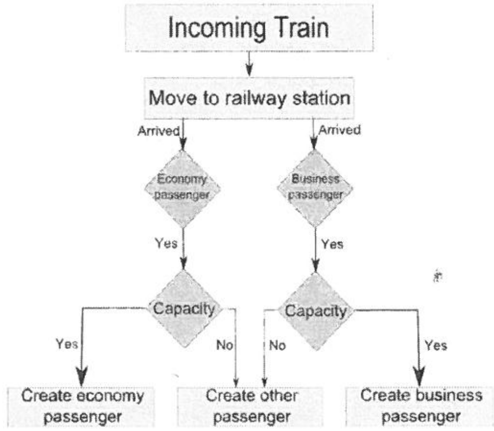

Figure 4: Decision making of an incoming train.

2.5 Outgoing trains

Every outgoing train is created according to the timetable [2] & [3], directly at the airports railway station.

Once created he sends a message to the incoming passengers waiting at the railway station for his train type (so either S-Bahn or CAT), that they are now able to enter the train. As long as the capacity of the train is not exceeded these travelers are removed from the simulation like described above in chapter 2.1. After the train waited for 3 minutes in the railway station, he is sent to the edge of the visualization along the railways. Once reaching border the agent is removed from the simulation.

3 Results

Since this model has various parameters that can be changed by the user, there is also a high amount different scenarios. For that reason there are only a few interesting scenarios presented in the following.

In the tables S-Bahn is abbreviated with SB, economy travelers with EC and business travelers with BU. In both scenarios the ticket prices are set with 4,4 € for travelling with the S-Bahn and 12 € for the CAT.

3.1 Scenario 1: Additional trains at peak hours

In Scenario 1 most parameters remain unchanged during the different runs. This scenario analyzes if the S-Bahn could increase its profit and/or the amount of transported passengers.

Table 1 shows, that S-Bahn profits decrease in all runs with additional trains. So with the given working expenses and ticket prices it is not profitable to extend the timetable at the chosen intervals.

But if the amount of transported passengers is considered, it is obvious, that especially in the night hours the amount of transported passengers increases significantly. It might be possible that the usage of trains in the night hours could be profitable with an increased ticket price and/or reduced working expanses.

The profit and passenger chances of the CAT are uninfluenced and within the probability variation.

	Run 1	Run 2	Run 3	Run 4
Train user EC	70%	70%	70%	70%
SB user EC	80%	80%	80%	80%
Only hand luggage EC	25%	25%	25%	25%
Train user BU	35%	35%	35%	35%
SB user BU	45%	45%	45%	45%
Only hand luggage BU	75%	75%	75%	75%
Working expenses per SB	1250	1250	1250	1250
Capacity SB	500	500	500	500
Capacity CAT	500	500	500	500
Additional SB amount	0	3	2	2
Add. SB time	-	14-18 h	6-10 h	1-6 h
Profit SB in €	19.074,56	12.131,60	15.357,60	16.169,68
Profit CAT in €	58.262,80	58.423,20	57.962,40	57.928,80
Passengers SB	27.062	27.241	27.354	27.537
Passeng. CAT	13.855	13.869	13.830	13.827

Table 1: Scenario 1. Most parameters remain unchanged during the different run. The only differences are extensions of the S-Bahn timetable during different intervals.

Analyzing the results of Table 2, it is obvious that even the use of 16 more trains still extends the company's profit. But it has to be considered that in Run 3 the amount of transported passengers is the highest although no further trains have been used. Therefore an increase of the capacity could be the best solution of this scenario if the working expenses could be reduced. Especially if it is not possible to use 16 trains additionally Run 3 is definitely the best option to choose, since 8 more trains with less capacity in Run 2 offer less profit.

The big loss of the CAT company is a consequence of the big reduction of its users in this scenario.

3.2 Scenario 2: Handling of increased use of the S-Bahn

In the second scenario a different initial position is taken. It is supposed, that nearly all (90%) of the travelers are using the S-Bahn. So this scenario analyzes the different opportunities of the S-Bahn operator to handle such an increased demand.

	Run 1	Run 2	Run 3	Run 4
Train user EC	90%	90%	90%	90%
SB user EC	90%	90%	90%	90%
Only hand luggage EC	25%	25%	25%	25%
Train user BU	90%	90%	90%	90%
SB user BU	90%	90%	90%	90%
Only hand luggage BU	75%	75%	75%	75%
Working expenses per SB	1250	1250	1900	1250
Working expenses per CAT	1500	1500	1500	1500
Capacity SB	500	500	750	500
Capacity CAT	500	500	500	500
Additional SB amount	0	8	0	16
Additional SB time	-	6-23 h	-	4-24
Profit SB in €	51.055,52	59.294,72	60.893,12	62.990,88
Profit CAT in €	-19.694,4	-19.557,6	-18.477,6	-19.000,8
Passengers SB	34.331	40.749	48.385	45.850
Passengers CAT	7.359	7.370	7.460	7.417

Table 2: Scenario 2. Most parameters remain unchanged during the different run. The only differences are extensions of the S-Bahn timetable during different intervals in run 2 and 4 and higher working expenses in run 3.

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[3] www.viennaairport.com/passagiere/anreise__parken/city_airport_train_cat, 25.08.2014.