Algorithms for Decision Support

# Simulation Assignment: The Uithoflijn

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# 1. Problem description:

The objective of this study is to develop, analyze, and implement a discrete event simulation system for the Uithoflijn, the new tram line between Utrecht central station and de P+R De Uithof . The Uithoflijn will provide the residents with a substitute to the existing bus route 12. which consists of 7.9 km of track, with 9 stops and will start operating in the summer of 2018. This simulation system will include a comprehensive overview of the tram line operation from the departure station to the arrival one. Furthermore, the simulation will tackle all the events that might influence the trams operation status.

The study primarily be focused on finding the answer to the following questions:

- What are feasible frequencies for the Uithoflijn? and
- What is the maximum amount of passengers the line can handle?

# 2. System scope:

The system will cover the connection from Utrecht Central station to P+R De Uithof as route 1 and from P+R De Uithof to Utrecht Central station as route 2. The alignment will have nine stations as the following : Utrecht central station, Vaartsche Rijn, Galgenwaard, Kromme Rijn, Padualaan, Heidelberglaan, UMC, WKZ, P+R De Uithof. Any other new stops/stations or new routes will not be covered by the system. The system will simulate the number of passengers that get in/out at each station, hence any other specific services that stations might provide will not be included by the system.

# 3. Assumptions

We assume the following:

- Tram operating hours 6:00 to 00:00
- The tram downtime = 0, no repair time no sudden break down or other disturbances in the model
- All the trams have the same capacity (400 passengers)
- The trams always travel in same speed / no influence from traffic jam
- There will be at least a 40 second time distance as safety rule between trams
- At stations fixed number of passenger can get in/out the tram per second

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- There are two fixed routes for the tram, the distance and the driving times are given by the following tables:

Table 1: Route 1

| **From** | **To** | **Distance (KM)** | **Avg. Driving time(sec)** |
|---|---|---|---|
| Centraal Station | Vaartsche Rijn | 1.4 | 134 |
| Vaartsche Rijn | Galgenwaard | 3.1 | 243 |
| Galgenwaard | Kromme Rijn | 0.6 | 59 |
| Kromme Rijn | Padualaan | 0.8 | 101 |
| Padualaan | Heidelberglaan | 0.4 | 60 |
| Heidelberglaan | UMC | 0.4 | 86 |
| UMC | WKZ | 0.6 | 78 |
| WKZ | P+R De Uithof | 0.6 | 113 |

Table 2: Route 2

| **From** | **To** | **Distance (KM)** | **Avg. Driving time(sec)** |
|---|---|---|---|
| P+R De Uithof | WKZ | 0.6 | 110 |
| WKZ | UMC | 0.6 | 78 |
| UMC | Heidelberglaan | 0.4 | 82 |
| Heidelberglaan | Padualaan | 0.4 | 60 |

| | | | |
|---|---|---|---|
| Padualaan | Kromme Rijn | 0.8 | 100 |
| Kromme Rijn | Galgenwaard | 0.6 | 59 |
| Galgenwaard | Vaartsche Rijn | 3.1 | 243 |
| Vaartsche Rijn | Centraal Station | 1.4 | 135 |

## 4. Performance measures:

To test and asses the punctuality of our model we have defined a **Gold Standard Time(GST)** to which we will test our model. GST, is defined as the sum of average driving times and the average dwell time.

We have defined the **Dwell time** as follows:

$$D = 2.3 * 10^{-5} * total.passengers^2 * (passengers_{in} + passengers_{out})$$

So the average dwell time is defined as

$$avg_1(D) = 2.3 * 10^{-5} * total.passengers^2 * (avg(passengers_{in}) + avg(passengers_{out}))$$

$$avg_2(D) = 12.5 + 0.22 * avg(passengers_{in}) + 0.13 * avg(passengers_{out})$$

So our **Gold Standard Time** is defined as follows

$$GST = \sum_{n=1}^{9} avg.driving.times_i + avg_2(D)$$

By analyzing the data from Table 1, we have computed the $avg.driving.time = 874\ seconds$. From 12a.csv and 12b.csv (data files provided by QBuzz) we have computed the $avg(passengers_{in}) = 65.0628$ and $avg(passengers_{out}) = 63.3891$. Therefore, $avg_2(D) = 35.0544\ seconds$. And finally, $GST = 874 + 35.0544 = 909.0544\ seconds$.

