

Written Exam Public Transport + Answers

Written Exam	Public Transport (195421200-1A)
Teacher	van Zuilekom
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Remarks	Closed book, calculator allowed, English dictionary allowed Formulas and tables are, when necessary, part of the question.

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Calculation of the marks:

- The maximum number of points of this written exam, P_{max} , is 100
- The marks for the written exam, C , is calculated by the sum of points, P , times ten divided by the maximum number of points:

$$C = 10 \cdot \frac{P}{P_{max}}$$

- Available time is 210 minutes.

Question 1 (14 points) – Development-teams North Brabant

The Province of North Brabant is the regional PT-authority. They have recently made a new PT-policy plan: the PT-vision. In this vision PT should be more demand focussed and more connecting between mobility and spatial developments. PT should deliver a real contribution to the community in terms of accessibility and vitality of the region. Simultaneously the Province has started a public procurement for the new 2015 concession. This is still in progress. So the new transport company is not yet available.

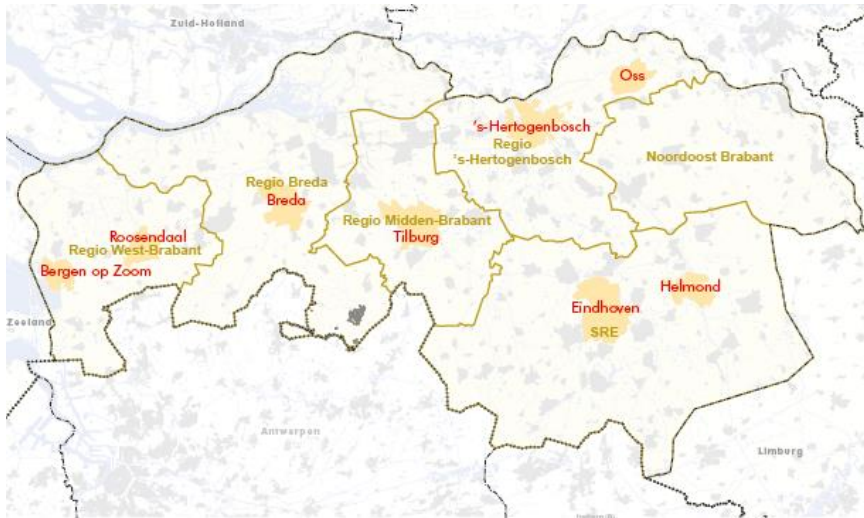


Figure 1 – The Province of North Brabant

Following the ideas of their new vision, North Brabant wants to have a more professional and business-like approach. So they are developing the idea of so-called 'development teams'. Primary partners in these teams are the municipalities (54 in North Brabant), the province and the (new) transport company. All with the purpose to maintain the quality of PT as much as possible. At the same time the budgets for PT in 2015 and following years will be reduced.

In the PT-vision there are three levels for these development teams:

- Strategic
 - Tactical
 - Operational
- a) [5 points] Describe – in your view – what themes they should address (for each level).
 - b) [5 points] Describe at least 5 important themes and describe 1) why they are important and 2) how they should be addressed.
 - c) [4 points] Also describe how these teams have to function in practise and on what level the representatives should participate. Also take into account other important actors besides the primary partners.

Question 2 (28 points) – Reducing budget for Public Transport

A PT-authority is faced with the cutting down of the budgets for PT in the city of 'Enschelo' with € 2.000.000 (per year). You, as an advisor, are asked to make good plan how to deal with this reduction.

These are the facts:

In the current situation Enschedo has 5 lines. All lines are exploited during all days of the week and from 07.00 – 23.00 hrs.

lines	costs (yr)	passenger revenues (yr)
1	1.000.000	200.000
2	3.000.000	2.000.000
3	2.500.000	1.200.000
4	1.500.000	600.000
5	2.000.000	1.000.000
total	10.000.000	5.000.000 (current cost cover: 50%)

Price per service hour:	€ 120,00
Revenues per travel kilometre:	€ 0,18 (no boarding tariff)
Average travel distance:	4,0 km

Spreading of the passenger revenues during the week (for all lines):

Workdays	75%	255 Days
Saturday	15%	52 Days
Sunday	10%	58 Days

Spreading of the passenger revenues during workdays (for all lines):

07:00 – 18:00	90%
18:00 – 20:00	5%
20:00 – 23:00	5%

- a) [14 points] A procurement for a new concession is on its way. In the new concession the authority is responsible for the passenger revenues. You are asked to develop 3 three different scenario's to deal with the reduced budget. Your goal is also to keep as much passengers as possible. You are asked to calculate the new cost cover-factor per scenario. Where data are missing you should make a realistic estimation.
- b) [14 points] Give for each scenario the advantages and disadvantages. Take into account the social consequences and alternative ways of transport for the citizens of Enschedo when PT is reduced. Out of the box suggestions are welcome.

Question 3 (7 points) – Scheduled versus frequency based assignment.

a) [7 points] Describe the difference between schedule based assignment and frequency based assignment, with respect to:

- Network definition
- Modelling of transfers
- Model output
- Calculation time

Answer

	<i>Frequency based</i>	<i>Schedule based</i>
<i>Network definition</i>	<i>Service lines with frequencies: average line characteristics</i>	<i>Individual runs in timetables: run specific characteristics</i>
<i>Modelling transfers</i>	<i>Average information on transfers is used, depending on frequency of target line</i>	<i>Transfer times can be calculated exactly from schedule</i>
<i>Model output</i>	<i>Flows at line level: average line usage</i>	<i>Flows at run level: vehicle occupation</i>
<i>Calculation time</i>	<i>Shorter calculation times</i>	<i>Longer calculation times</i>

Question 4 (24 points) – Route searching

Consider the following PT network, consisting of 1 origin, 1 destination, 1 access link, 1 egress link, 2 nodes / stops (A and B), 1 transit link and 2 transit lines (I and II). Both transit lines call at stop A and B. Transit line I has frequency (F) 4 per hour and is a faster service with travel time $T = 15$ minutes between stop A and B. Transit line II has frequency 8 per hour and travel time $T = 20$ minutes between A and B. Both transit lines are in the candidate set of the travellers. The access and egress times are both equal to 3 minutes of walking time.

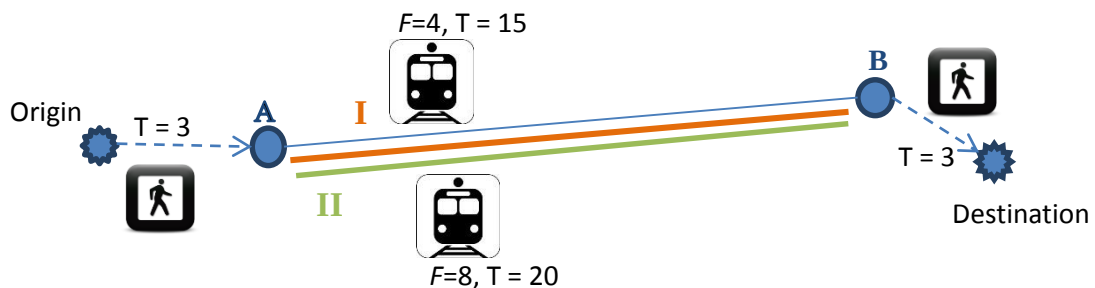


Figure 1 The PT network

For searching routes through this PT network and calculating average travel times, several methods exist. Two of those methods are:

- The method of 'optimal strategies', developed by Spiess and Florian in 1989. Calculate the waiting time at stop A by assuming that passengers arrive completely random at the stop and that the transit services run completely reliable with equal headways.
 - The Zenith method, as implemented in the OmniTRANS modeling software. The formula for line choice in the Zenith method is shown below, the access service choice parameter λ is 0.1. Travel time is the only element of generalized costs considered here. The combined waiting time at stop A is 3.39 minutes when using the Zenith method in the network above.
- a) [12 points] Calculate the average travel time from the origin to the destination using the method of 'optimal strategies'
- b) [12 points] Calculate the average travel time from the origin to the destination using the Zenith method.

For both methods, as an intermediate step, you have to calculate the fraction of the travellers that use transit line I and transit line II.

Formula for service choice (= line choice):

$$P_l = \frac{F_l e^{-\lambda C_l}}{\sum_{x \in T} F_x e^{-\lambda C_x}}$$

Where:

P_l : fraction for line l

F_l : frequency of line l

C_l : generalized costs when using line l

T : set of candidate lines at the stop

λ : service choice parameter

Answers

Optimal strategies:

- *Waiting time based on combined frequency. Assumptions equal headway and random arrival result in half the headway. That is $60/(F*2) = 60/(12*2) = 2.5$ minutes.*
 - *Fractions are calculated proportional to frequency, so line I receives 0.333 and line II receives 0.667.*
 - *Travel time when leaving stop A is:*
 - *18 minutes in line I*
 - *23 minutes in line II*
- This includes 3 minutes of egress time*

- Average travel time when leaving stop A is (using the fractions) $0.333*18+0.667*23 = 21.33$ minutes.
- Access time 3 minutes and waiting time 2.5 minutes, resulting in a total travel time of 26.833 minutes.

Zenith

- Line fractions at stop A can be calculated using the formula, using the costs (=travel times) when leaving stop A:
 - o 18 minutes in line I
 - o 23 minutes in line II
 This includes 3 minutes of egress time
- $P_I = \frac{F_I e^{-\lambda C_I}}{\sum_{x \in T} F_x e^{-\lambda C_x}} = \frac{4e^{-0.1*18}}{4e^{-0.1*18} + 8e^{-0.1*23}} = 0.452$
- $P_{II} = 1 - P_I = 0.548$
- Average travel time when leaving stop A is (using the fractions) $0.452*18+0.548*23 = 20.74$ minutes.
- Access time is 3 minutes and waiting time is 3.39 minutes (given), resulting in a total travel time of 27.13 minutes.

Question 5 (7 points) – Lines and networks

- [3 points] What is the definition of area coverage of a transit network?
- [4 points] Explain the relation between stop density and area coverage

Answers

- Area coverage: fraction of total area that is within X minutes walking distance of a transit station
- A higher stop density results in a higher area coverage. However, due to overlap this relation is less strong in networks that are already dense.

Question 6 (12 points) – Demand modelling

Trip end models are sometimes used in plan studies for Public Transport.

- [3 points] Explain for which kind of demand issues these models are used in practice
- [3 points] Explain a major drawback of such models

Answers

6 a. These models are used to determine if and where a new station for local trains is needed. The model forecasts the expected number of passengers that will use the new station. Because of its simplicity, it is relatively easy to make estimates for (many) different locations, and select the best one, i.e. the one that will attract most passengers.

6 b. A drawback is that the forecast is only based on the direct environment of the station (i.e. based on the number of inhabitants and activities within a certain radius). However, the accessibility to other stations is also important, and is not taken into account (e.g. for two cities with similar sizes, the city that is in the center of the Netherlands will attract many more train passengers than the border city).

In a plan study a selected link analysis of car traffic was used to estimate the potential for a new rail track.

- c) [2 points] Explain the concept of a selected link analysis.
- d) [4 points] Explain in three steps how a selected link analysis for car traffic can be used to determine whether a new rail track is desirable, and if so, which trajectory would be optimal.

Answers

6 c. A selected link analysis shows the number of trips per OD relation traversing the selected link. It is thus providing information about which travelers, i.e. based on their origin and destination, are using a certain link.

6 d. The following steps are followed:

1. Select the most important car OD pairs in the selected link, i.e. those with the highest volumes. If a fraction of travelers on these OD pairs decide to travel via the new railway, this will significantly reduce the traffic loads on the highway.
2. For all OD pairs, estimate the travel time ratio between the new railway and car (normally free flow travel times are used, but one could include certain delays for the car due to congestion. Note that travel times for cars can be modeled when a dynamic macroscopic model is used). If the travel time ratio is around 1, the new railway can be a serious alternative to the car. Select all OD pairs below a certain travel time ratio (e.g. below 1.5). If these OD pairs correspond with the important OD pairs in the selected link, the railway could be a serious alternative for travelers on the highway.
3. However, the future railway will only attract travelers from the highway, if there is no public transport alternative present at the moment. Check this for the OD pairs selected in steps 1 & 2. If there are no PT alternatives, the new railway will most likely compete with the highway, and will therefore not only attract enough travelers (because of favorable travel time ratio's), but also lead to a significant reduction of traffic on the highway. If there are already good public transport alternatives available, the new railway will compete with existing public transport, and the new railway will probably not reduce the traffic on the highway significantly.

Question 7 (8 points) – Electric busses

In the article 'Electric buses – An efficient urban transport means' Reinhart Kühne states: *'It makes sense to search for new powertrain concepts for city buses and to preserve the Diesel engine for other applications.'*

Question

- a) [2 points] Why does it make sense to search to new powertrain concepts for city busses?
- b) [2 points] What are the key arguments in favour of a trolley bus above a battery electric bus?

The author states that one of the advantages of the electric engine is *'(the) unproblematic recuperation of braking energy'*.

It is true that an electric engine is capable of transforming kinetic energy to electricity, but the electric engine is just one element of a complete recuperation system.

Recuperation requires at least (1) a conversion of kinetic energy to another form of energy (2) storage of the converted energy, (3) conversion of the stored energy to kinetic energy (/propulsion) and (4) a control unit to manage the energy flows.

In case of a trolleybus, tram or metro with recuperation it is possible to place the energy storage in the vehicle and/or in the sub power stations (as for instance in Moscow).

- c) [2 points] Give arguments for and against energy storage in the vehicles.
- d) [2 points] Give arguments for and against energy in the sub power stations.

Answers

7 a:

Arguments against current diesel power trains: it is of strategic importance to become less dependent of fossil fuel as this resource is limited and polluting; extra emission demands will result in extra costs and larger complexity of the exhaust after treatment; pollution in dense populated areas; ...

Arguments for electric power trains: opportunity to use sustainable energy sources (sun, wind, water, tide, geothermic, ...); no local pollution; less noise; no vibrations; relative easy recuperation; ...

7 b:

Arguments against a battery bus: low energy density (high weight, large volume) of the battery; battery needs a long recharge time; battery has a relative low (unloading/loading) power; limited lifetime; expensive

Arguments in favour of an trolley bus: no need for large and heavy batteries in the vehicle; still recuperation possible (using SuperCaps in vehicle or electricity network); proven technology (and still under further development); ...

7 c:

+ energy management can include the state of charge of the energy storage in brake/acceleration strategy

+ peak shaving of energy demand in the vehicle

- extra weight in the vehicle

- limited storage (as a result of weight and volume restrictions)

- only possible in new (or refurbished) vehicles

7d:

+ hardly any limitations in weight and volume of the energy storage (compared to in-vehicle)

+ share of stored energy over all vehicle in the network section; economy of scale

+ reduced complexity of the vehicles; reduced weight of the vehicles; with limited changes recuperation with existing vehicles possible

+ peak shaving over the whole of the network section

- network losses due to long transmission distances