For each route, we will test the results of our model against the $GST$ . Other performance measures include:

- Average of departure delays
- Percentage of trams with departure delays of 1 min or more.
- Maximum departure delay.
- Passenger waiting times.

## 5. Event graph

The following figure represents the event graph for the Uithoflijn simulation system:

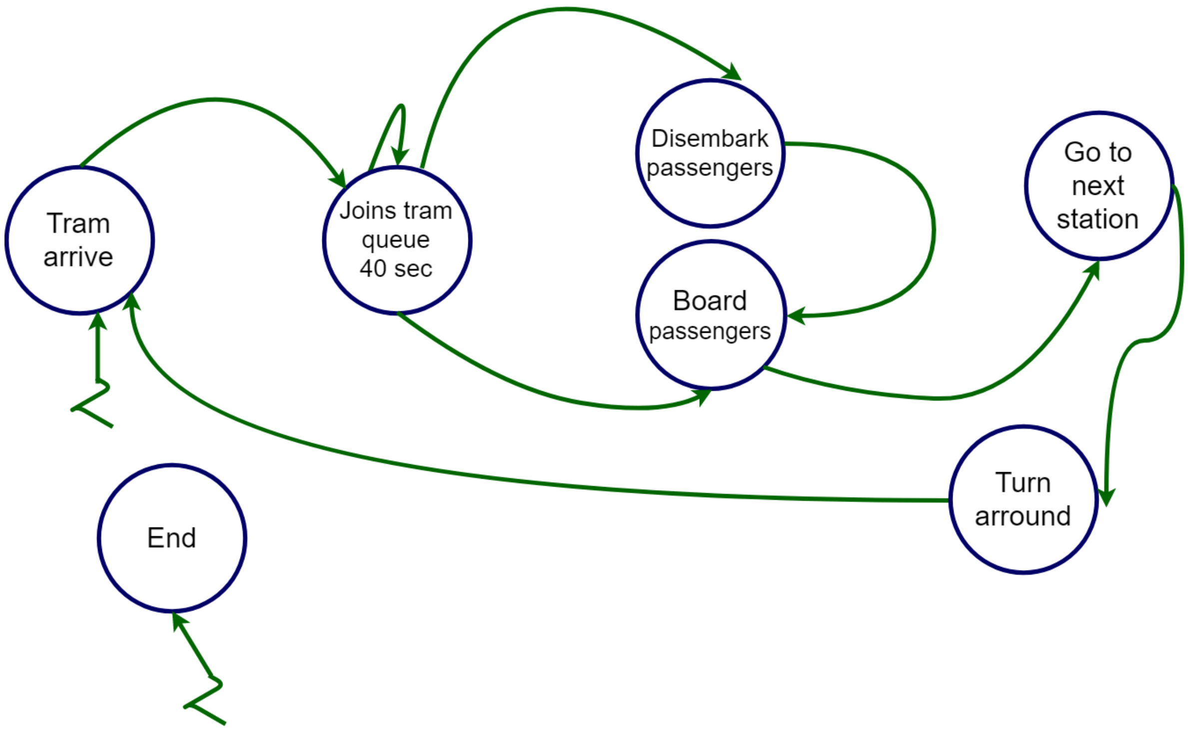
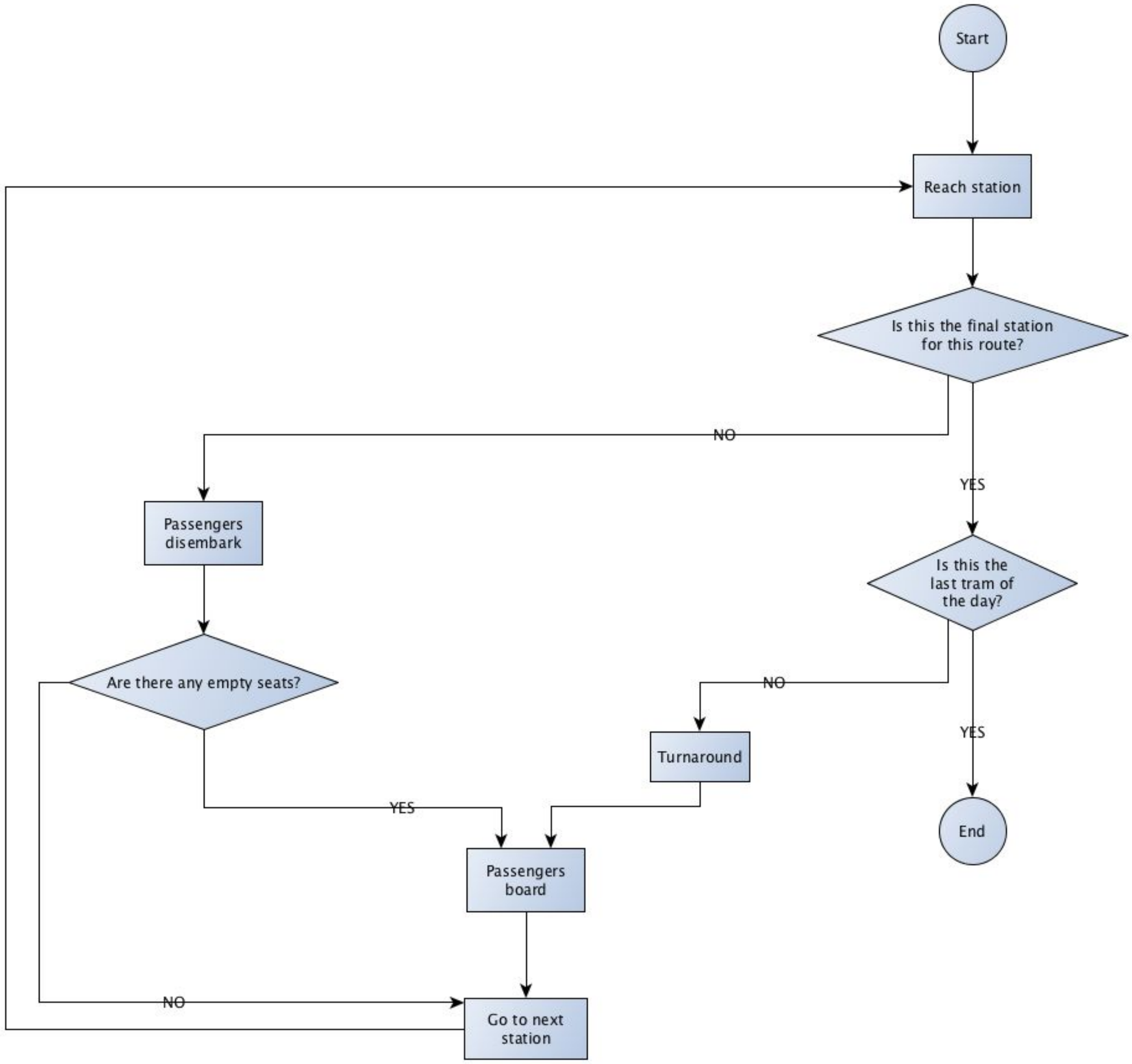



Figure 1: event graph

# 6. Flow diagram

The following figure shows the flow diagram for the Uithoflijn simulation system:




# 7. Scenarios:

We will discuss two scenarios:

- **Forward travel** (from Utrecht central station to P+R De Uithof)

- **Backwards travel** (from P+R De Uithof to Utrecht central station)

## 8. Software:

We are developing a software simulation based on the Java programming language, as shown in the appendix A

## 9. Resources: