MASTER THESIS

IMPROVING TRANSPORT OF ELDERLY AND PEOPLE WITH DISABILITIES IN DRENTHE

Koen Sonnenberg

INDUSTRIAL ENGINEERING AND BUSINESS INFORMATION SYSTEMS

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Summary

This thesis is centred on the transportation system for elderly and people with disabilities in the southeast area Drenthe, The Netherlands. Since the beginning of 2014, the municipalities of Borger-Odoorn, Coevorden and Emmen (BOCE) have been joining forces to put effort into improving the transportation system of elderly and people with disabilities. To allow for these frail groups of society to equally engage in social environments, demand-responsive transportation (DRT) systems have been tailored to service specific user requests. One such DRT system is subsidized by several municipalities in the southeast region of Drenthe, The Netherlands. This system is meant to serve people who are not self-reliant enough to use conventional public transport. These people are eligible for WMO support, named after the Dutch law.

To improve the efficiency of WMO transport in the area under study, we need to address several research problems. We know that a few destinations are visited frequently by elderly and people with disabilities. Organizations at these destinations can arrange for groups to visit their locations together by shifting transportation requests from the passengers to the organizations that these passengers visit. In order to establish for which organizations this is possible, we need to overcome the geocoding problem, i.e., various notations refer to similar addresses. Furthermore, some organizations are more suited for a shift of transportation requests than others. Once we have an idea of potential organizations, we want to know the yield of shifting transportation requests from the passengers to these organizations, in comparison to the current situation. To test our hypothesis of improved transport efficiency, we have formulated the following research problem:

- **In which way and to what degree can the efficiency of transport of elderly and people with disabilities be improved, by shifting transportation requests from the passengers to the organizations that these passengers visit?**

To solve this problem, we have formulated the following research questions:

1. How is transport of elderly and people with disabilities organized in the current situation?
2. How can literature help to solve our research problem?
3. For which kind of organizations is a shift of transportation requests from the passengers to the organizations that these passengers visit possible?
4. To what degree can the efficiency of transport of elderly and people with disabilities be improved, by shifting transportation requests from the passengers to these organizations?

The current system provides around 6,000 elderly and people with disabilities with door-to-door service whenever they need it, but only half of them request a trip more than once a month. In total, more than 200,000 trips are driven each year, which adds up to 1.8 million kilometres. An average trip spans a distance of 8.5 kilometres and lasts 23 minutes between pick-up at one location and drop-off at another location. The price of each trip starts at €5.60 and another €1.40 is charged for every kilometre. This adds up to €17.50 for an average trip, which is almost completely charged to the respective municipality. We conclude that the occupation of a typical WMO taxi bus rarely exceeds 2 passengers during busy hours.

Next, we determine which organizations are visited frequently in the transport of elderly and people with disabilities in Drenthe, the Netherlands. As many different address notations in the data refer to similar addresses, geographic locations cannot be found for many of these addresses. This is referred to as the geocoding problem. In effect, trips and distances are linked to different data entries, even though they refer to similar addresses. To solve this problem, we devise a method in which addresses are compared on the basis of a known string similarity measure, which is the

longest common substring algorithm. Our method is unique with respect to the preparation procedure, splitting common prefixes and suffixes from street entries, enabling us to compare only the differentiating middle part of a street entry. The structure of our method can easily be adapted to fit data from other geographic areas. The adjustments that the method makes can be verified and corrected if needed.

Based on a list of unique address notations, we construct a top 50 of organizations in the transport of elderly and people with disabilities in Drenthe, The Netherlands. Remarkably, this small selection of organizations turns out to be responsible for roughly 50% of all transport in terms of trips, distance and travel time. Some of these organizations are more suitable for a shift of transportation requests than others. Therefore, we introduced a set of criteria on which to evaluate each organization in our top 50. Based on these evaluations, we classified various types of organizations that show potential to engage in the transportation process. Most types of organizations can be found in every transportation system for elderly and people with disabilities across the globe. The types of organizations that have the highest potential are day care centres, community centres and other facilities for day care activities. Requests for transport to these organizations often share the same purpose and schedule, and both passenger and organization share a common interest.

To asses to what degree the efficiency of transport can be improved by shifting transportation requests from the passengers to the organizations that these passengers visit, we identify the case of 5 community centres in Klazienaveen, each hosting a game of bingo between 7 and 9 pm on different days of the week. Based on the idea that communities can play an important role in the transport of elderly and people with disabilities, we introduce the concept of a bingo bus. For each day of the week, we design efficient routes along which regular customers of the respective community centre are to be picked up and dropped off again at the end of the evening. These routes take into account the capacity of a typical WMO taxi bus and the total time that passengers spend both inside and outside the vehicle. In the present system, multiple different vehicles are deployed, each serving a single passenger. The bingo bus can potentially serve more than 90% of all current transport requests on its own, giving this alternative means of transport an overall advantage. To break even, the bingo bus service is allowed to cost €1.79 per driven kilometre. Through analysis of similar cases in this or in other geographic areas, efficient transport schemes can be developed and implemented gradually to accommodate the transport of elderly and people with disabilities.

Demand-responsive systems have largely proven to be sustainable in terms of the environment and social needs requirements. However, economic viability is still a big issue. Given that a large proportion of the operating cost of transport services such as DRT is based on the wages of drivers and personnel, a future of driverless vehicles and automated communications opens up a spectrum of options. In the meantime, the involvement of social enterprise operators and voluntary services should be investigated further to decrease costs. Last but not least, funding from different sources that recognise the benefits of DRT to their particular environment should be explored in order to relieve the pressure on local government budgets.

Preface

For the period of a year, I've been allowed to conduct my thesis at Infostructure B.V., Rijswijk. My supervisors at the University of Twente introduced me there to André Oldenburger, who familiarized me with a network of colleagues and clients. Soon, I benefitted from the cooperation with members of the BOCE municipalities, who assigned me the subject of this thesis. Additionally, I spent some time at Geon B.V., Groningen, to get acquainted with the SQL database language and GIS programming. Employees at Geon were kind enough to set me up with a voluntary agreement to enable me to access the WMO data in their own protected environment. Initially focussing on the data, the possibilities of data analysis soon became apparent. Infostructure challenged me to provide insight in the abnormalities seen in everyday transport of elderly and people with disabilities. Eventually, I was even awarded the responsibility to present my findings in front of various municipal councillors. I have enjoyed these events to a high level, opening the eyes of several influential people. I think the cooperation between the parties involved brought new insights to the discussion on the topic of WMO transport in the area. Perhaps, this thesis also contributes to the wider discussion on transport of elderly and people with disabilities across the globe. I consider the experience drawn from this exercise to be very valuable to my future career and I hope to engage in similar challenges. In particular, I would like to thank my supervisors at University Twente for guiding me in my research, and André Oldenburger, for giving me all the opportunities to conduct my thesis in a professional environment.

Content

1 Introduction

This thesis is centred around the transportation system for elderly and people with disabilities in Drenthe, The Netherlands. Since the beginning of 2014, the municipalities of Borger-Odoorn, Coevorden and Emmen (BOCE) have been joining forces to put effort into improving the transportation system of elderly and people with disabilities. This chapter is subdivided into four sections. Section 1.1 outlines the research motivation. Section 1.2 discusses the problem definition. Section 1.3 explains the research design. Section 1.4 gives a summary and provides the outline of this thesis.

1.1 Research motivation

In the context of an ageing population globally, Al-Shaqi, Mourshed, and Rezgui (2016) stress the importance of “easy access to the social environments (e.g. healthcare facilities, care support, supermarkets, cultural centers and places to socialize)”. Access to these environments proves to be a growing concern among elderly and people with disabilities, as research in several countries indicates (Higgins et al., 2015) (Mulumba et al., 2014). The restricted mobility of these people constitutes a considerable barrier to effectively use a transportation system (Sundling et al., 2014). The needs of elderly and people with disabilities should be taken seriously in order to give these people the same level of access to services as others. Even though legislation over the past decades has focussed on the non-discrimination of these frail groups of society, discrimination remains widely perceived by elderly and people with disabilities (Rogers et al., 2015). In particular, difficulties of enduring the discomforts of travel and securing a means of transportation are especially affecting vulnerable people (Reif, DesHarnais, & Bernard, 1999). See Figure 1 for an illustration of special transport requirements of elderly and people with disabilities.

Figure 1: Illustration of special transport requirements (Roper & Mulley, 1996)

Many initiatives have been employed to overcome the physical limitations of people. These initiatives include developments in both assisting equipment at home (Al-Shaqi et al., 2016) and digital applications in health care (Silva et al., 2015). However, regardless of technology, elderly and people with disabilities will always need to make a number of trips, be it either for medical, social or other travel purposes. To facilitate in this need, flexible transport services (FTS) have emerged that bridge the flexibility gap between conventional fixed-route buses and taxis. More specifically, demand responsive transport services (DRT), which are based on specific user requests, have been introduced to address the special transport requirements of elderly and people with disabilities.

One such DRT system is subsidized by several municipalities in the southeast region of Drenthe, The Netherlands. This system is meant to serve people who are not self-reliant enough to use conventional public transport. These people are eligible to use this so called WMO transport, named after the Dutch law that provides support for elderly and handicapped people. Every person that is eligible for WMO support is free to use the WMO transport system at any time. Whenever the user needs to go somewhere, he or she simply calls for an appointment. A taxi or taxi-bus driver will then pick up the person at a designated time and place, providing assistance from door to door. The user pays a small contribution while the rest is paid for by the municipality.

Since the beginning of 2014, the municipalities of Borger-Odoorn, Coevorden and Emmen (BOCE) have been joining forces to put effort into improving the WMO system. In this regard, a representative of BOCE has challenged us to come up with a solution to make the DRT system for elderly and people with disabilities more cost-effective. We know that some destinations are visited more often than others, particularly service facilities such as hospitals and day care institutions. Some of these locations are visited throughout the entire day and for many different reasons. On the other hand, several locations might be visited on specific times of the day, enabling a more efficient deployment of vehicles to that location. For example, if ten people visit a physiotherapist on a Monday morning for a group session, it makes sense to dispatch two buses instead of ten different taxis. The physiotherapist could encourage this by making group arrangements for transport. Within BOCE, there is a need to explore the potential of involving service facilities, such as the one in the example, in the planning and execution of WMO transport. This way, the BOCE communities aim to improve the quality of service for elderly and people with disabilities, while at the same time making the transport system more efficient.

1.2 Problem definition

Before we continue to elaborate on the research design, we first define the problem we want to solve. As the reason for improvement of the DRT system for elderly and people with disabilities stems from a continuous drive to improve the overall quality of the service system, demarcation of the core problem is not evident. First of all, the quality of a DRT system is related to many different aspects, from the perceived quality of users to the occupancy rates of vehicles. In the DRT system under study, the taxi company that provides the WMO service is restricted to a number of rules to assure a certain quality level. For example, time-windows at pick-ups serve as upper bounds to the waiting times of customers. Furthermore, the extra ride-time of a passenger, related to the pick-up of another passenger during a trip, is also restricted. Other factors that affect the perceived quality of users include comfort and flexibility of transport, such as the possibility to bring a wheel chair or an accompanying person. Early studies have shown how the mere design of vehicles can enhance these quality factors (Petzäll, 1993).

However, what is not directly perceived by its users is the efficient deployment of vehicles in the DRT system. As the taxi company that provides the WMO service gets paid for every user transported, the taxi company is motivated to do this as efficiently as possible. This means the taxi company will try to transport multiple passengers at the same time to minimize the number of vehicles and drivers needed to perform the service. Such a minimization of resource requirements given quality constraints is, for example, studied by Diana, Dessouky, and Xia (2006). The efficient deployment of vehicles and drivers is directly linked to various cost aspects of the DRT system. It is therefore in the interest of both the BOCE community and the taxi company to efficiently deploy vehicles. One way to look at this problem is to examine the information about transport requests we know beforehand. For example, if we knew that a number of people had to visit a day care facility at a certain time of the day, the day care facility could arrange for daily group transports. Furthermore, within that same day care facility, people from a similar area could be grouped on the same day. This form of clustering is also applied in Dutch high school classes to ensure that children can travel to school together. This way, the transport requests of WMO users could be directed towards a certain time or location. In effect, this would mean a shift in demand for transport from a single user to an organization that arranges transport for an entire group of WMO users. Interviews with representatives of both the BOCE municipalities and the taxi company indicate there is currently no active pursuit of such opportunities. This leaves us to question whether the deployment of vehicles for WMO transport is optimal, or perhaps, far from it.

A preliminary literature study, together with an initial analysis of WMO data that have been provided by the BOCE communities, revealed the following:

- Registration of transport is based on single customer requests for WMO transport from one location to another. The shortest distance from one location to another, rather than actual distances, is used to calculate prices.
- Roughly, only 70% of departure addresses and only 70% of arrival addresses can be linked to BAG coordinates (Dutch database for administration of buildings), which we refer to as the geocoding problem. This means there are many variations in zip codes and addresses within the data provided.
- Looking at geographic destination coordinates from the first four months of 2013, the 14 most frequently visited of 5000 different destinations in total account for 20% of all requests for transport. The 92 most frequently visited destinations account for 40%.
- In 2012/2013, only about 900 requests for transport of 200,000 in total have the same group ID, which means the transport of these passengers is carried out at the same time in the same vehicle. Such a group ID cannot be found in data of 2014/2015. This makes it difficult to accurately assess the occupancy of vehicles used for WMO transport, although the 2012/2013 numbers suggest combinations of customer requests are rare.
- Literature presents several models to enhance the cost-effectiveness of DRT systems and to make services more accessible for elderly and people with disabilities. However, no theory suggests an active role of organizations in the deployment of WMO transport, such as mentioned in our examples.

These preliminary results strengthen the idea that the deployment of WMO vehicles in the southeast region of Drenthe is not optimal. Although most of the WMO transport requests are linked to a small number of destinations, no effort is currently being made to involve the organizations at these destinations in the pursuit of efficient vehicle deployment. This observed discrepancy leads to the research design of this thesis.

1.3 Research Design

This section discusses the research design. Section 1.3.1 describes the research objective and research questions. Section 1.3.2 demarcates the scope of the research and Section 1.3.3 outlines the research approach.

1.3.1 Research objective and research questions

To improve the efficiency of WMO transport in the southeast region of Drenthe, The Netherlands, we need to address several research problems. Our findings in Section 1.2 suggest that only a few destinations are visited frequently by elderly and people with disabilities. We discussed several examples of how transportation requests can be shifted from the passenger to the organizations at these destinations, in order to improve transport efficiency. However, we still need to establish which destinations, and therefore which kind of organizations, are visited frequently. In the process, we need to overcome the observed geocoding problem. Furthermore, some organizations are more suited for a shift of transportation requests than others. Once we have an idea of potential organizations, we want to know the yield of shifting transportation requests from the passenger to these organizations, in comparison to the current situation. To test our hypothesis of improved transport efficiency, we have formulated the following research problem:

- **In which way and to what degree can the efficiency of transport of elderly and people with disabilities be improved, by shifting transportation requests from the passengers to the organizations that these passengers visit?**

To solve this problem, we have formulated the following research questions:

1. How is transport of elderly and people with disabilities organized in the current situation?
2. How can literature help to solve our research problem?
3. For which kind of organizations is a shift of transportation requests from the passengers to the organizations that these passengers visit possible?
4. To what degree can the efficiency of transport of elderly and people with disabilities be improved, by shifting transportation requests from the passengers to these organizations?

Efficiency of transport can be perceived differently by passengers, organizations, municipalities or the taxi company. It very much depends on the type and perspective of implementation. For example, if actual distances driven decrease, but the origin and destination pairs on which reported distances are based remain the same, then the taxi company is driving more efficiently, even though the municipality and the passengers pay the same. If on the other hand, taxi services are partly substituted by voluntary services, then it is a whole other story. To compare efficiency of transport, we look at various key performance indicators such as the number of passengers per vehicle and the cost against which a service can be provided.

1.3.2 Research scope

- Our research focusses on the southeast region of Drenthe, The Netherlands, comprising the WMO transport financed by the municipalities of Borger-Odoorn, Coevorden and Emmen (BOCE). We are convinced that a region as comprehensive as this, comprising both urban as well as rural areas, is representative for at least most regions in the Netherlands.
- Historical data of WMO trips carried out in this region are available for the period of January 2014 to the end of May 2015. These data are provided by the taxi company that provides the WMO service, as a basis for billing to the respective municipality.

1.3.3 Research approach

To achieve our research objective, the research questions are answered one by one. As each of the research questions aims to find particular knowledge, we need to address them separately:

1. **How is transport of elderly and people with disabilities organized in the current situation?**
   By answering this question, we want to get a broad understanding of the current system. First, we perform queries on the WMO database to extract the necessary information needed for zero-measurement purposes. Second, we look into relational patterns between passengers and the destinations they visit. We also describe the problem of geocoding these destinations. To better understand the data, we conduct informal interviews with representatives of BOCE and the taxi company. For the information that we cannot retrieve from the data or from interviews, we make some assumptions.

2. **How can literature help to solve our research problem?**
   We perform a literature study to study various aspects related to our research problem. First, we look at strategic and tactical aspects involved in transportation network design. Second, we study literature related to a DRT system, but we also examine the vehicle routing problem that is used to solve such a system to optimality. Finally, we look into algorithms to overcome the observed geocoding problem. This enables us to determine which kinds of organizations are visited frequently by elderly and people with disabilities.

3. **For which kind of organizations is a shift of transportation requests from the passengers to the organizations that these passengers visit possible?**
   We construct a classification method of organizations to determine which kinds of organizations are suitable for a shift of transportation requests from the passengers to the organizations. First, we apply a method to overcome the observed geocoding problem. Based on the output of this method, we establish which kind of organizations are visited frequently in the transport of elderly and people with disabilities. These organizations are then compared on the basis of several criteria to determine which kinds of organizations are potentially suited for a shift of transportation requests, and which are not.

4. **To what degree can the efficiency of transport of elderly and people with disabilities be improved, by shifting transportation requests from the passengers to the organizations?**
   By answering this last research question, we examine whether a more efficient deployment of vehicles is attainable for organizations labelled as potential candidate. First, we select a case based on our classification method. Second, we construct a business case to demonstrate to what degree the efficiency of transport of elderly and people with disabilities can be improved in this and in similar cases.

1.4 Summary and thesis outline

This thesis focusses on the opportunities to involve service facilities in the transport of elderly and people with disabilities. The goal is a more efficient deployment of vehicles. The research design is constructed to test whether the efficiency of transport of elderly and people with disabilities can be improved by shifting demand from the passengers to the organizations that these passengers visit. We test our hypothesis within the scope of a DRT system for elderly and people with disabilities in the southeast region of Drenthe, the Netherlands. The remainder of this thesis is structured as follows. In Chapter 2 we answer the first research question, outlining the current situation and system performance. In Chapter 3, a literature study provides answers to the second and third research questions. The first part gives insight into tactical and operational aspects of DRT system design. The second part of this chapter studies literature that helps us to solve the geocoding problem. The fourth and fifth research questions are answered in Chapter 4 and 5 respectively. In Chapter 4, we construct a classification method to identify potential organizations for a shift of transportation requests from the passenger to these organizations. In Chapter 5, we discuss how and to what degree efficiency of transport of elderly and people with disabilities can be improved for organizations labelled as potential. In Chapter 6, we present our recommendations and conclusions.

2 Context Analysis

In the previous chapter, we discussed the relevance of our research and we explained the research design of this thesis. To improve the efficiency of transport of elderly and people with disabilities, several research questions have been formulated. The first of those questions is answered in this chapter. To determine how and to what degree transport efficiency can be improved, we first look at the current situation in the area under study. Section 2.1 explains how the transport of elderly and people with disabilities is currently organized in Drenthe, The Netherlands. Section 2.2 discusses how the current system performs. In Section 2.3 we present a short summary and conclusions.

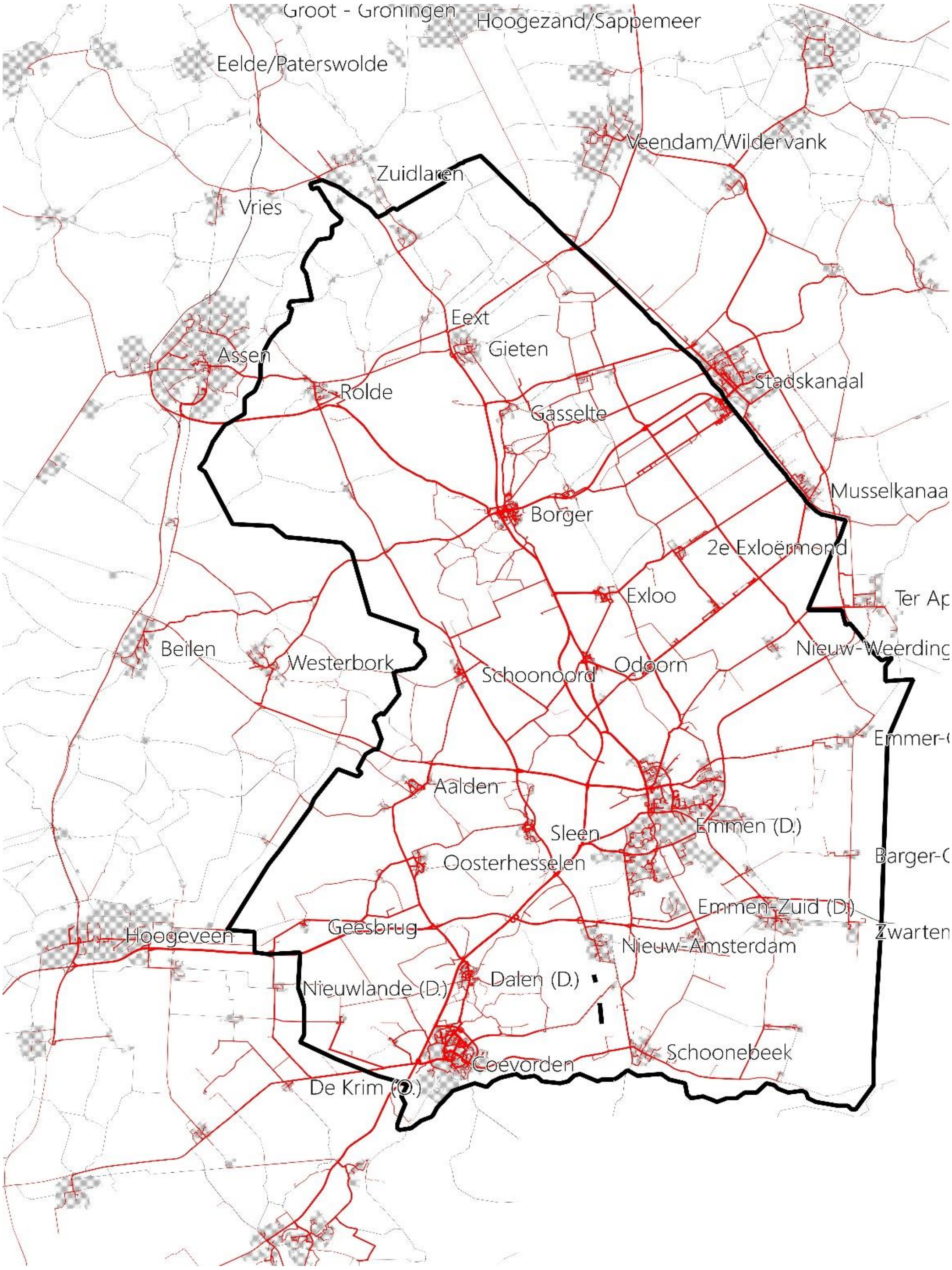

Figure 2: WMO regions of Borger-Odoorn, Emmen and Coevorden (BOCE)

2.1 Current situation

Given the scope of this thesis, we examine the transport of elderly and handicapped people in the southeast region of Drenthe, The Netherlands. This area is demarcated in Figure 2.

From the first of August 2010, Taxi Dorenbos B.V. is (by tender) granted exclusive rights in Borger-Odoorn and from the first of January 2011 also in Coevorden and Emmen. Originally, this contract would end in December of 2014. However, because of pressuring changes in budgets and requirements, the transport agreement has been extended multiple times to mid-2017. This means that, at the moment of writing, Taxi Dorenbos B.V. is still the sole provider of WMO transport in these regions.

The Dutch WMO law provides support to elderly and handicapped people who lack the ability to be fully self-reliant. One of the WMO rights is to apply for a WMO transport ID, which in this particular area, allows for unlimited access to the taxi service of Taxi Dorenbos. This works as follows. Whenever a person needs to go somewhere, he or she calls at least 1 hour in advance to make an appointment for a pick-up time and location. The place of destination is also communicated for planning purposes. A time window of 30 minutes ensures that the pick-up will occur at most 15 minutes early or 15 minutes late. The taxi company is rewarded financially for the percentage of trips starting on time. At pick-up, the taxi driver accompanies the passenger to his or her seat in the taxi bus. A typical WMO taxi bus offers six normal seats and two places for wheelchairs and such alike. During a trip, the driver is allowed to make a detour of at most thirty minutes to pick up other passengers. At drop-off, the driver again accompanies the passenger from seat to front door. Travelled distances are measured based on the fastest route on public roads. The commercial price for a trip begins at a pick-up fee of €5.60. Per kilometre, a price of €1.40 is added to this price. All prices include taxes. With a WMO ID card however, the starting fee is reduced to a mere €0.88 and a kilometre price of only €0.16. The difference is paid for by the municipality.

2.2 Current system performance

In this section, we determine the current efficiency of the transport of elderly and people with disabilities in Drenthe, The Netherlands. Section 2.2.1 gives a summary of the data. Section 2.2.2 analyses trip frequency and Section 2.2.3 estimates current system performance in terms of vehicle occupancy.

2.2.1 Summary of data

The subject of analysis consists of transport data gathered over the period from January 1, 2014 until May 31, 2015. Access to the data was provided to us in January 2016. As stated before, the registration of transport is based on single customer requests for WMO transport. From here on, we define each request for transport from one location to another as a trip. Each trip is described in over 100 different columns of data. A trip basically consists of a passenger ID, departure and arrival information such as time and location, distance travelled and related costs. Furthermore, a standardized set of zeros and ones denotes whether certain conditions apply. For example, 15% of all trips reports the presence of a walker and 10% a(n) (electric) wheelchair. Other conditions are rare. For some trips, additional information is provided, such as a destination synonym such as ‘physiotherapist’. A summary of relevant data can be found in Table 1, Table 2 and Table 3.

The time in Table 1 includes both travel time and transfer time to walk someone to the front door before and after a trip. In November of 2015, some basic WMO data of 2013 had already been provided to us as a means of familiarizing with the data and preliminary research. However, these data only describe trips until the end of May, just as the data of 2015 do. Therefore, for the purpose of comparison, totals have been provided for these periods only. For completeness, the differences between 2014 and 2015 as a whole are shown as well, albeit artificial, since the 2015 numbers are simply extrapolated based on the differences between the first five months and the total of 2014.

Period	Trips	Distance (km)	Time (h)	Travel Time (h)
2013 until May 31	98,528	834,119	37,754	30,717
2014 until May 31	94,584	800,914	36,172	29,617
2015 until May 31	92,912	753,235	35,781	28,923
2014	219,680	1,882,847	84,680	69,365
2015 (forecast)	215,797	1,770,761	83,765	67,740

Table 1: Trips, distances and times compared over different years

Table 2 encompasses the same periods, only here we see averages, rather than summations. This gives us insight into an average WMO trip in the southeast region of Drenthe, The Netherlands. The total time is the sum of travel time and transfer time.

Period	Average Distance (km)	Average Total Time (min)	Average Travel Time (min)	Average Transfer Time (min)
2013 until May 31	8.5	23.0	18.7	4.3
2014 until May 31	8.5	23.0	18.8	4.1
2015 until May 31	8.1	23.1	18.7	4.4
2014	8.6	23.1	18.9	4.2
2015 (forecast)	8.2	23.3	18.8	4.5

Table 2: An average WMO trip

Looking at Table 2, we see no clear difference over time in trip efficiency. Therefore, it is easy to infer from Table 1, that the drop in total time and travel distance over the past few years can only be explained by the decline in the number of trips over these years.

In Table 3, we split the numbers by municipality that pays for the transport in question. This is based on the home address of the passenger that requests the transport. For clarity, the numbers have been translated into percentages. For the reader's information, Regiotaxi (CVV) is transport not specifically used for the transport of elderly and people with disabilities. One example is the transport of asylum seekers. Every municipality uses a separate WMO ID to register trips for such purposes. Therefore, these trips are included in the WMO data. However, because it is less relevant for our research, in Table 3, we merely show the sum of Regiotaxi (CVV) over the three municipalities.

Trips	2013 (unitl May 31)	2014 (until May 31)	2015 (until May 31)	2014
Emmen	76.2	76.2	77.9	76.2
Coevorden	13.0	12.3	11.9	12.5
Borger-Odoorn	8.9	9.6	8.6	9.3
Regiotaxi (CVV)	1.8	1.9	1.6	2.0
Distance (km)				
Emmen	69.5	69.0	70.4	69.1
Coevorden	16.6	15.5	15.8	15.6
Borger-Odoorn	12.1	13.3	12.0	13.0
Regiotaxi (CVV)	1.8	2.1	1.9	2.2
Total Time (hours)				
Emmen	75.7	75.4	77.0	75.3
Coevorden	13.5	12.5	12.3	12.7
Borger-Odoorn	9.1	10.2	9.1	10.0
Regiotaxi (CVV)	1.7	1.9	1.6	2.0
Travel Time (hours)				
Emmen	75.8	75.1	76.6	75.1
Coevorden	13.2	12.5	12.4	12.7
Borger-Odoorn	9.4	10.6	9.5	10.4
Regiotaxi (CVV)	1.6	1.8	1.5	1.8

Table 3: Division of trips, distances and times among BOCE

Although the information presented in Table 3 is comprehensive, the underlying pattern is clear. More than 75% of all trips can be attributed to Emmen. Furthermore, the share of Emmen is steadily growing as where the share of Coevorden is declining. Indirectly, comparing trips and distances, we can also deduct that distances travelled by WMO clients in Coevorden and Borger-Odoorn are greater than the distances travelled by WMO clients in Emmen. This might of course be due to the fact that Emmen, as the biggest city, houses a lot more services, where WMO clients, also from outside of Emmen, make use of.

2.2.2 WMO trip frequency

About 10,000 people are currently in the possession of a WMO ID, however, only about 6,000 have been registered to have made at least 1 taxi trip within the period of analysis. See Figure 3 for more details. On the horizontal axis we find the amount of trips people make in a month. The left vertical axis corresponds to the bars of the histogram. The right vertical axis corresponds to the cumulative line in the graph. In the analysis of each graph in this section, we relate frequencies in the group *More* to the total number of trips registered to get a complete picture.

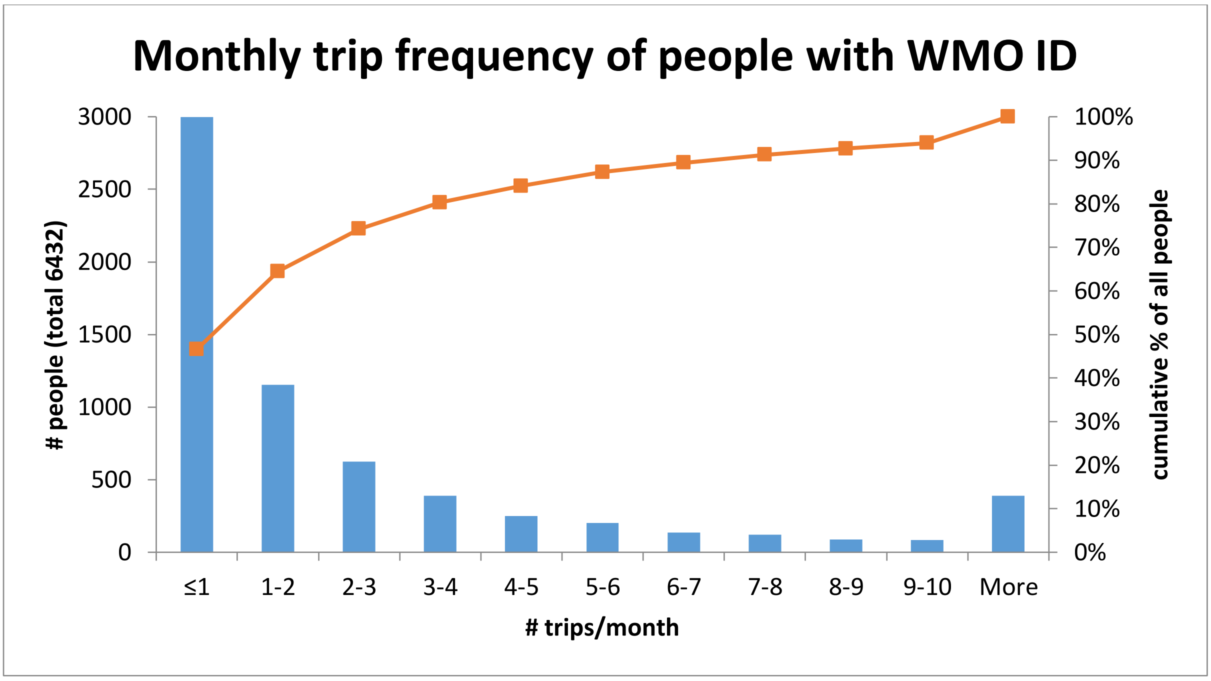

Figure 3: Monthly trip frequency of people with a WMO ID

We see that 3000 people make at most 1 trip every month. Furthermore, 94% of all people with a WMO ID makes at most 10 trips a month. As some of the people in the group 'More' make over 50 trips a month, these top 6% WMO users account for approximately 35% of all trips registered, not even counting the trips on WMO IDs used for Regiotaxi (CVV). To give an idea, limiting those people to a yearly maximum of 2500 or 2000 kilometres, would already result in a 3.4% or 5.6% reduction in total distance registered.

Another perspective would be to look at the destinations people visit. In Figure 4 we again looked at monthly trip frequency, but now by destination.

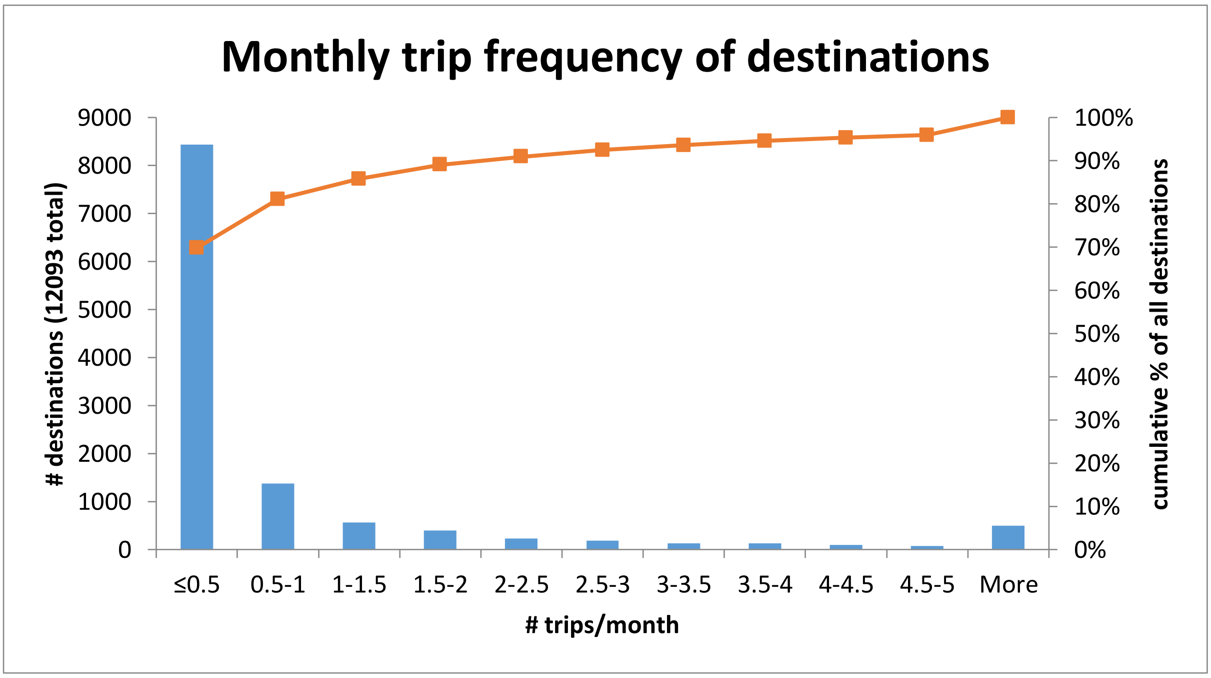

Figure 4: Frequency by which destinations are visited

Similar to Figure 3, from which we learned that most people hardly ever make a trip, here, we see that most destinations are hardly ever visited. Most people travel from and to their home address. This means that their destination on the way back is often their home address. Since most people hardly ever make a trip, these home addresses are also hardly ever visited. Therefore, the results in Figure 4 can partly be explained by the results in Figure 3. The destinations at the far right however, which are visited more than 5 times a month, are not likely to be home addresses, at least not the addresses of private homes. These top 4% destinations account for 57% of all trips registered. To be even more specific, the top 40 destinations already account for 25% of all trips registered.

The destinations in Figure 4 are actually coordinates on a map. As explained briefly in Section 1.2, only 70% of all addresses in the data can be linked to coordinates in the BAG (Dutch database for administration of buildings). Looking closely at the addresses without BAG coordinates revealed that many variations in address notations and zip codes occur in the data. For example, the word *straat* is often abbreviated to *str.* Also, type errors occur and multiple different zip codes appear for one address. We refer to this as the geocoding problem. In effect, a lot of trips are not accounted for in the analysis, because no geographic coordinates could be found for their destinations. This geocoding problem becomes even more troublesome when we plot lines between origin/destination pairs, as can be seen in Figure 5. Here, only 67% of all trips registered are accounted for, because no geographic coordinates could be found for either the origin, the destination, or both.

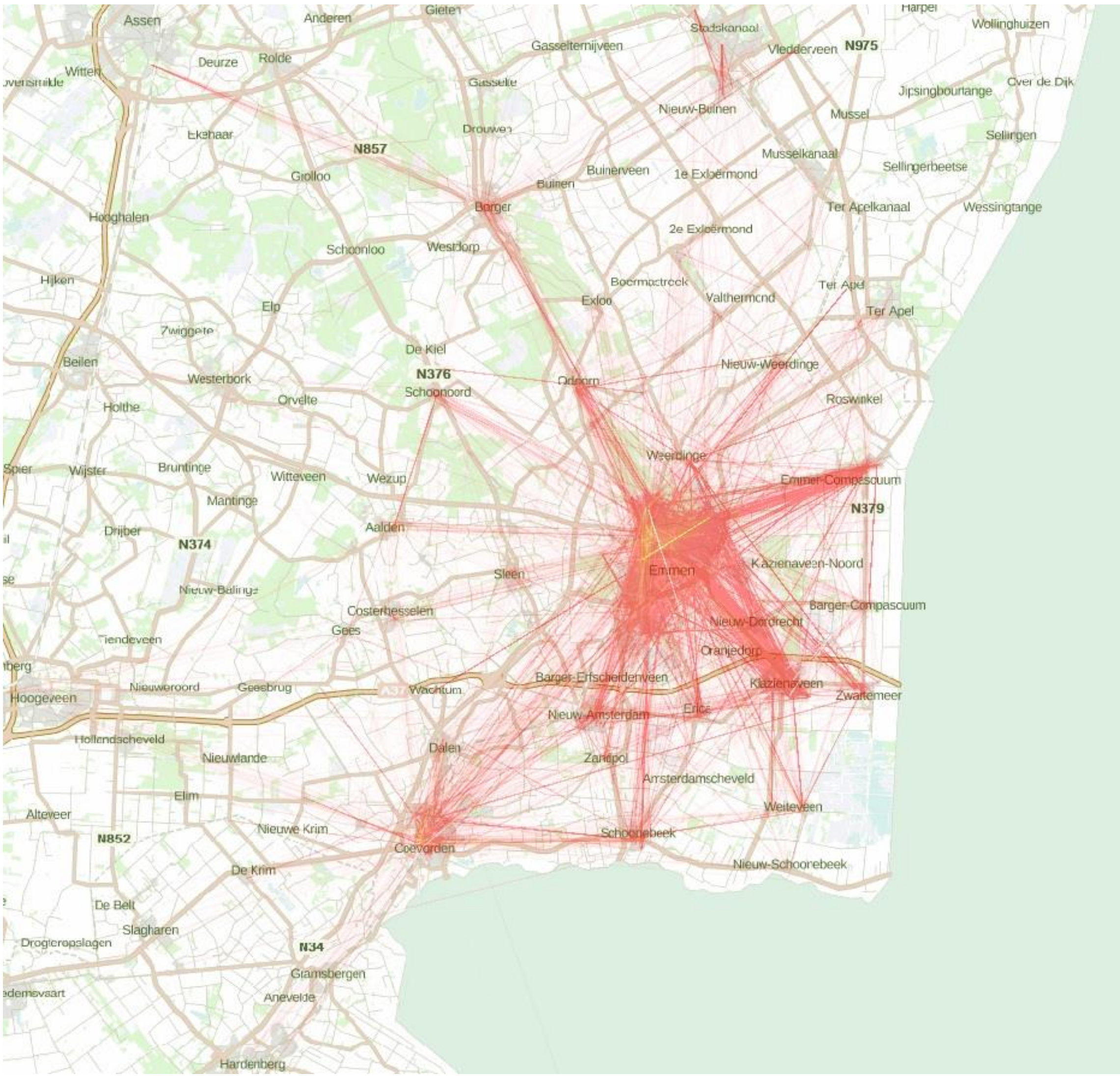

Figure 5: Origins and destinations (QGIS 2.12.2)

Figure 6 gives an idea of trip frequency of each distinct origin/destination pair in Figure 5. The direction of a pair matters here. To clarify, in Figure 4 we only looked at destinations. Here, we look at combinations of origins and destinations.

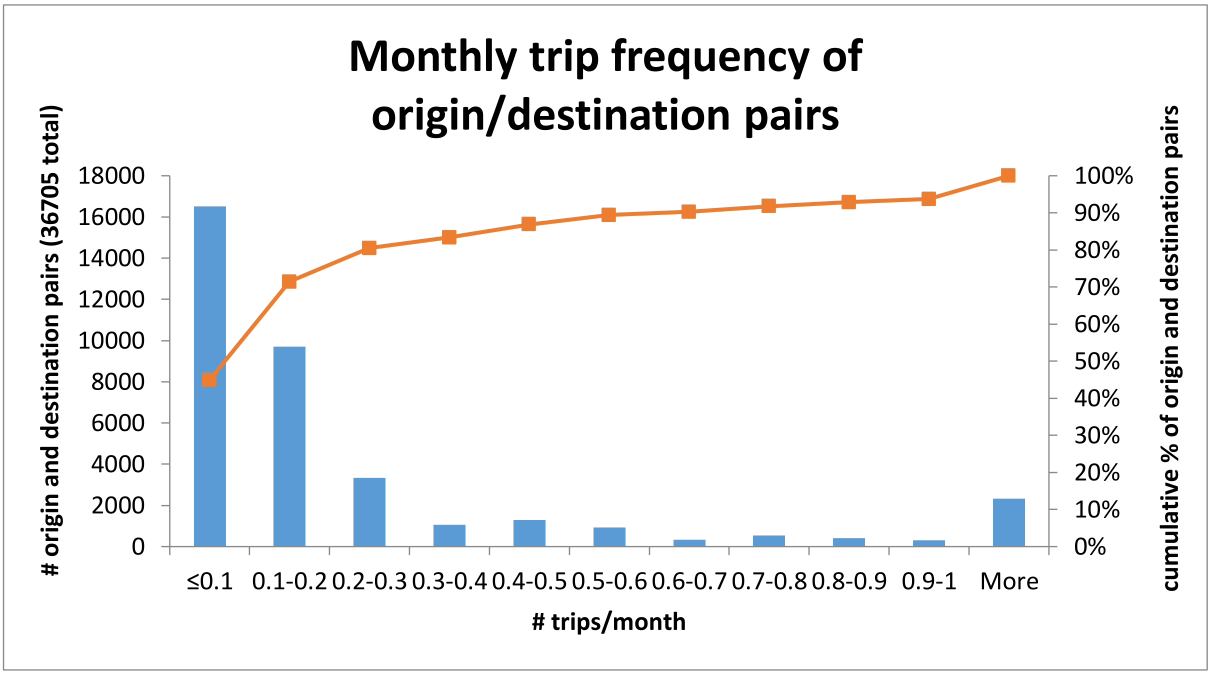

Figure 6: Frequency by which trips occur between distinct orgins and destinations

Almost 94% of all the origin/destination pairs occurs less than once a month. The 2313 origin/destination pairs (top 6%) that occur more than once a month account for 57% of all trips registered. However, it would be a cumbersome task to look at each of these pairs individually. Looking only at the top 100, these origin/destination pairs account for less than 10% of all trips registered.

With regard to the geocoding problem, it is plausible to assume that some frequently as well as some less frequently visited locations are absent in our analysis. Therefore, the pattern we see throughout Figure 3, Figure 4, Figure 5 and Figure 6 would not likely be any different if there was no geocoding problem. However, the results clearly show that a small group of locations is visited significantly more than others. Since we want to determine which kind of locations are visited frequently, we should find a way to overcome this geocoding problem.

2.2.3 Vehicle Occupancy

As stated before, trips are registered based on single customer requests for WMO transport. This means that each trip is linked to only one WMO identity number, even though multiple people might be travelling together. Furthermore, the only reported distance is the shortest distance from origin to destination. We cannot see if other passengers are picked up along the way. This makes it especially difficult to assess the occupancy of a vehicle at a certain point in time. In the data of 2013, a group identity number keeps track of trips occurring together within the same vehicle. Such a group consists of at most six trips with the same pick-up and drop-off locations and times. In a period of more than a year, only 420 different groups are registered, consisting of 908 trips.

In the data of 2014 and 2015, such a group number cannot be found. For these years, we can only rely on two numbers when it comes to vehicle occupancy. The first is the number of fellow travellers, registered within the same trip. Every WMO client is allowed to bring along one accompanying person, who travels under the same conditions. In 2014 and 2015, 6.8% and 5.9% of all trips respectively carried an accompanying person.

A second number we can calculate is the amount of WMO clients travelling at a discount. Whenever two WMO clients decide to travel together from the same pick-up to the same drop-off, one of these clients travels at a 50% discount. From this information, it can be derived that 6.2% and 5.3% of trips in 2014 and 2015 respectively were carried out simultaneously with another trip. To clarify, these numbers are different from the prior mentioned numbers in the sense that the latter combinations consist of people all in the possession of a WMO identity card.

Both of the aspects discussed here give some information pertaining to the occupancy of WMO vehicles. However, both aspects relate to a situation where both pick-up and drop-off locations and times are the same. This gives us a part of the story, but in many cases, people might be picked up at a similar location and might be dropped off at a different location, for example their home address. In these cases, we cannot derive from the data whether these people were driven by the same driver. Furthermore, people might be picked up during another person's trip. These people might be travelling together for a long time. Besides, even in the case where pick-up and drop-off locations and times are exactly the same, a person might not receive a discount, because it was not discussed in advance.

In the absence of a group tracking number, we have to make some assumptions about the current occupancy of WMO vehicles in the southeast region of Drenthe, The Netherlands. Figure 7 shows the average amount of WMO trips during each hour of the week. To clarify, on average, 3.5 trips are carried out on Monday between 23:00 and midnight.

Average Week (trips/hour)

hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0	1.7	1.4	1.8	1.9	2	5.2	8.2
1	0.4	0.5	0.6	0.6	0.6	1.6	2.4
2	0.2	0	0.1	0.1	0.2	0.6	1.6
3	0.1	0	0.1	0.1	0.1	0.4	1.5
4	0.2	0.1	0.1	0.2	0.2	0.2	1.2
5	0.1	0.1	0.2	0.3	0.1	0.2	0.6
6	6.5	6.6	6.1	5.5	4.2	0.9	0.6
7	11.8	11.6	12.2	11.2	9	2.7	2.2
8	25.9	35.9	37.2	31	30.4	9.5	8
9	53.8	61.3	59.8	60.4	56.8	24.6	26.1
10	38.5	49.8	48.8	49.4	48.8	25.3	25.7
11	34.5	45.1	42.4	41.6	42.2	22.2	20.7
12	48.3	55.5	53.9	57.1	49.4	33.2	30.9
13	58.3	67.1	69	67.8	61.8	51.4	62.4
14	51.3	56.6	59.2	56.7	51.5	41.6	51
15	68.6	68.6	68.3	72.1	58	35.3	32
16	48.8	56.1	59.2	58.6	49	46.8	53.4
17	26.2	31.7	32.7	34.4	28.7	34.7	38.9
18	34	34.8	35.9	38.3	31.9	39.4	35
19	27.8	18.2	25.1	27.8	28.1	44.5	30.3
20	27.6	20.2	19.9	22.9	15.5	18.4	23.7
21	18.2	17.2	16.6	18.9	17.6	23.7	15.6
22	10.8	10.1	17	14.6	23.9	33.4	17.6
23	3.5	3.9	4.4	5.2	11.3	0	6.7

Figure 7: Trips/hour during an average week

Thursday between 15 pm and 16 pm is the busiest hour of the week, with, on average, 72 trips per hour. However, Figure 8 shows that in some hours, peaks of more than 100 trips have been registered. Although the occurrence of this happening is very rare, the WMO system should at least be prepared for peaks up to 80 trips an hour. These 80 trips can be dispersed across the entire southeast area of Drenthe. To start every trip on time, the taxi company will therefore have to dispatch her fleet across the entire region.

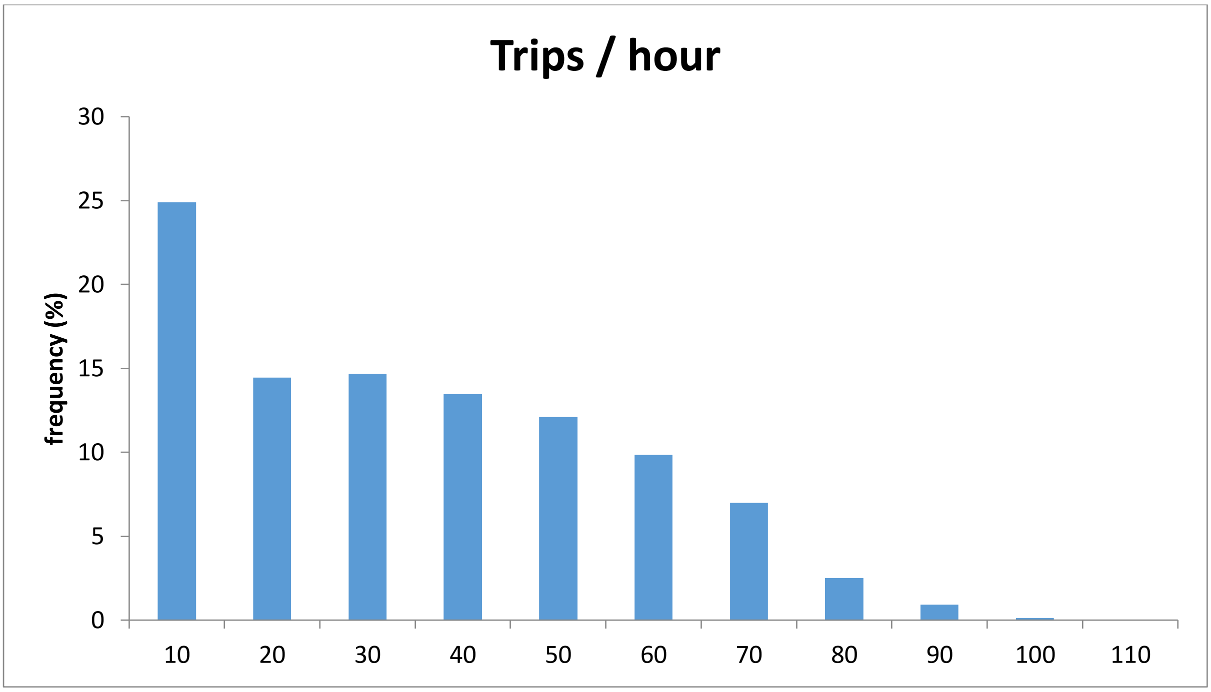

Figure 8: Frequency of trips per hour

The diagram in Figure 9 shows that almost 75% of the trips is driven within the Emmen region, i.e., from an address in area 78 to another address in area 78 on the map. So, on busy days, 75% of 80 trips per hour are driven within this particular area, in other words 60 trips per hour.

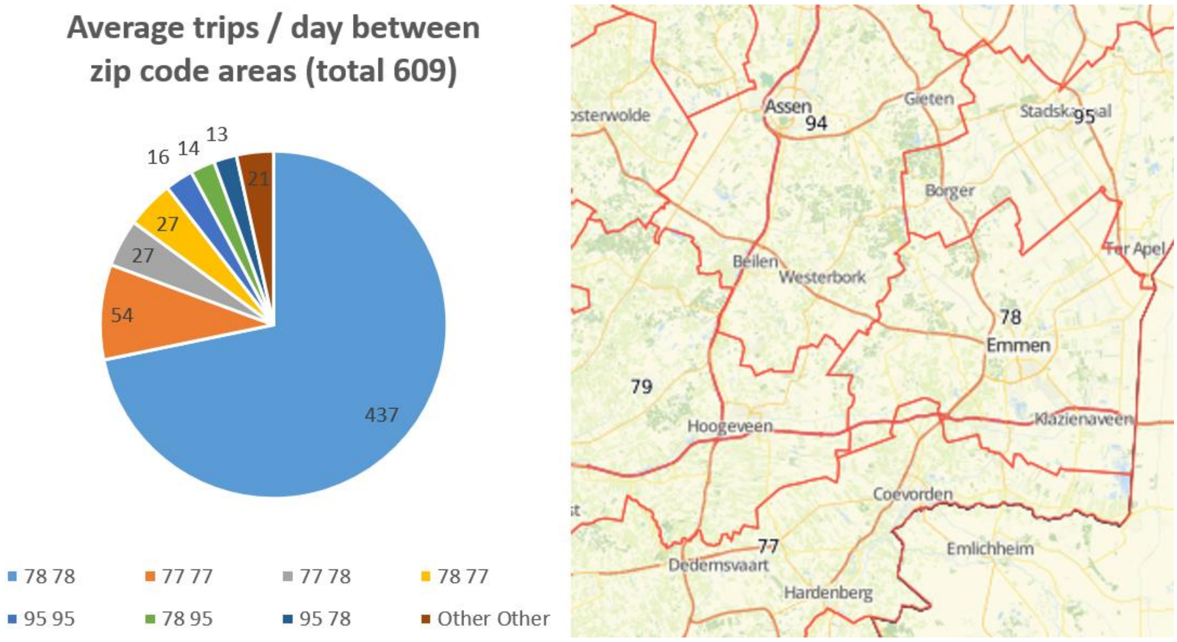

Figure 9: Daily movements in number of trips between the zip code areas depicted on the map

The taxi company claims to dispatch 40 taxi buses every day for the purpose of WMO transport in the area. Looking at the diagram in Figure 9, we could assume that 75% of the entire fleet of vehicles is allocated to the Emmen region. However, it is likely that taxi buses in the urban area of Emmen are able to drive more efficiently than buses in the surrounding areas. To be on the safe side, we assume that at least 50% of the fleet is dispatched to the Emmen region. In other words, at least 20 buses are used to serve a peak of 60 trips per hour. This comes down to at most 3 trips per vehicle in busy hours. Taken into account 6% fellow travellers, this adds up to little more than 3 passengers per vehicle per hour. Given an average trip duration of 23 minutes, see Table 2, it is likely that more than one trip is executed in an hour, which means these 3 passengers are not likely to be in the same vehicle at the same time. Therefore, we can say with great certainty that there are rarely more than 2 passengers in a taxi bus at the same time. A typical bus used for WMO transport offers room for 6 normal seats and 2 wheelchairs. In conclusion, the occupancy of WMO vehicles in the southeast region of Drenthe, The Netherlands, is very low.

2.3 Conclusion

In the southeast area of Drenthe, The Netherlands, a single taxi company provides WMO transport for elderly and handicapped people in Borger-Odoorn, Coevorden and Emmen. A fleet of 40 buses, suited to special needs, is dispatched daily to execute about 200 thousand trips a year. Analysis of trip data shows that only 40 frequently visited destinations account for 25% of all trips registered. As most trips are requested by a relatively small group of frequent travellers, group arrangements for transport might be possible at some of these locations. It depends on the type of organization at these locations whether this is really an option. In order to determine which kinds of organizations are located at the frequently visited destinations, we need to overcome the observed geocoding problem. This problem revealed that a lot of variations in address notations occur in the data. Therefore, many trips are linked to false or non-existent locations, i.e., locations of which no geographic coordinates could be found. Finally, to assess current performance of the WMO transport system, we looked into the occupancy of WMO vehicles. Based on a number of substantiated assumptions, we estimated that there are currently rarely more than two passengers in a taxi bus at the same time.

3 Literature

In this chapter, a literature study provides insight into strategic, tactical and operational aspects of the design of a DRT system for elderly and people with disabilities. Furthermore, we look at ways to overcome the observed geocoding problem. This enables us to determine which kinds of organizations are visited frequently. Section 3.1 summarizes the background of DRT systems. In Section 3.2, we look at strategic and tactical aspects of network design. Section 3.3 discusses the Dial-a-ride problem. In Section 3.4, we look into algorithms to solve the geocoding problem. Section 3.5 presents a short summary and conclusions.

3.1 Background of DRT

As we outlined in the introduction of this thesis, elderly and people with disabilities are especially vulnerable. Their restricted mobility discourages them from using regular public transport, making it difficult to access social environments. To enable these frail groups of society to participate, significant progress has been made in the development of more personalized demand-responsive transportation (DRT) services (Bruni, Guerriero, & Beraldi, 2014). Demand responsive transport ranges from a conventional bus route with flexible operating modes, to a shared taxi service (Nelson et al., 2010). However, a more strict definition is used by Parragh, Doerner, and Hartl (2010), who declare that both vehicle routes and schedules in a DRT system must be generated on the basis of user requests. DRT systems are usually operated by smaller vehicles (small buses, minibuses) and maxi-taxis (large taxis, often seating up to 10 passengers) (Mulley et al., 2012). DRT is mostly coined with so called dial-a-ride services, which were predominantly used for highly dispersed trips and to provide transportation in suburban areas for non-working purposes (Mageean & Nelson, 2003).

Over the past decades, demand-responsive services have gained popularity because of a need for more flexible transportation than regular buses can provide. Early studies have shown high demand for door-to-door services by elderly and people with disabilities (Stern, 1993). Stern shows that older people need to make a certain limited number of trips, regardless of price or mode availability. These findings are also supported in more recent studies (Nguyen-Hoang & Yeung, 2010). Governments all over the world recognise the central role of transport in providing accessibility and have included flexible transport services, as a means to enhance social participation, in their political agendas (Mulley et al., 2012). Furthermore, anti-discrimination legislation has forced transit agencies and local governments to provide vulnerable people with comparable means of transportation (Nelson et al., 2010). Take the USA for example. “Since the enactment of the Americans with Disabilities Act (ADA) in 1991, DRT has expanded from a national total of 42.4 million passenger trips for the year to a total of 73.2 million passenger trips in 2000” (Palmer, Dessouky, & Abdelmaguid, 2004). In the USA, we see a continuous trend of contracting DRT services to the PHV (private-for-hire vehicle) industry, giving transit agencies the opportunity to focus on their core activity and thus remain cost-effective (Gilbert et al., 2002). However, there is little evidence on the economic viability of DRT systems (Afonso, Telhada, & Carvalho, 2016). DRT services have not demonstrated to be viable self-supporting systems, except for certain niches such as airport-shuttle services and rail-feeder services (Mageean & Nelson, 2003; Ryley et al., 2014). The subsidy involved in DRT services is usually very high (Enoch et al., 2006) A pilot study for a tele-bus service in Krakow indicated an increase in public transport availability, although vehicle occupancy should be further increased to cut cost per passenger (CIVITAS, 2014). In Denmark, open DRT services are integrated with transport of elderly and people with disabilities in order to meet this requirement. However, it seems that the actual cost benefits of DRT services should be sought in the relative savings due to increased public transport income and reallocation of fixed-route resources. Nevertheless, improvements in routing and scheduling software, along with the development of smartphone-based applications continuously make DRT services more effective (Davison et al., 2014).

3.2 Network design

In the planning of transportation systems, we can distinguish three levels of decisions to be made, namely strategic, tactical and operational (Crainic & Laporte, 1997). Decisions that pertain to the strategic level and the tactical level are discussed in Sections 3.2.1 and Section 3.2.2 respectively. We elaborate on operational aspects in Section 3.3.

3.2.1 Strategic decisions

At the strategic level, upper management has to set out policies and decide on available resources such as locations of facilities and hardware. To determine these locations and their service coverage, first, we look at several location models. Second, we elaborate on the resource requirements of a transportation system. As these requirements depend on policy, technology and quality of the service, these aspects are discussed in the remainder of this section.

As discussed in Section 3.1, DRT services are designed for different purposes, but the common denominator of DRT and public transport in general is to improve access to a network of services. Access to services in an area can be assessed using different spatial accessibility models. The location set covering problem (LSCP) introduced by Toregas et al. (1971), aims to find as few facilities as possible, to ensure full coverage of all the demand areas. The more popular maximal covering location problem (MCLP), introduced by Church and ReVelle (1974), maximizes the population covered by a limited number of locations. On the basis of these models, (new) facility locations can be determined, as well as caveats in the current transportation network. The first location models lack accuracy because of outdated distance measures (Apparicio et al., 2008). In the presence of geographic information systems (GIS), new methods have been exploited to incorporate more realistic network attributes. A network covering location problem (net-CLP) has been introduced by Ye and Kim (2016), to capture actual road distances and travel times. Besides accuracy, another advantage of using existing transportation networks, is to account for various modes of transport and different traffic conditions (Ye & Kim, 2016). Using different thresholds of travel time, the authors demonstrate that a more accessible transportation system could help to increase service coverage in the area (Ye & Kim, 2016). An issue that all location models need to deal with is their spatial resolution and the aggregation errors it entails (Murray & O'Kelly, 2002; Murray, O'Kelly, & Church, 2008). To minimize these errors, Benenson et al. (2017) discuss the potential of analyzing transit accessibility at the resolution of individual buildings.

Once the service area and demand for transportation in that area has been determined, the requirements of the transport service itself have to be considered. Researchers have presented several models to estimate the resource requirements of proposed DRT systems. The required number of vehicles for example, depends on constraints on ride-times and time-windows (Diana et al., 2006). One advantage of these approximation methods is that they merely require the demand density of the service area, which may prove convenient if data about demand patterns is not available during the planning phase. A recent, much more detailed study, that also accounts for spatial and temporal dependencies between transportation requests, has been performed on the case of Flanders (Neven et al., 2015). Given different policy scenarios, resource requirements are calculated for the transport system. For example, more flexibility of users in time-windows allows for more efficient schedules. The results of the Flanders study show that the base scenario of 100% coverage by subsidized adapted transport would not be attainable by the Flemish government, because of disproportional costs. A 50% coverage would reduce the required resources by almost 50%, but this would also ask for a complex framework to distinguish which request for transport would be eligible for subsidy and which would not. According to the authors, the context-sensitive input parameters can easily be modified to fit other countries, perhaps also incorporating social benefits of different policies, related to quality of service (Neven et al., 2015).

Resource requirements of a transportation system depend on the type of service and the technology used. In the light of technological advancements, the US Department of Transportation presented a study, estimating expected benefits of several advanced public transportation systems (APTS), such as Fleet Management Systems (Goeddel, 2000). Several other intelligent transportation systems (ITS) used to improve the performance and attractiveness of public transport are discussed by Blythe et al. (2000). To establish the actual impact of advanced technologies on the performance of DRT providers, a nationwide study has been executed, comparing 62 paratransit companies in the USA (Palmer et al., 2004). The results show that the adoption of computer aided dispatching (CAD) technology, using automated scheduling and dispatching functions, is beneficial in terms of passenger miles per vehicle, but not in terms of operating costs. The opposite revealed to be true for the implementation of advanced communications technology, which showed no productivity benefits, but did reduce operating expenses. The authors conclude that the implementation of CAD systems might entail extra training of personnel and additional functions associated with the software. Furthermore, the adoption of advanced communications technology probably reduced supervisory and dispatch labour costs, rather than fuel costs (Palmer et al., 2004). It must be noted that the study examines National Transit Database (NTD) data from 1997 to 1999. This might pose a discrepancy in the interpretation of the word ‘advanced’ in advanced technologies.

In the trend of growing social networks, smartphone-based applications have enabled ride-sharing services as an alternative to expensive taxi services (Simonin, 2014). These applications match riders to drivers who travel along their route, taking into account time-windows of the participants and vehicle capacity. Similar to ride-sharing services for the public, a location-based dial-a-ride service for elderly and people with disabilities in Taiwan has been proposed by Cheng (2011). A server processes requests based on the availabity of vehicles in the neighbourhood and their current route. One of the vehicles is then assigned to the request and rerouted, based on an ant colony algorithm (Cheng, 2011). The downside of such a service is that it requires investment in a system architecture. Furthermore, it requires elderly and people with disabilities to use smartphones to submit a request for transportation. Finally, last minute modifications of current routes might not always be feasible in terms of additional travel times of passengers on board of a vehicle, especially when the fleet is dispersed over a large area of service. One step further in the future is the use of automated vehicles for door-to-door services, such as the cybercars discussed by Parent (2007). Although currently only implemented in protected environments, large improvements have been made in obstacle avoidence and fleet management techniques to support the use of automated vehicles (Parent, 2007).

Last but not least, the quality of the proposed transportation system has to be considered. Quality of service in public transport in general has been widely studied. Waiting times, cleanliness and comfort have been found to be the most important factors valued by users of public transport (dell’Olio, Ibeas, & Cecin, 2011). However, the subjective users’ perception should be evaluated against more objective performance measures to guide quality improvement efforts (Eboli &

Mazzulla, 2011). A broad review of literature on quality of service of dial-a-ride (DAR) systems in particular can be found in work of Paquette, Cordeau, and Laporte (2009). The authors recognize the gap in literature between customer-based perceptions of quality, covered in the marketing literature, on the one hand, and the technical-based specifications of quality, defined in the operations research literature, on the other hand. The specifications used in OR models usually tend to focus on the more quantifiable aspects of quality, such as time-windows and ride times (Paquette et al., 2009). Their work also addresses the need for an improved measurement scale of quality that is internally consistent and valid, something earlier research lacked evidence of. This need is met in later research by Paquette et al. (2012). Several of the results in this research prove relevant for management practice. First of all, the most important quality criterion for improving service turns out to be the ability to make last-minute changes to reservations. To allow for this level of flexibility, DRT services should incorporate dynamic planning tools. The second most important criterion for improvement is that of always having the same driver. The consistent vehicle routing problem could be extended to the context of dial-a-ride operations to facilitate in this requirement (Groër, Golden, & Wasil, 2009). Other important factors are related to time and punctuality, easily modifiable constraints in OR models. However, the authors themselves recognize that importance of a service attribute may depend on the current quality level (Paquette et al., 2012). Furthermore, this study indicates that user perceptions of quality vary for different subgroups of society, which is also supported by other research (dell'Olio et al., 2011). Therefore, efforts to improve quality of service for elderly and disabled, should be tailored to their specific needs.

3.2.2 Tactical decisions

Once decisions about the type of service, service policy and system requirements have been made at the strategic level, design of the service network has to be determined at the tactical level. Decisions at the tactical level are medium-term decisions concerned with the allocation of resources that are determined at higher levels. Tactical planning in the transport of people involves decisions about the design of routes along a sequence of stops, the frequency at which vehicles operate along a route and their associated timetables. We find different terminology in literature regarding the transport of freight and the transport of people. To avoid mixing, we briefly summarize the tactical decisions involved in freight operations, before we continue to elaborate on the tactical decisions involved in the transport of people. The design of demand responsive networks will be discussed towards the end of this section.

The service network design problem is usually associated with the tactical planning of intermodal freight operations (Crainic & Laporte, 1997). Consolidation and trans-docking at terminals are important cost aspects of these operations that determine the optimal allocation of available resources. The service network design problem (SNDP) focuses on generating a transportation plan that minimizes costs while satisfying transportation demand (Ng & Lo, 2016). However, an SNDP may also be used to maximize the level of service, for example in the redistribution of bikes across stations in a bike-sharing service (Neumann-Saavedra et al., 2016). An SNDP is usually modelled using network design formulations, such as path formulations, node-arc formulations and tree formulations (Wieberneit, 2008). Pick-up and delivery operations within a local service area of a hub or terminal are generally not considered in a service network design problem (Guastaroba, Speranza, & Vigo, 2016).

Tactical planning in the transport of people is associated with the first three steps of the transit planning process. There are 5 steps in the transit planning process: (i) designing the network of routes, (ii) frequencies setting, (iii) timetabling, (iv) vehicle scheduling and (v) crew scheduling and rostering (Asadi Bagloee & Ceder, 2011). Early studies focussed primarily on vehicle and crew scheduling activities because of the potential cost reduction of more efficient schedules. However, with automated scheduling methods being widely accepted, it became feasible to focus on higher level decisions of the transit planning process, such as network design and frequency setting (Ceder & Wilson, 1986).

The first step in the transit planning process is the network design problem. Based on origin and destinations matrices with the expected amount of passengers between possible stops and transfers, a number of routes and stops has to be set in this step, such that demand of a particular area is covered (Guihaire & Hao, 2008). In a case study of Singapore, researchers have designed new bus routes, based on clusters of taxi rides (Chuah et al., 2016). These clusters are presented in Figure 10 as origin/destination pairs, encircled with red dots. The blue arrows represent newly designed bus routes.

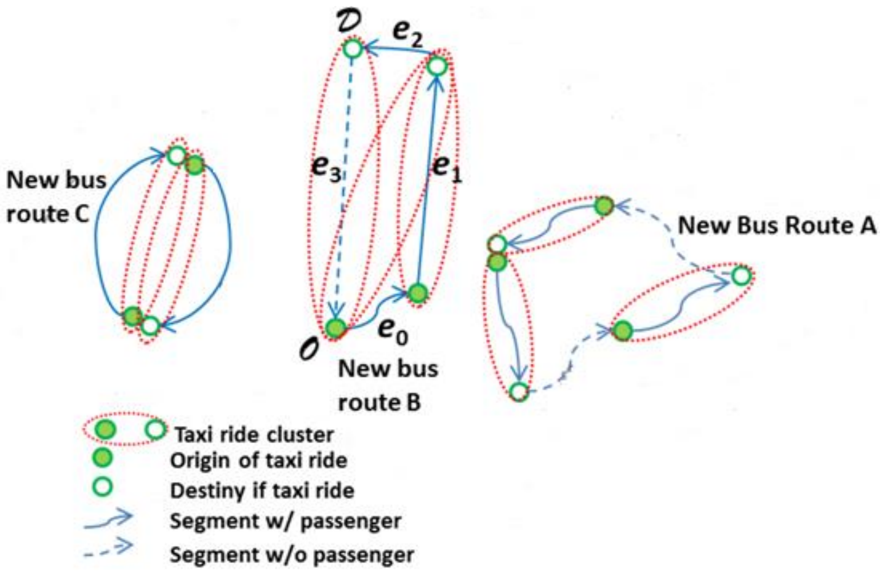

Figure 10: Clustering of frequent taxi rides in Singapore (Chuah et al., 2016)

Consider route B: The bus starts at the origin of two clusters of taxi rides (O). Following segment e_0, the bus picks up passengers from a second cluster with a similar destination. Segment e_1 takes the bus to its first destination, alighting most of the passengers, after which only segment e_2 has to be traversed to get to the final destination of the remaining passengers (D). This way, three different taxi routes can be coverd by only 1 bus line with only small deviations from the shortest path. In this case, segment e_3 needs to be added as a connection to complete the route. Since this is a segment without transport of any passengers, this segment is represented as a dashed arrow. Preferably, we want as few emtpy segments as possible without deviations from the shortest path between origins and destinations. Therefore, alternative C in Figure 10 is preferred over alternative A.

A lot of aspects have to be taken into consideration in the first step of the transit planning process, as the network of routes will have great impact on all the next steps. For example, an existing network infrastructure might already be in place, meaning investments would have to be made to adept to a new situation. Conflicting interests between users and operators make the network design problem even more complex. Users want a network with great accessibility and directness, meaning the routes almost entirely follow their shortest path from origin to destination. The operators essentially want to minimize route length for an efficient use of resources. The problem of locating and relocating bus stops along routes to maximize service coverage can be solved by the accessibility models discussed in Section 3.2.1. The route selection of the transit network design problem is modelled in various ways, as discussed by Guihaire and Hao (2008).

After routes and sequences of stops have been determined, the next step in the transit planning process is frequencies setting. To optimize frequencies along each route, demand information has to be known for different days of the week and times of the day, as well as vehicle capacities. From a user's perspective, headways, i.e., the times between each line run, cannot be short enough. Operators on the other hand, want to minimize the amount of drivers and buses needed to perform the service, without excessive waiting times. The network frequencies setting problem is modelled in various ways, discussed by Guihaire and Hao (2008).

The third step in the transit planning process is the development of timetables for trips. This is especially important for the timing of transfers in the network. Especially when headways are large, such as is the case in rural areas, coordination of transfers becomes useful. One of the models that weighs transfers in timetabling is discussed by Wu, Tang, and Zhang (2013). A model for efficient vehicle scheduling while at the same time balancing timetables from a passenger's point of view has been explored by Schmid and Ehmke (2015). The last steps in the transit planning process concern operational decisions rather than strategic and tactical decisions. These are further discussed in Section 3.3.

For the transportation of elderly and people with disabilities, demand-responsive transportation is the designated type of service. The design of demand-responsive systems is fundamentally different from the design of public transit systems with respect to the first steps in the transit planning process. In demand-responsive transportation, the routes and departures are usually subject to users' demands, which puts an entirely different perspective on network design. The most commonly known demand-responsive system is a taxi-service, in which people are transported from door to door along the shortest path. In this case, network design is confined to questions such as the number of vehicles and (re)positioning strategies. Another common DRT system is one in which people are still transported from door to door, however the route depends on a sequence of passengers picked up along the way. Such a system is currently used for the transportation of elderly and people with disabilities in Drenthe, The Netherlands. Common practice in these systems is to construct a set of a priori routes once the majority of bookings is known. These routes may later be modified to accommodate late requests (Bruni et al., 2014). The design of such practices is driven by two conflicting criteria. On the one hand, incorporating late requests in the design of routes increases occupancy of the vehicle. On the other hand, allowing for too many different deviations from existing routes may increase the travel time of passengers to an undesirable level (Bruni et al., 2014). This is where hybrid systems come into play (Aldaihani et al., 2004). The idea behind such systems is to integrate one or more fixed lines with a flexible demand-responsive system for the first or the last mile of a passenger's trip. For example, to minimize walking and transfer time between train stations and commuter work places, a circulator service network design is proposed by Yu, Machemehl, and Xie (2015). Their proposed concept is to construct routes and stops based on real-time destination information of passengers, minimizing their walking distance as well as the time of passengers spent on board of the vehicle. Several other hybrid systems such as feeder bus services are discussed by (Aldaihani et al., 2004). The authors themselves introduce a model that aids decision makers in the design of a hybrid network. The model determines an optimal number of zones in a service area, as well as the optimal number of buses operating on fixed lines between the centres of each zone, see Figure 11.

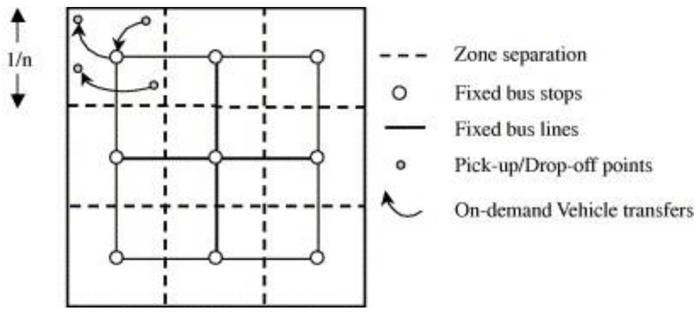

Figure 11: Hybrid grid structure (Aldaihani et al., 2004)

Within each zone, the number of on-demand vehicles is based on the demand rate in the service area and the probability that a passenger has to travel within the same zone, to a zone along the same fixed bus line, or to a zone which is diagonally positioned, meaning two fixed lines have to be traversed (Aldaihani et al., 2004). The total cost of the system varies with the cost of on-demand vehicles and buses and the travel times of passengers, which depend on the zone structure. (Aldaihani et al., 2004). More and smaller zones result in less expensive on-demand miles, but at the same time, the probability of one or two transfers is increased, along with waiting times.

3.3 Dial-a-ride Problem

In the previous section, we covered strategic and tactical aspects involved in the design of a transportation service. Operational aspects are considered in several vehicle and crew scheduling models in literature (Bunte & Kliewer, 2009; Mesquita, Paias, & Respício, 2009). However, these considerations turn out to be very different for different systems. The dial-a-ride system that is currently used in Drenthe, The Netherlands, requires a particular approach. The routes of the door-to-door service for elderly and people with disabilities depend on a sequence of passengers picked up along the way. Some of the requests are known in advance and some may be accommodated later. The operational aspects involved in the planning of such dial-a-ride systems are covered in the Dial-A-Ride problem (DARP), which we discuss in this section. First, we outline the background on dial-a-ride problems. Second, we look into exact algorithms to solve the DARP. Finally, we discuss the development of heuristics that have been introduced to solve realistic sized instances of dial-a-ride problems.

Progress in dial-a-ride systems has largely evolved around the implementation of automated dispatching and scheduling systems. Depending on algorithmic solutions, these systems have developed over the years, with advancements in operations research. The Dial-a-Ride Problem (DARP) is initially based on the vehicle routing and scheduling problem, of which many variants are discussed by Sbihi and Eglese (2007). These models were extended to include pick-ups and deliveries. Pick-up and delivery problems (PDPs) can further be classified in terms of static and dynamic problems. An overview of static PDPs, in which all information about pick-ups and deliveries is assumed to be known in advance, is given by Berbeglia et al. (2007). Dynamic PDPs, in which current solutions are adjusted over time to incorporate new information, are discussed in later work (Berbeglia, Cordeau, & Laporte, 2010). As the pick-up and delivery of people in DRT systems received more attention during the seventies, algorithms were improved to incorporate constraints on ride-times and time-windows, commonly known as the dial-a-ride problem (DARP) (Cordeau & Laporte, 2007).

In terms of exact algorithms for the DARP, early work has focussed on dynamic programming algorithms to solve the single vehicle many-to-many DARP to optimality (Psaraftis, 1980) (Psaraftis, 1983). The multiple vehicle many-to-many DARP has been solved by Desrosiers, Dumas, and Soumis (1988), using a cluster first and route second procedure. First, nearby customers with similar requests are grouped together into mini-clusters. These mini-clusters are then optimally assigned to vehicles during the routing phase (Desrosiers et al., 1988). Branch-and-cut algorithms, which employ new valid inequalities and inequalities developed for the pick-up and delivery problem, are presented by Cordeau (2006). In other work, Ropke, Cordeau, and Laporte (2007) introduce a more efficient 2-index formulation model, as opposed to a 3-index formulation mixed integer program (MIP). The model introduced by Parragh (2011) incorporates heterogeneous modes of transportation into a new branch-and-cut algorithm and also penalizes waiting time of passengers on board of the vehicle. A variable neighbourhood search heuristic, proposed by Mladenović and Hansen (1997), is adapted and used to compute an initial upper bound to the DARP solution (Parragh, 2011).

Heuristics for the dial-a-ride problem have been developed alongside exact algorithms to solve real-size problems. The situation where transportation requests are received well before the time of vehicle dispatching is considered by Jaw et al. (1986). Their ADARTW (Advanced Dial-A-Ride with Time Windows) heuristic is used to tackle the time-constrained version of the multi-vehicle many-to-many DARP. Each customer is inserted sequentially into the work schedule of one of the available vehicles. The REBUS solution algorithm introduced by Madsen, Ravn, and Rygaard (1995) is an improved and generalized version of ADARTW. Along with other developments such as reduced computation time and sorting of jobs based on complexity of insertion, REBUS allows for more flexibility. Furthermore, it is designed to solve dynamic route problems, meaning a job, i.e., customer request, may enter the system at a random time or may be cancelled at any time (Madsen et al., 1995).

In the light of anti-discrimination legislation in the USA and the increased burden of DRT services on the budgets of transit agencies that accompanies this, a hybrid heuristic is proposed by Aldaihani and Dessouky (2003). The idea of their solution approach is based on a hybrid system in which DRT services are combined with conventional fixed-route services. A trip from start to destination can now be cut into a maximum of three legs, having at most two transitions. “Clearly, a curb-to-curb system as opposed to a hybrid system minimizes the travel time for the passenger. However, shifting some of the demand to fixed routes may alleviate some of the demand pressure for the on-demand vehicles caused by ADA (Americans with Disabilities Act) requirements” (Aldaihani & Dessouky, 2003). Their model minimizes total vehicle distance of on-demand vehicles (TVD) and the total trip time of passengers (TTT), following the insertion and improvement procedure in Figure 12. The input of the insertion procedure is a set of candidate paths for each request, based on a number of threshold values. For example, the ratio of the distance from and to bus stops compared to the fixed-route distance may not be too big, to justify a transfer. If one or more of the criteria are not met, the path is infeasible for the request. If at least one path is feasible for a request, it is a hybrid request. Otherwise it is a door-to-door request. The first step of the insertion procedure, depicted on the left of Figure 12, is to find the shortest path for each hybrid request in terms of on-demand vehicle distance. The first legs of these paths, i.e., from origin to the first bus stop, along with the door-to-door requests are stored in a set N, which is sorted based on pick-up time. The request with the earliest pick-up time is selected and scheduled into the work schedule of the vehicle that results in the lowest on-demand vehicle distance. The schedule is constrained to time-windows. If no vehicle can adhere to the time-windows of the request, another vehicle is added. Based on the schedule of the first leg of a hybrid request, the pick-up time and point of the final leg can be determined. This request is resorted into the set N to repeat the procedure until N is empty. The initial solution does not consider the total trip time of the passengers, which includes waiting time at bus stops and travel time on buses. During the improvement phase, depicted on the right of Figure 12, the hybrid request with the earliest pick-up time is selected. All the alternative paths for this request are evaluated in terms of both TVD and TTT. A swap is made if a proposed alternative improves the objective function.

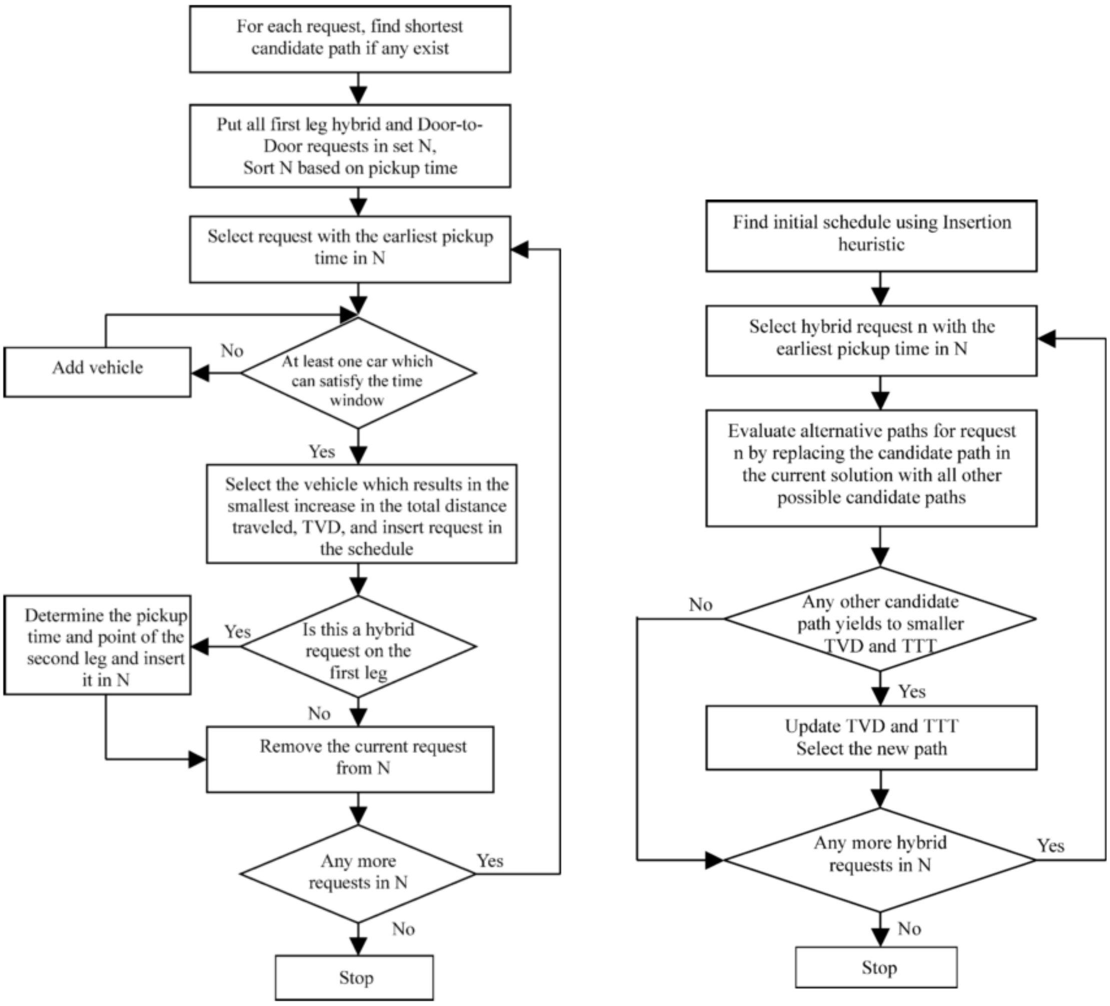

Figure 12: Insertion procedure (left) and improvement procedure (right) (Aldaihani & Dessouky, 2003)

After the improvement steps, Tabu Search is applied for re-sequencing requests and re-assigning them to a different vehicle. Results of running the complete method showed that almost 20% of DRT requests could be shifted to a hybrid system, reducing DRT vehicle distance by almost the same amount (Aldaihani & Dessouky, 2003). However, the introduction of Tabu procedures increased computation time considerably, while solution quality did not.

In more recent research, flexible scheduling procedures are being developed to cope with uncertain events such as vehicle breakdowns, traffic jams, cancellations and new requests (Xiang, Chu, & Chen, 2008). Fast re-optimization is needed to implement these techniques in real-time environments. This is ensured by simultaneous employment of inter-trip and intra-trip exchanges. Furthermore, a secondary objective function enables this method to escape from local optima efficiently, steering it in a promising direction, rather than a random direction such as many meta-heuristics do (Xiang et al., 2008).

A heterogeneous version of the dial-a-ride problem was developed by Melachrinoudis, Ilhan, and Min (2007) for the purpose of patient transportation in a health care organization. The vehicles in their model are heterogeneous in terms of their varying capacity to transport a number of patients. However, users can be different in terms of the resources they need, such as a wheelchair or a stretcher, and vehicles have varying capacities for such resources. These aspects are included in the patient transportation model of Beaudry et al. (2010). Metaheuristics are used to solve these models for the problem at hand.

Since dial-a-ride problems often occur in dynamic real-world settings, there is a growing interest in fast methods for obtaining high quality DARP solutions (Ritzinger, Puchinger, & Hartl, 2016). In a study on the daily operation of the Australian Red Cross, among others, variable neighbourhood search (VNS) and stochastic VNS (S-VNS) are applied to a semi-dynamic environment (Schilde, Doerner, & Hartl, 2011). There is a certain probability that a request for transportation from a patient’s home to the hospital, also generates a corresponding inbound request on the same day. Their research shows that using stochastic information on return transports leads to average improvements of around 15% (Schilde et al., 2011).

A multi-trip DARP (MTDARP) has been used by (Zhang, Liu, & Lim, 2015) to solve a patient transportation problem in Hong Kong, taking into account the need to disinfect ambulances regularly between trips. This way, lunch breaks can be modelled as well. In other research, restrictions on user combinations, as well as a limited set of drivers (with proper medical training) are modelled in a new multi-directional local search algorithm (Molenbruch et al., 2016). Many of these new methods can be generalized for various DRT applications. Together with faster computation and communication, these developments aid in the objective to make DRT services cost-effective.

3.4 Geocoding Problem

In order to determine which kinds of organizations are visited frequently by elderly and people with disabilities in Drenthe, The Netherlands, we have to overcome the observed geocoding problem, as discussed in Chapter 2. This section relates this problem to data recognition methods in literature.

The cause of failure to find geographic coordinates for frequently visited destinations in our subject data is related to variations in zip codes and addresses. These variations occur as a result of either unintended errors, such as typos, or intended choices of notation, such as abbreviations. Both of these events induce a variety of address notations for similar locations. Therefore, the numbers of trips and their associated reported distances are dispersed over a variety of data entries. In order to aggregate this data to unique locations and conduct a proper analysis on frequently visited organizations, address notations have to be adjusted. The only way we can do this is by comparing address notations to each other in order to determine whether they are actually the same, i.e., referring to the same address.

The problem of data comparison had already been investigated by Glantz (1957), who established a crucial set of data recognition errors by machines. The central problem in data comparison is the subjective threshold against which we measure similarity. If we set this threshold too low, the computer recognizes a pattern or similarity, where it should not. On the other hand, if we set a threshold that is too high, the computer fails to recognize a match, where it should have (Glantz, 1957). In fact, even humans might not be able to distinguish whether NEWYRK must be a typo of either NEWYORK or NEWARK, without proper context. This particular context determines the appropriate threshold value and pattern recognition method to be used (Glantz, 1957). According to Glantz, the best one can do is to pre-process data and do a test run on the subject data in order to determine the particular errors that are being made in the procedure.

Data can be represented differently in terms of structure and semantics, which we call data heterogeneity (Chatterjee & Segev, 1991). The inconsistencies in heterogeneous data are resolved through data cleaning (Rahm & Do, 2000) and scrubbing (Widom, 1995). The problem we have to deal with in our data is that of lexical heterogeneity, i.e., different records refer to the same real-world object (Elmagarmid, Ipeirotis, & Verykios, 2007). For example, *kanaal wz* and *kanaal westzijde* refer to the same street name. The well-known problem of Record Linkage or Record Matching is concerned with identifying such records in data (Elmagarmid et al., 2007). However, many different terms are used in areas such as data integration (Bar-Yossef et al., 2002), autocompletion (Chaudhuri & Kaushik, 2009) and data mining (Cohen, Ravikumar, & Fienberg, 2003). The application of our particular interest is that of deduplication (Sarawagi & Bhamidipaty, 2002). The addresses in our data consist of a sequence of characters, in other words, a string. As mismatches occur due to typographical variations that are either intended or unintended, deduplication relies on string similarity measures. "A string similarity measure quantifies the similarity between two text strings for approximate string matching or comparison" (Lu et al., 2013). A variety of string similarity measures is given in a survey by Elmagarmid et al. (2007).

The longest common subsequence problem (LCS) is an extensively applied method to solve pattern matching problems, for example in the process of matching strings of DNA in genome alignment (Delcher et al., 1999). Given a finite sequence $S = s_1, s_2, \dots, s_n$, a subsequence $S'\ of\ S$ is defined by Maier (1978) to be any sequence which consists of S with between 0 and n terms deleted (e.g. ac, ad, and abcd are all subsequences of abcd). "Given two sequences *X* and *Y* , the longest common subsequence (LCS) problem is to find a subsequence of *X* and *Y* whose length is the longest among all common subsequences of the two given sequences" (Zhu, Wu, & Wang, 2016). For any input of strings of lengths m and n, a dynamic programming procedure takes $O(mn)$ time to solve the longest common subsequence problem (Hirschberg, 1977). This method is explained in more detail by (Cormen et al., 2001). Subsequences, as opposed to substrings, do not have to be positioned consecutively in the original sequences, i.e., gaps are allowed. Allowance for gaps increases the number of comparisons that can be made but it also induces recognition errors in terms of string similarity. The longest common substring problem does not allow gaps in the matching procedure (Gusfield, 1997). An extension of the longest common substring problem, the longest common substring problem with k mismatches is discussed by (Flouri et al., 2015).

3.5 Summary and Conclusions

This chapter has provided insight into the characteristics of demand-responsive transportation (DRT). To address the needs of elderly and people with disabilities, DRT systems have been designed, providing specialized transport. Anti-discrimination policies as well as technological advancements have contributed to this development. With optimized dispatching and scheduling software, focus of transit planners has shifted towards strategic and tactical aspects of network design. Geographic information systems enable accessibility measures at higher resolutions to accurately pinpoint caveats in the transportation network. This information, along with current policies and infrastructure has to be taken into consideration when considering service requirements. Tactical aspects of network design involve the setting of routes and frequencies, along with timetables of vehicles. These steps of the transit planning process can be applied in the design of hybrid demand responsive systems, in which door-to-door services are connected to more cost-effective fixed-route lines. In our case, frequently visited destinations can perhaps be considered as stops in the design of a similar hybrid solution. Finally, we looked into the longest common subsequence and the longest common substring problems as a means of tackling the observed geocoding problem. The challenge is to adept these problems to fit our particular geocoding problem. We take up this challenge in Chapter 4.

4 Method

From Chapter 2, we learned that a very small group of destinations is visited frequently by elderly and people with disabilities in the southeast area of Drenthe, The Netherlands. Group arrangements for transport might be possible at some of these locations. It depends on the type of organization at these locations whether this is really an option. In order to determine which kinds of organizations are located at the frequently visited destinations, we need to overcome the observed geocoding problem. In Chapter 3, we explored string similarity measures to solve this problem. In Section 4.1, we tailor a string similarity measure to fit the specific needs of our data structure. In the process of solving the geocoding problem, we devise a list of the 50 most frequently visited organizations. Section 4.2 is devoted to the construction of a classification method to determine which types of organizations are actually suitable for a shift of transportation requests from the passengers to the organizations that these passengers visit. Section 4.3 presents a short summary and conclusions.

4.1 Solving the geocoding problem

The first step in identifying organizations that are suitable for a shift of transportation requests from the passengers to the organizations that these passengers visit, is the construction of a list of relevant organizations. We know that a small group of locations is visited frequently. However, as we have observed, many different address notations occur in the data for similar destinations. Therefore, the numbers of trips and the reported distances cannot be linked to a unique set of locations. To determine the locations of frequently visited organizations, we need to solve this geocoding problem. The main steps of this process can be seen in Figure 13. The first three steps are considered preparation steps that we use in our method to compare and correct street entries. Both in step 1 and step 4, we employ a string similarity measure.

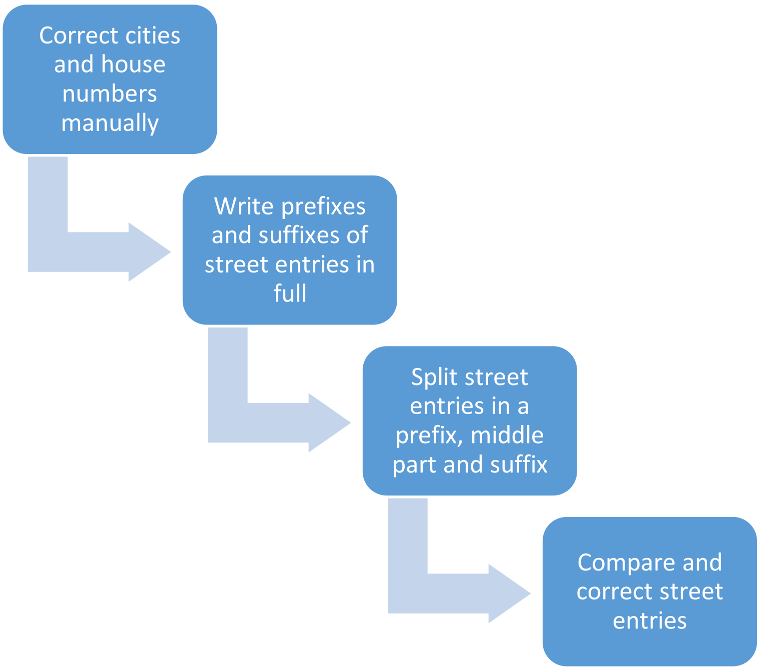

Figure 13: Process of solving the geocoding problem

Section 4.1.1 discusses the considerations involved in the choice of a string similarity measure. Section 4.1.2 details the preparation steps. Section 4.1.3 explains our method and finally, Section 4.1.4 interprets the results.

4.1.1 Choice of string similarity measure

As discussed before, variations in addresses can occur due to both unintended errors on the one hand and intended choices of notation on the other hand. The latter is mainly where our efforts are focussed on, since they represent a certain logic, which we can act upon. Unintended errors may be targeted in the process, although human interaction is needed to verify these cases. In the case of streets or cities, humans are able to recognize unintended errors fairly easy, since they result in unreadable words. However, an unintended error in a zip code or house number cannot be easily spotted by a human, as this would require each zip code or house number to be matched against other address information. Perhaps because of this, there are a lot more different combinations of zip codes and house numbers in our data than combinations of city, street and house number. This makes the latter a more reliable source of address information. Therefore, in our efforts to determine which organizations are visited most frequently by elderly and people with disabilities in Drenthe, The Netherlands, we focus on city, street and house number entries.

In our data, not much information is given about an origin or destination, other than its address. Therefore, verification of house numbers would require an unrealistic amount of effort. We do correct, for example, house numbers that appear to be negative, as discussed in Section 4.1.2. However, we assume the rest of the house numbers to be either correct or irrelevant. By irrelevant, we mean that the address is visited only once or twice, or at least, could not possibly affect the order of the most frequently visited addresses. In contrast to house numbers, cities can be verified easily by a human with limited knowledge about the language and the cities in the area. Since the amount of different city entries in the data is relatively small, this is preferred over any other method, because the results of every method should always be checked in some way by a human. This narrows the scope of our method to the comparison of the various street entries in the data.

For the comparison of street entries, we need to establish some kind of string similarity measure. Based on a certain threshold value of this measure, we can assess whether two street entries actually refer to the same street. However, the choice of a correct threshold value depends on the chosen similarity measure. As explained in Chapter 3, these choices can induce a variety of recognition errors. Therefore, we have been designing our method in an iterative way, correcting mistakes in each iteration.

The first choice we need to make is whether or not we want to allow for gaps in the computation of similarity between street entries. We illustrate the difference by using examples of the longest common substring (1&2) and subsequence (3&4) algorithms, presented in Figure 14. Examples 1 and 3 in Figure 14 represent the comparison of two strings of DNA: ACTGGCA to CGGTA. The longest common subsequence can provide a lot of information about similarity in this particular case. However, if we apply this same measure on two written words, see the comparison of BROEKJE to REKTE in examples 2 and 4, the resulting similarity from the subsequence algorithm seems counterintuitive. The words *BROEKJE* and *REKTE* are two completely different Dutch words, but according to the subsequence algorithm, they are remarkably similar.

Each comparison problem is given in a matrix in which each character of a string is compared to each character of the other string. The two algorithms follow a dynamic procedure, starting at the upper left of the matrix. At the start, the matrix is filled with zeroes and an extra row and column of zeroes is added at the upper left of the matrix. The longest common substring problem compares each character and adds 1 to the number left above it, if characters are the same. The highest number is stored as the longest common substring length, as can be seen in bold. The longest common subsequence algorithm does essentially the same, with one crucial difference. Whenever a character is not the same, the highest from the number above it and left of it is chosen. This way, the sequence does not start at 0 whenever the sequence is interrupted by a gap. Analogue to the longest common substring algorithm, the highest number (in bold) is stored as the longest common subsequence. The similarity is calculated as follows:

$$Similarity = 2 * lcs/(l_1 + l_2)$$

The term lcs represents either the longest common subsequence or substring length, and l_1 and l_2 represent the string lengths of string 1 and 2 respectively.

Longest common substring = GG
Similarity = 33.3%

①		A	C	T	G	G	C	A
	0	0	0	0	0	0	0	0
C	0	0	**1**	0	0	0	1	0
G	0	0	0	0	**1**	1	0	0
G	0	0	0	0	0	**2**	0	0
T	0	0	0	1	0	0	0	0
A	0	1	0	0	0	0	0	1

Longest common substring = EK
Similarity = 33.3%

②		B	R	O	E	K	J	E
	0	0	0	0	0	0	0	0
R	0	0	1	0	0	0	0	0
E	0	0	0	0	**1**	0	0	1
K	0	0	0	0	0	**2**	0	0
T	0	0	0	0	0	0	0	0
E	0	0	0	0	1	0	0	1

Longest common subsequence = CGGA
Similiarity = 66.7%

③		A	C	T	G	G	C	A
	0	0	0	0	0	0	0	0
C	0	0	**1**	1	1	1	1	1
G	0	0	1	1	**2**	2	2	2
G	0	0	1	1	2	**3**	3	3
T	0	0	1	2	2	3	3	3
A	0	1	1	2	2	3	3	**4**

Longest common subsequence = REKE
Similarity = 66.7%

④		B	R	O	E	K	J	E
	0	0	0	0	0	0	0	0
R	0	0	**1**	1	1	1	1	1
E	0	0	1	1	**2**	2	2	2
K	0	0	1	1	2	**3**	3	3
T	0	0	1	1	2	3	3	3
E	0	0	1	1	2	3	3	**4**

Figure 14: Examples of the longest common subsequence and substring algorithms

In our case, we would definitely not want to mix up BROEKJE and REKTE as referring to the same street. Of course, this can be avoided by setting a relatively high threshold for similarity. However, tests of the longest common subsequence algorithm on our data revealed that street entries are particularly not well suited for this method. Take the comparison of the following street entries from our data for example: *DORDSEDWARSSTRAAT* and *DORDSESTRAAT*. The longest common subsequence algorithm results in a similarity of 82.8% even though the strings represent different streets. In contrast, the longest common substring algorithm results in a similarity of only 41.4%, indicating that the streets are probably different. In the context of street entries, there are many more of these examples, sometimes only differing in one character. The longest common substring algorithm recognizes these subtle differences where the subsequence algorithm does not. Therefore, as a basis for comparison, we use the longest common substring algorithm. We programmed this algorithm in VBA, which can be seen in Appendix 1.1.

4.1.2 Preparation phase

Unfortunately, the longest common substring algorithm is not sufficient in recognizing similar streets. Take the address strings *1e BOKSLOOT* and *2e BOKSLOOT* for example. The similarity between these two strings is 90.9%, even though the first character represents an essential difference. In fact, in many cases, the first character turns out to be a determinative character of the street name. Of course, we added this in the form of a constraint in our method, which we discuss in Section 4.1.3. However, even when the first character is the same and strings are almost identical, minor differences may very well be intended. Take *STATIONSLN* and *STATIONSPLN* for example. The first string is an abbreviation of the street *Stationslaan*. The second is an abbreviation of the street *Stationsplein*. The former refers to a street, while the latter refers to a square, although both might appear in the neighbourhood of the same train station. As these subtle differences can lead to many errors, we need to address them with care.

To avoid mistakes, we propose an important step in the solution to the geocoding problem. In this step, the data is carefully prepared before it is subjected to the aforementioned string similarity measure. Just as the choice of similarity measure and threshold is subject to the context of the data, the preparation phase should also be tailored to particular characteristics. However, the goal of this section is to introduce a preparation structure, which can be adapted easily to fit the address data of other geographic areas. The preparation of data is programmed in VBA, which can be seen in Appendix 1.2 (1, 2 and 3).

First of all, cities can be corrected manually, since there are not too many different cities. However, this task can be greatly simplified if we sort the cities first. Furthermore, the sorting of cities in itself, is an important preparation step to efficiently compare streets within these cities. The easiest choice would be to sort on alphabet. However, this does not necessarily bring similar cities closer together. Therefore, we compare cities to each other, based on the longest common substring algorithm and sort the cities based on similarity scores. We programmed the sorting procedure in VBA, which can be seen in Appendix 1.3. It encompasses similar features as the ones that we use to compare street entries once the preparation phase has been completed. This method is discussed in detail in Section 4.1.3. After sorting, similar cities can be compared and corrected easily by a human, as can be seen in Figure 15. For example, we simply replace the city entries 2E EXLOERMOND by TWEEDE EXLOERMOND.

City
2E EXLOERMOND
TWEEDE EXLOERMOND
EMMEN
OMMEN
ANNEN
BUINEN
NIEUW BUINEN
NIEUW BEERTA
NIEUW BALINGE
BALINGE
RINGE

Figure 15: Cities sorted on similarity

Since there are many different streets in each city and many different house numbers in each street, this manual correction step already results in a large number of unique addresses being eliminated. By eliminated, we mean that the city entry *2E EXLOERMOND* is manually replaced by *TWEEDE EXLOERMOND,* which is the equivalent. In effect, a lot, if not all of the addresses belonging to *2E EXLOERMOND* then become the same addresses as those belonging to *TWEEDE EXLOERMOND*. This means the number of trips and reported distances associated with these addresses can be added under one unique address, potentially one that is now ranked as being frequently visited by elderly and people with disabilities.

Some house numbers can be corrected manually as well. After sorting, exceptionally high numbers are spotted easily, as well as negative or fractional numbers. However, the correct number may be hard to track in those cases. We did incorporate some logic in the preparation method concerning house numbers, to correct them, wherever possible. Sometimes, house numbers appear double, in the number entry and at the end of street entries. These numbers are tracked and deleted from street entries. Furthermore, multiple examples revealed that house numbers with a negative sign should simply be positive, and these are corrected as such. Possibly, the negative sign is a hyphen that had been previously used to separate the number from the street.

The main part of the preparation phase consists of the restructuring of street entries into three different parts: prefixes, suffixes and the middle part. The reason for this effort stems from the fact that a lot of common prefixes and suffixes appear in street entries, which makes it especially difficult to differentiate between different streets. Take for example *KANAAL A NZ* and *KANAAL B NZ*. These strings are different, only with respect to their middle part. The first part translates to the word *channel*. The last part gives a direction. Since various combinations of these parts occur in our data, it is convenient to treat the direction as a suffix and the first part as a prefix. If we compare the entire string, the longest common substring algorithm would calculate a similarity score of 63.6%. If on the other hand, we require strings to have the same prefix and suffix and choose to compare only their middle part, the similarity score would be equal to 0.0%, which is exactly what we want.

A problem with prefixes and suffixes is that they are sometimes abbreviated and sometimes not. This alone already constitutes a basis for variety in address notations. Fortunately, as we are familiar with the Dutch road network, we can easily think of common prefixes and suffixes and their abbreviations. After a few iterations of programming and evaluating the results, we managed to come up with a rather complete list of prefixes and suffixes and their abbreviations. Some prefixes and suffixes are common throughout The Netherlands, such as the suffixes *WEG, STRAAT, SINGEL, LAAN* and the prefixes *DE, HET, VAN, LAAN*. Others might be more apparent in specific regions, although suffixes such as *VAART* or *AKKERS* and prefixes such as *KANAAL* and *MEESTER* are still likely to appear at least in some streets of every province in The Netherlands. We find abbreviations such as *LN* for *LAAN*, *STR* for *STRAAT*, *WG* for *WEG*, *KAN* for *KANAAL* and *MR* for *MEESTER*. First, we write these abbreviations in full, before we split them from the middle part. An example of preparation output in Excel is shown in Figure 16.

Street	Prefix	Middle part	Suffix
VERL OOSTERD OZ	VERLENGDE	OOSTERD	OZ
GAREEL		GAREEL	
VERL OOSTERD OZ	VERLENGDE	OOSTERD	OZ
HLT VEENPARK	HLT	VEENPARK	
VERL OOSTERD WZ	VERLENGDE	OOSTERD	WZ
DE STIKKER	DE	STIKKER	
J BERENDSTR		J BEREND	STRAAT
PAST VROOMSTR		PAST VROOM	STRAAT
DISSEL		DISSEL	
LIMIETWG		LIMIET	WEG
J BERENDSTR		J BEREND	STRAAT

Figure 16: Street entries (on the left) are prepared for comparison (right)

We refrain from detailing all the tedious programming, which can be seen in Appendix 1.2. Instead, we continue to explain the structure and the complications that arise. The main part is roughly comprised of four parts: writing suffixes in full, writing prefixes in full, splitting suffixes from street names and splitting prefixes from street names. Prefixes and suffixes can easily be added or deleted, without further programming. This enables the preparation procedure to prepare similar data from other regions, even outside The Netherlands.

Complications arise for example, when *PLN* has to be rewritten into *PLEIN* and *LN* has to be rewritten into *LAAN*. To solve this, a hierarchy of programming has to be taken into consideration in which longer prefix or suffix abbreviations have to be checked first. Another example of increasing complexity is given by the following. The prefix O may refer to either OOST or OUDE or something else. Therefore, we choose not to write single character prefixes in full. In fact, not treating them as a prefix is the best way, since this would still enable a comparison of for example, *OUDE ROSWINKELWEG* and *O ROSWINKELWEG*, which refer to the same address. To illustrate, if *O* was to be rewritten into *OOST*, comparison would not be possible in our method, because prefixes *OUDE* and *OOST* are not the same. Moreover, if *OUDE* is considered a prefix, but *O* or *OOST* is not, comparison is also not possible.

Finally, a lot of addresses remain with the house number *0*. These numbers probably represent missing entries. Most of them are irrelevant in terms of their frequency of visits, which is also the case for other strange house numbers that we cannot correct. However, some of these addresses appear among the most frequently visited locations. In these cases, we try to find the correct address through information we can find in the data of these trips and searching the internet for important addresses in the neighbourhood.

4.1.3 Method

After city, street and house number entries have been prepared for comparison, our method decides which street entries are to be compared and rewritten. This method is programmed in VBA, which can be seen in Appendix 1.4. To change street entries, we do not need to perfectly sort street entries on their relative similarity, because we do not have to check manually whether similar street entries actually refer to the same street, as we do with cities during the preparation phase, recall Figure 15. Almost each city entry had to be compared to each other city entry in order to completely sort the cities on their relative similarity. When correcting street entries, we only need to calculate similarity between entries if certain conditions are met. For example, a street with a different prefix cannot be the same, which makes comparison useless. The naive approach would be to check every address on several conditions and sort nearly all the addresses in each iteration. However, now that we have a list of addresses sorted on cities (be it on similarity or alphabet), we can easily restrict ourselves to check streets only within the same city. Then, only the streets with similar prefix, suffix and the same first character of the middle part are compared, based on the similarity measure. If the similarity is 60% or more, we assume similarity and rewrite the street entry into the street entry that we compare to, irrespectively of their string length. These changes are logged to check them afterwards. This way, we can review every modification of the data and easily detect a mistake. After a change, the similarity score is changed to 1 in order to sort correctly. The addresses are sorted on their similarity scores such that addresses with the same city and street are ranked first, followed by addresses with similarity scores below 60% and then addresses with no similarity score, i.e., addresses that do not meet the conditions for comparison. The scores are removed after each iteration in order not to disrupt the next sort. Then, a check is performed whether the cities and streets on top of the list are now the same. If they are, these addresses are skipped during the next iteration. Part of the sorting results can be seen in Figure 17.

City	Street	House number	Prefix	Middle part	Suffix
EMMEN	W B SCHRAGESTR	16		W B SCHRAGE	STRAAT
EMMEN	W B SCHRAGESTR	101		W B SCHRAGE	STRAAT
EMMEN	W B SCHRAGESTR	61		W B SCHRAGE	STRAAT
EMMEN	W SCHOUTENSTR	13		W SCHOUTEN	STRAAT
EMMEN	WALSTR	53		WAL	STRAAT
EMMEN	WALSTR	0		WAL	STRAAT
EMMEN	WALSTR	61		WAL	STRAAT
EMMEN	WALSTR	21		WAL	STRAAT
EMMEN	WALSTR	22		WAL	STRAAT
EMMEN	WINKELAKKERS	2		WINKEL	AKKERS
EMMEN	WINKELAKKERS	17		WINKEL	AKKERS
EMMEN	WINKELAKKERS	11		WINKEL	AKKERS
EMMEN	WINKELAKKERS	0		WINKEL	AKKERS
EMMEN	WINKELAKKERS	14		WINKEL	AKKERS
EMMEN	WINKELAKKERS	15		WINKEL	AKKERS
EMMEN	DE NYKAMPEN	7	DE	NY	KAMPEN
EMMEN	DE NYKAMPEN	0	DE	NY	KAMPEN
EMMEN	DE NYKAMPEN	69	DE	NY	KAMPEN

Figure 17: Sorting results

Part of the changes that have been made to street names can be viewed in Figure 18.

City	Old Street	New Street
EMMEN	NOTARIS OOSTINGSTRAAT	NOT OOSTINGSTRAAT
EMMEN	PAUS JOHANNESSTRAAT	P JOHANNESSTRAAT
EMMEN	ACHTER DE SMIDSE	A DE SMIDSE
EMMEN	O ROSWINKELERWEG	OUDE ROSWINKELWEG
EMMEN	O WILHELMSWEG	OUDE WILHELMSWEG
EMMEN	VERZ ZUIDERMARKE HI	VERZ ZUIDERMARKE
EMMEN	J LE MAIRESTRAAT	J L MAIRESTRAAT
EMMEN	GROENE SPECHT	G SPECHT
EMMEN	EMMERWEG	ERMERWEG
EMMEN	LOO ACKERS	LOOACKERS
EMMEN	LOO-ACKERS	LOOACKERS
EMMEN	OUDE ZUIDBARG STRAAT	O ZUIDBARGERSTRAAT
EMMEN	ZWARTE SPECHT	Z SPECHT

Figure 18: Changes in street names

As can be seen, a change does not necessarily have to be an improvement in address notation. The changes merely reduce the variety of address notations in a way that unique locations can be identified. By doing this, transport trips and distances that were previously linked to addresses in for example the streets LOO ACKERS and LOO-ACKERS, can now be linked to addresses in the street LOOACKERS. These new addresses now become more relevant in our analysis. The only thing that remains is to correct the notation of relevant addresses. For example, we probably want to use the full form of an address to find the organization behind this address. Another point to remark is that not every change in Figure 18 is deemed correct, i.e., the new notation refers to the same street as the old notation. These mistakes often involve caveats in the preparation procedure, which are addressed if useful. The few exceptions are corrected manually, such as the example here, of EMMERWEG and ERMERWEG, which are different streets in the city of Emmen. Ideally, we want a threshold value for similarity that is low enough to capture all similarities. However, experiments with threshold values indicated that values lower than 60% result in too many mistakes.

4.1.4 Results

After summation of the amount of trips, reported distances, and total travel times that are linked to each address, we were able to construct a top 50 of the most frequently visited locations. However, for each location, we looked at transport to this location as well transport from this location. As transport *from* one location in the top 50 is also counted as transport *to* another location, transport between locations in the top 50 is counted double in terms of trips, reported distances and total travel hours. Therefore, we looked at the proportion of transport of each location in the top 50 to the total transport between locations in the top 50. We reduced the transport of organizations in the top 50 by these amounts to get an accurate idea of their proportion relative to the total transport. We illustrate this with an example of trips that are driven between an imaginary top 3 of locations, see Table 4. In total, transport within the top 3 adds up to 100 trips. In Table 5, we calculate the proportions of these locations in relation to the amount of transport between them. Finally, we correct our top 3, as demonstrated in Table 6. The total amount of trips is 10,000. The uncorrected top 3 (trips 1) accounts for 18.0%. However, as the 100 trips within the top 3 are counted double, the trips are adjusted according to the proportions calculated in Table 5. The result shows that only 17.0% (trips 2) of 10,000 trips in total is linked to the top 3 of locations.

From	**To**	**Trips**
hospital	municipal office	0
train station	municipal office	30
municipal office	hospital	0
municipal office	train station	10
hospital	train station	20
train station	hospital	40
		100

Table 4: Example of numbers of trips between 3 top locations

Location	**Trips**	**%**
hospital	60	30
train station	100	50
municipal office	40	20
	200	100

Table 5: Example of proportions of transport within a top 3

Location	**Trips 1**	**%**	**Trips 2**	**%**
hospital	1000	10.0	970	9.7
train station	500	5.0	450	4.5
municipal office	300	3.0	280	2.8
Top 3	1800	18.0	1700	17.0
Total	10000	100	10000	100

Table 6: Example of correction of the amount of trips

After application of adjustments, the resulting top 50 of addresses can be seen in Table 7. As explained before, reported distances represent the shortest path from origin to destination over the road network. These are given in kilometres. Time represents the total travel time including transfer time at pick-up and drop-off. Times are given in hours. In the end, it is important to look at the amount of trips, as well as distance and travel time. However, as travel time depends on a variety of changing conditions, the amount of trips and the reported distances constitute a more robust basis for evaluation. Since distance is dependent on both numbers of trips and the length of these trips, this give us more information than the amount of trips alone. Therefore, we choose to sort the top 50 on distance, rather than trips.

The results are remarkable. From the analysis of geographic coordinates of destinations in Chapter 2, we learned that the 40 most frequently visited destinations (for which we could find geographic coordinates) already account for 25% of all trips registered. Based on our more accurate analysis of addresses, we now know that the top 50 of addresses accounts for roughly 50% of all trips, kilometres and travel hours, see Table 7.

City	Street	Number	Trips	%Trips	Distance(km)	%Distance	Time(h)	%Time
Emmen	Boermarkeweg	60	38574	12.3	281332	10.7	14957	12.4
Emmen	Rondweg	97	10326	3.3	84729	3.2	4261	3.5
Emmen	Hoofdstraat	34	9506	3.0	70789	2.7	3745	3.1
Emmen	Emmerhoutstraat	22	5905	1.9	55924	2.1	3410	2.8
Emmen	Laan v. h. Kwekebos	118	6878	2.2	45310	1.7	2556	2.1
Weiteveen	Ir. Biewengaweg	42	2839	0.9	39027	1.5	1391	1.2
Emmen	Stationsplein	14	3607	1.2	35626	1.4	1423	1.2
Coevorden	Henriette R. Holstlaan	2	3226	1.0	35541	1.3	1333	1.1
Schoonebeek	Europaweg	98	2316	0.7	33204	1.3	1123	0.9
Hardenberg	Jan Weitkamplaan	4a	1597	0.5	28874	1.1	799	0.7
Emmen	Leeuwerikenveld	7	2598	0.8	24938	0.9	1283	1.1
Emmen	Wendeling	13e	1871	0.6	18932	0.7	753	0.6
Emmen	Abel Tasmanstraat	7	2285	0.7	18896	0.7	811	0.7
Emmen	Spehornerbrink	1	2243	0.7	17697	0.7	833	0.7
Assen	Europaweg-Zuid	1	816	0.3	17495	0.7	434	0.4
Emmen	De Nijkampen	7	1581	0.5	17205	0.7	722	0.6
Coevorden	Comm. Gaarlandtlaan	23	1281	0.4	17189	0.7	585	0.5
Stadskanaal	Boerhaavestraat	1	1453	0.5	16771	0.6	629	0.5
Klazienaveen	De Kwakel	6	2702	0.9	16367	0.6	816	0.7
Nieuw-Dordrecht	Klazienaveensestraat	98	3024	1.0	16018	0.6	1298	1.1
Klazienaveen	De Lauden	6	2235	0.7	15856	0.6	979	0.8
Odoorn	Valtherweg	9	1214	0.4	15405	0.6	547	0.5
Schoonebeek	Ratelaar	2	975	0.3	15228	0.6	519	0.4
Emmen	Hondsrugweg	101	2950	0.9	15140	0.6	1025	0.9
Emmen	Holtingerbrink	62	2030	0.6	14232	0.5	760	0.6
Coevorden	M. v. d. Thijnensingel	1	2140	0.7	14187	0.5	644	0.5
Emmen	Baander	165	2576	0.8	14102	0.5	862	0.7
Emmen	Statenweg	107	3166	1.0	13494	0.5	963	0.8
Emmen	De Lemzijde	55	1679	0.5	13434	0.5	668	0.6
Coevorden	Schutseln	26	2305	0.7	13038	0.5	720	0.6
Nieuw Schoonebeek	Europaweg	143a	3822	1.2	12031	0.5	1288	1.1
Coevorden	Stationsplein	1	1302	0.4	11513	0.4	411	0.3
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
Emmen	Nijverheidsstraat	16	582	0.2	5643	0.2	271	0.2
		Top50:	**150520**	**48.2**	**1216975**	**46.2**	**60187**	**50.0**
		Total:	**312592**		**2636083**		**120461**	

Table 7: Top 50 addresses in terms of trips, reported distances and total travel time

4.2 Classification method of organizations

Now that we know the locations that are visited most frequently by elderly and people with disabilities in the southeast region of Drenthe, The Netherlands, we can start to identify the types of organizations that are most prominent in the transport of these frail groups of society. After some internet research and phone calls, we were able to identify the organizations behind the addresses in Table 7. These organizations and their types are given in Table 8.

Organization	Type	Trips	%Trips	Distance(km)	%Distance	Time(h)	%Time
Scheper Ziekenhuis	Hospital	38574	12.3	281332	10.7	14957	12.4
Woonzorgcentrum De Horst	Nursing home	10326	3.3	84729	3.2	4261	3.5
Hema Koffieshop Emmen	Shopping area	9506	3.0	70789	2.7	3745	3.1
Zorgboerderij De Hooimijt	Day care centre	5905	1.9	55924	2.1	3410	2.8
Woonzorgcentrum De Schans	Nursing home	6878	2.2	45310	1.7	2556	2.1
Woonzorgcentrum Veltman	Nursing home	2839	0.9	39027	1.5	1391	1.2
Station Emmen	Train station	3607	1.2	35626	1.4	1423	1.2
Woonvoorziening Steege	Nursing home	3226	1.0	35541	1.3	1333	1.1
Woonvoorziening d'Olde Beke/Beekdal	Nursing home	2316	0.7	33204	1.3	1123	0.9
Röpcke-Zweers Ziekenhuis	Hospital	1597	0.5	28874	1.1	799	0.7
De Trans Leeuwerikenveld	Nursing home	2598	0.8	24938	0.9	1283	1.1
Woonvoorziening Holtstee	Nursing home	1871	0.6	18932	0.7	753	0.6
Emco Training en Diagnosecentrum	Social employment	2285	0.7	18896	0.7	811	0.7
Verpleeghuis De Bleerinck	Nursing home	2243	0.7	17697	0.7	833	0.7
Wilhelmina Ziekenhuis	Hospital	816	0.3	17495	0.7	434	0.4
De Trans Nijkampen	Nursing home	1581	0.5	17205	0.7	722	0.6
Woonvoorziening In De Goorn	Nursing home	1281	0.4	17189	0.7	585	0.5
Refaja Ziekenhuis	Hospital	1453	0.5	16771	0.6	629	0.5
Emco Plantsoenonderhoud	Social employment	2702	0.9	16367	0.6	816	0.7
Dagzorg Heerendordt	Day care centre	3024	1.0	16018	0.6	1298	1.1
Woonvoorziening De Hilde	Nursing home	2235	0.7	15856	0.6	979	0.8
Woonvoorziening Tellinghof	Nursing home	1214	0.4	15405	0.6	547	0.5
Woonvoorziening Stroomdal	Nursing home	975	0.3	15228	0.6	519	0.4
Woonzorgcentrum Holdert	Nursing home	2950	0.9	15140	0.6	1025	0.9
Woonwijkcentrum Holtingerhof	Nursing home	2030	0.6	14232	0.5	760	0.6
Dagziekenhuis Aleida Kramer	Hospital	2140	0.7	14187	0.5	644	0.5
Albert Heijn Emmen (Baander)	Shopping area	2576	0.8	14102	0.5	862	0.7
De Marke (cultureel centrum)	Community centre	3166	1.0	13494	0.5	963	0.8
Appartementencomplex Emmerhout	Nursing home	1679	0.5	13434	0.5	668	0.6
Woonwijkcentrum De Schutse	Nursing home	2305	0.7	13038	0.5	720	0.6
Dagcentrum De Beek	Day care centre	3822	1.2	12031	0.5	1288	1.1
Station Coevorden	Train station	1302	0.4	11513	0.4	411	0.3
De Trans Brandgans	Nursing home	1491	0.5	11376	0.4	648	0.5
Winkelcentrum Emmerhout	Shopping area	1474	0.5	10501	0.4	476	0.4
Woonzorgcentrum St. Franciscus	Nursing home	1201	0.4	10397	0.4	449	0.4
Gemeentehuis Emmen	Municipal office	1430	0.5	10372	0.4	575	0.5
Woonvoorziening Tuindorp	Nursing home	1663	0.5	10352	0.4	533	0.4
Woongroep Zweelo	Nursing home	571	0.2	10106	0.4	277	0.2
Winkelcentrum Zuid Emmen	Shopping area	1720	0.6	9816	0.4	597	0.5
Appartementencomplex Bastion	Nursing home	941	0.3	9166	0.3	319	0.3
Woonzorgcentrum De Voorde	Nursing home	976	0.3	9067	0.3	387	0.3
Woonzorgcentrum Het Ellertsveld	Nursing home	679	0.2	8851	0.3	308	0.3
Woonzorgcentrum Dillehof	Nursing home	1433	0.5	8830	0.3	517	0.4
De Trans Tweede Exloërmond	Nursing home	613	0.2	8774	0.3	285	0.2
Manege De Eekwal	Day care activity	1151	0.4	7808	0.3	487	0.4
MozaïeKKunstgroep	Day care activity	1247	0.4	7422	0.3	466	0.4
Zwem- en golfslagbad Aquarena	Day care activity	1212	0.4	6788	0.3	530	0.4
Buurtcentrum Bargermeer/Meerveld	Community centre	743	0.2	6373	0.2	317	0.3
AZC Ter Apel	Asylum centre	379	0.1	5812	0.2	198	0.2
Werkprojecten Emmen	Day care activity	582	0.2	5643	0.2	271	0.2
		150520	**48.2**	**1216975**	**46.2**	**60187**	**50.0**
		312592		**2636083**		**120461**	

Table 8: Top 50 organizations in terms of trips, reported distances and total travel time

These 50 organizations account for roughly 50% of all trips, kilometres and hours registered in the transport of elderly and people with disabilities in Drenthe, The Netherlands. The hospital in Emmen alone, Scheper Ziekenhuis, already accounts for more than 10% of all the transport. Trips to some organizations require particularly much travel time, such as trips to Zorgboerderij De Hooimijt (4th). Since this is a day care centre for handicapped people, this can easily be explained by the condition of the passengers, which probably requires extra care. Trips to other organizations are particularly long in terms of their reported distances, such as trips to and from the hospital in Hardenberg, Röpcke-Zweers Ziekenhuis (10th). We can explain this by the geographic distance between Hardenberg and the centre of the transport region, Emmen, where most people live. In contrast, the community centre De Marke (28th) is positioned at the centre of Emmen. Therefore, trips to and from this community centre are relatively short. Furthermore, it is not likely that people from Hardenberg travel frequently to a community centre in Emmen, as community centres mostly serve their own local community. A lot of the organizations in Table 8 turn out to be nursing homes. Furthermore, we see hospitals, train stations and a variety of other organizations. In Figure 19, the organizations are displayed on a map to give an overview of the landscape of different organizations in the transport of elderly and people with disabilities in Drenthe.

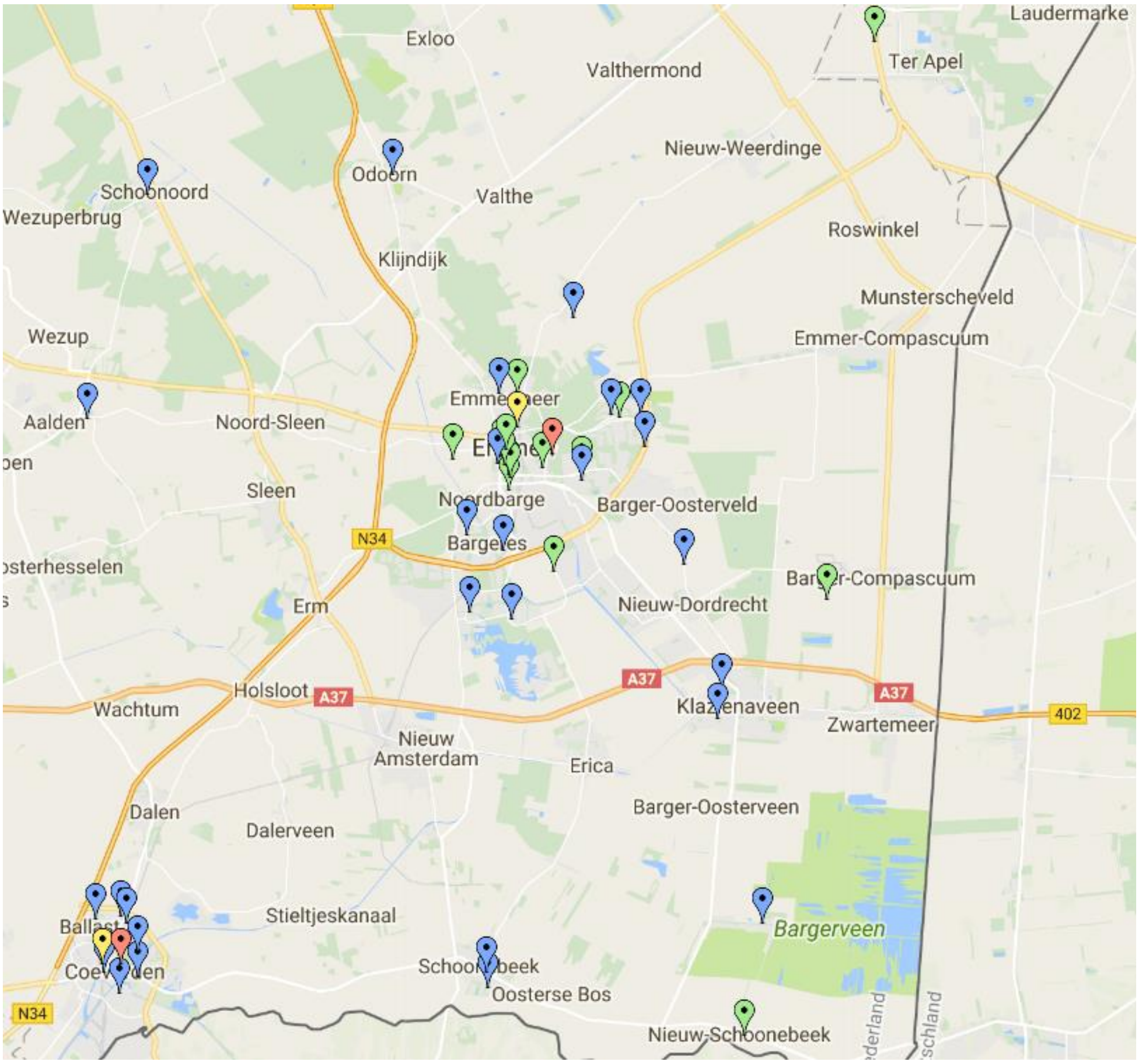

Figure 19: Top 50 organizations on a map

The red markers in Figure 19 correspond to hospitals. For clarity, the hospitals in Assen and Hardenberg have been omitted from the picture. The yellow markers correspond to the train stations in Emmen and Coevorden and the blue markers represent all the nursing homes in the top 50. The green markers belong to the group of other organizations, which comprises day care centres, facilities for day care activities, social employment facilities, shopping areas, community centres, the municipal office of Emmen and the asylum centre of Ter Apel.

As nursing homes represent more than half of all the organizations in the top 50, we displayed them by care provider in Figure 20. The red markers belong to locations of De Trans, which belongs to Espiria. De Trans is specifically focussed on helping handicapped people and people with autism. The other care providers are Tangenborgh (yellow), Treant (purple) and Promens Care (green). The blue markers represent independent nursing homes. Although each care provider specializes in different care and each location is tailored to specific needs, all these organizations generally provide care to elderly and people with disabilities.

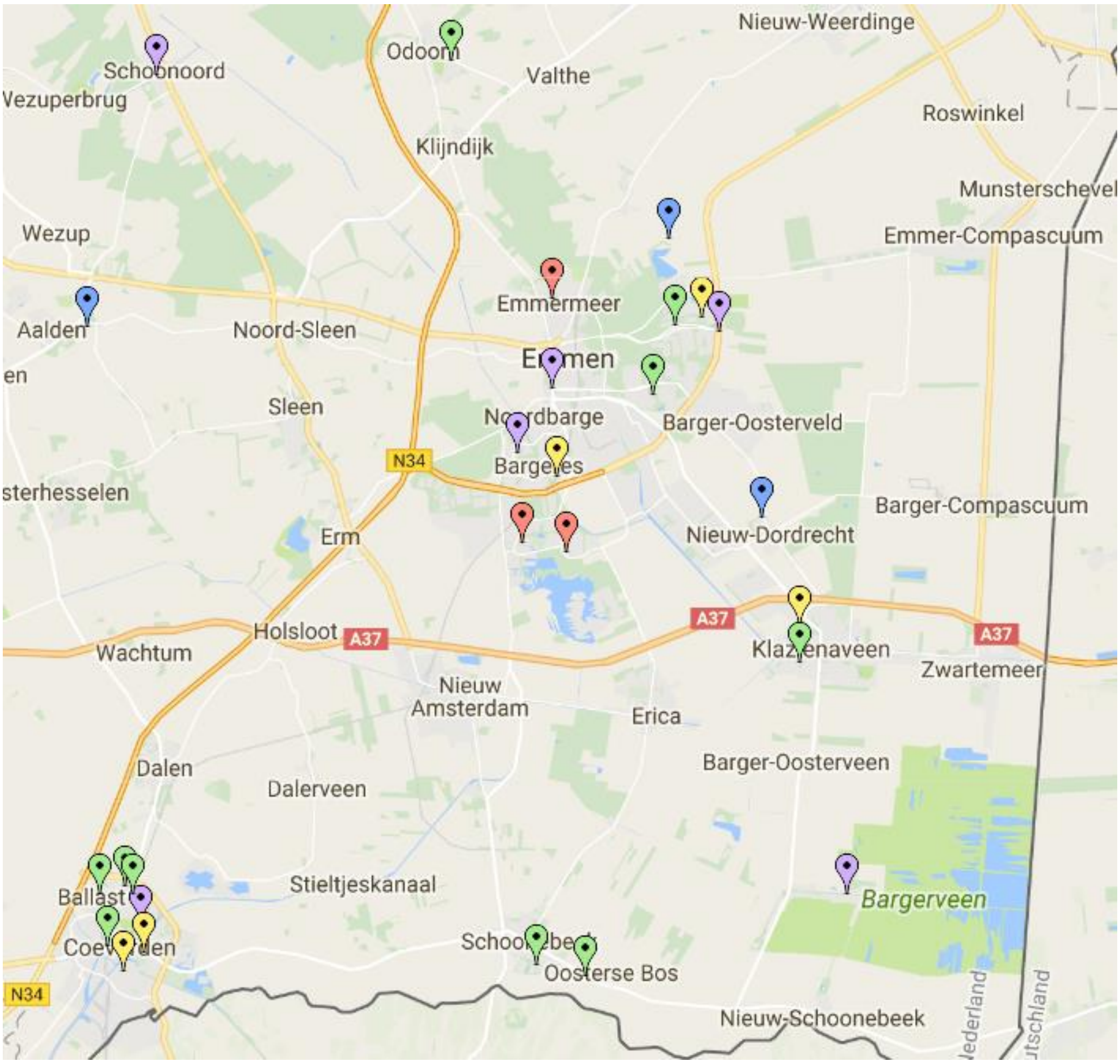

Figure 20: Nursing homes by care provider

Not every type of organization in Figure 19 and Figure 20 is equally suitable for a shift of transportation request from the passengers to the organizations that these passengers visit. It really depends on the type of organization. To assess which types of organizations are actually suitable for shift of transportation requests from the passengers to the organizations that these passengers visit, we propose a method to classify organization types on five different criteria, as can be seen in Figure 9.

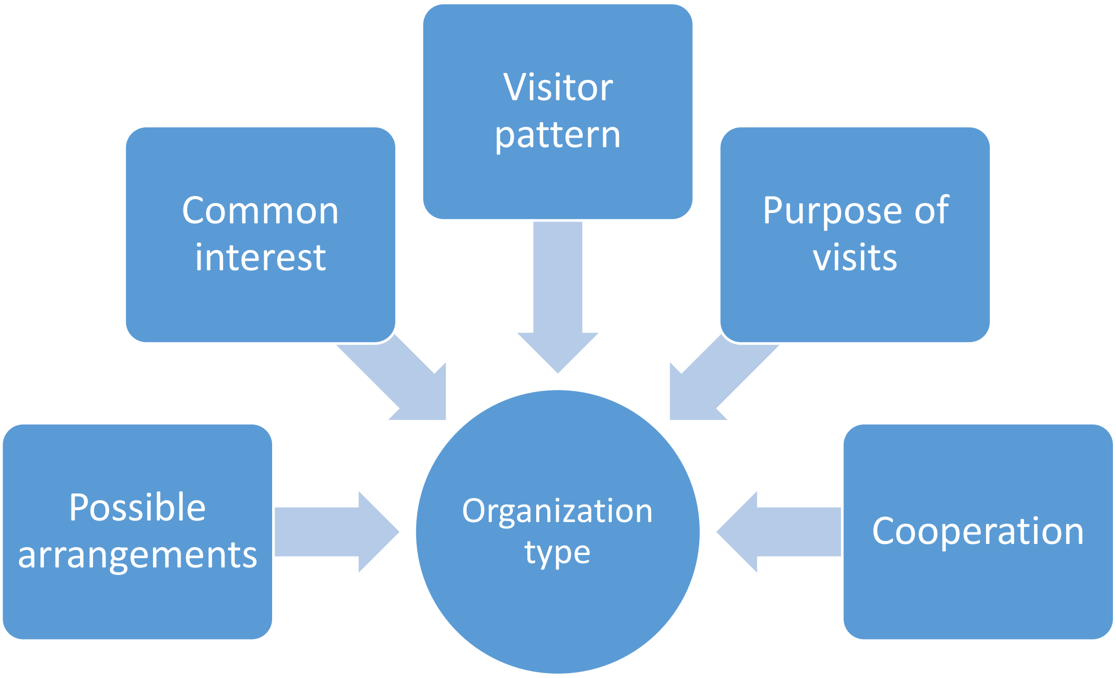

Figure 21: Method to classify organization types

Input for the method are all the organization types that are relevant in the transport of elderly and people with disabilities, i.e., the organization types listed in Table 8. The criteria on which to classify each type of organization are:

- **Possible arrangements**
  Is it possible to make transportation arrangements with the organization and if so, to what extent?
- **Common interest**
  Is there a common interest between the organization, the passengers and the transport service provider to change the current situation?
- **Visitor pattern**
  Do people visit the organization throughout the entire day or are there specific times during the day and the week?
- **Purpose of visits**
  Is the purpose of passengers visiting the organization clear and the same for each visit and each person?
- **Cooperation**
  Is cooperation with other organizations possible?

The evaluation of each criterion tells us something about the potential for a shift of transportation requests from the passengers to the organizations that these passengers visit. A summary of our analysis is given in Table 9, after which we elaborate on the details. Green corresponds to a positive evaluation of the criterion in terms of suitability to shift transportation request from passengers to that type of organization. Orange indicates there are positive as well as negative arguments concerning the criterion. Red implies there are serious issues that prevent a successful shift of transportation request from the passengers to that type of organization.

	Arrangements	Common interest	Visitor pattern	Purpose of visits	Cooperation
Hospital	Green	Green	Red	Red	Green
Train Station	Red	Red	Red	Red	Red
Nursing home	Green	Green	Red	Red	Green
Day care centre	Yellow	Yellow	Green	Green	Yellow
Day care activity	Green	Green	Green	Green	Yellow
Social Employment	Green	Green	Green	Yellow	Yellow
Community centre	Green	Green	Green	Green	Green
Shopping area	Red	Red	Red	Red	Red
Municipal office	Green	Yellow	Red	Red	Red
Asylum centre	Yellow	Yellow	Green	Yellow	Red

Table 9: Classification of organizations types

Visitor patterns of the various types of organizations can be seen in Appendix 2 (1) through (9). The numbers of Appendix 2 correspond to the various types of organizations. At least 2 visitor patterns of each organization type are shown in the appendix to see that patterns within one type of organization are similar.

First of all, train stations and shopping areas are not organizations, at least people do not interact directly with them whenever they visit these types of locations. Furthermore, the visits comprise many different purposes. When visiting a train station, people might travel to any other train station. A shopping area covers many different shops and organizations. Moreover, people visit train stations and shopping areas throughout the entire day, because every person has a different purpose.

Hospitals and nursing homes have similar issues with visitor patterns as train stations and shopping areas, but for different reasons. Nursing homes are, as the name gives away, the homes of a lot of elderly and people with disabilities. Therefore, a nursing home is usually the start of a journey to various other locations, including many different purposes at different times of the day. On the other hand, nursing homes would be happy to make arrangements for transport as a way to complement and improve care for their inhabitants. For example, a special shopping day or swimming day, giving people the opportunity to undertake activities together, would be much appreciated by inhabitants. Furthermore, this reduces the events of people waiting for their individual transport in the lobby of the nursing homes. Hospitals, especially large ones, receive a lot of visits every day from elderly and people with disabilities, creating a hotspot for WMO vehicles. In the neighbourhood of the Scheper Ziekenhuis in Emmen, this is known to cause traffic congestion. This constitutes a common interest to improve the situation and arrange for group transports. The problem here is that people need to visit the hospital for various different reasons. To shift transportation requests from the passengers to the hospital, we would have to look at the purposes of their visits. The Scheper Ziekenhuis in Emmen is the only organization in our data for which such information is available. Examples of visitor patterns for different departments of the Scheper Ziekenhuis are displayed in Appendix 2 (10).

Day care centres are suitable for a shift of transportation requests from passengers to the organizations that these passengers visit, under certain circumstances. In the case of WMO transport in Drenthe, The Netherlands, visitors of day care centres are not meant to use WMO transport, because the day care centre already receives WMO support to arrange the transport for themselves. In fact, this is exactly the situation we want to create: Organizations that arrange for the transport of their visitors. In this case, not only the planning but also the execution of transport is on the part of the organization. However, in practice, these municipal policies are only recently imposed on day care centres, meaning their fleet of vehicles is not yet sufficient to cover all the transport. Therefore, the additional transport is still supplied by WMO transport, but the requests for transportation still reside with the day care centre. In areas where such practices are not yet common, we advise local governments to look into this, as the transport requests are very similar for each day of the week.

Facilities for day care activities are different from day care centres in the sense that the activities fill only a part of the day. These activities include, but are not limited to, swimming, horse riding, animal therapy and artistic activities. The facilities are not entirely focussed on elderly and people with disabilities. Therefore, these organizations do not receive direct WMO support for their customers, such as day care centres do. The activities are sometimes organized by volunteers but this is not always the case. However, from interviews, we conclude that transport is rarely organized by the activity initiators, even though these activities take place on the same day(s) of each week. There is however a shared interest in the arrangement of transport. This is illustrated by the example of handicapped people, who need to plan their way home after an evening at the horse riding grounds. The taxi bus drivers are allowed to arrive 15 minutes early or 15 minutes late, but whenever this time window is not met, this results in troublesome situations. Either the person has to interrupt the activity early or worse, the person has to wait 30 minutes in the outside, after closing time of the horse riding grounds. Cooperation with other organizations is more difficult as the activities and times of activities can be very different at various facilities for day care activities.

Social employment organizations help people to integrate in society, providing them with social work such as park maintenance. The schedule of work can vary for people who only work in the mornings or an entire work day, often starting early in the morning. Sometimes, different work activities and schedules can apply to the same geographic location, meaning the purpose of visits may differ for different people. However, common interest for transport arrangement is present for the same reasons as those associated with day care activities. Cooperation in transport planning efforts with other social employment activities might be possible if schedules are the same.

Community centres serve local communities, often the same people that are well known to the organization. Several different day care activities can be organized at these facilities, such as dancing and bingo, making it a special type of facility for day care activities. The difference with other facilities is the special involvement of the community in these organizations. The main purpose of the community centres is to provide their visitors with activities, without commercial interests, at least in most cases. Furthermore, several community centres within the same geographic area often provide similar activities on different days. This makes it easy to coordinate activities between community centres, as well as transport, which is currently not seen in practice. The activities at community centres often involve a lot of volunteers. Some elderly and people with disabilities are already driven by volunteers. However, interviews with chairmen of several community centres reveal that a lot of taxi buses still arrive simultaneously at their front door, with only a single passenger on board.

The types of organizations that remain to be discussed are municipal offices and asylum centres. However, these are somewhat unique organizations which might nog appear in every top 50 of transport for elderly and people with disabilities. The visitor patterns of these organizations reveal that group arrangements for transport to the asylum centre in Ter Apel are realistic. In fact, group transports to the asylum centre are requested by the municipality and is common practice.

4.3 Summary and conclusions

Findings in Chapter 2 already revealed that a few locations are visited frequently by a relatively small group of people. This chapter built on these findings to find the types of organizations that are visited most frequently. As different address notations in the data refer to similar locations and therefore similar organizations, we first developed a method to solve this observed geocoding problem. Based on the discussed literature on string similarity measures and the particular structure of address fields in our data, we identified the longest common substring algorithm to be an appropriate basis on which to compare addresses. Based on the principle that common prefixes and suffixes are often used in different street entries, we developed a procedure to prepare street entries for accurate comparison. This method can easily be adapted to fit data from other geographic areas. If the method recognizes data entries to refer to the same address, the notation of the address is changed such that trips and distances of transport can be linked to unique addresses. Then, we constructed a top 50 of addresses in terms of their related trips, distance and travel time. Through some internet research, we constructed a similar list of the organizations that are located at these addresses. It turns out that this small selection of organizations is responsible for roughly 50% of all trips, kilometres and travel hours in the transport of elderly and people with disabilities in the southeast area of Drenthe, The Netherlands. Not every type of organization is equally suitable for a shift of transportation requests from the passengers to the organizations that these passengers visit. Therefore, we classified organizations based on a set of criteria. We identified community centres to be particularly suited to facilitate in efforts to shift transportation requests from the passengers to the organizations that these passengers visit. Other facilities for day care activities and day care centres are equally suited under certain circumstances. This answers our third research question. The next chapter analyses to what degree the efficiency of transport can be improved for organization types that are classified as potential.

5 Solution & Implementation

In the previous chapter, we identified several types of organizations that are most prominent in the transport of elderly and people with disabilities. Each type has its own merits when it comes to the ability of organizations to engage in the transportation process. We classified each type of organization based on a number of criteria to determine whether a shift of transportation requests from the passengers to the organizations that these passengers visit is possible. We discovered that community centres are especially suited to facilitate such efforts. Particularly in the situation where multiple community centres serve the same community, coordination of activities and coordination of transport is realistic. To assess the potential of such efforts, we zoom in on the case of 5 community centres in Klazienaveen, which is a city southeast of Emmen. Through analysis of such a case, we demonstrate to what extent the efficiency of transport can be improved. The results of this case are generalized to similar cases. In Section 5.1, we describe the case at hand. Section 5.2 analyses the characteristics of transport to the various community centres. In Section 5.3 we construct a business case to demonstrate to what degree the efficiency of transport can be improved. Finally, in Section 5.4, we present a short summary and conclusions.

5.1 Case description

As our classification method revealed that community centres are potential organizations to involve in a solution to improve efficiency of transport, we looked at several community centres in the southeast area of Drenthe, The Netherlands, that appear within or just outside of our top 50. Taking into account their geographic location and visitor patterns, the case of 5 community centres in Klazienaveen was identified, each responsible for a peak of WMO transport on a different day of the week, see Figure 22. The surface of the circles is related to the yearly amount of WMO trips.

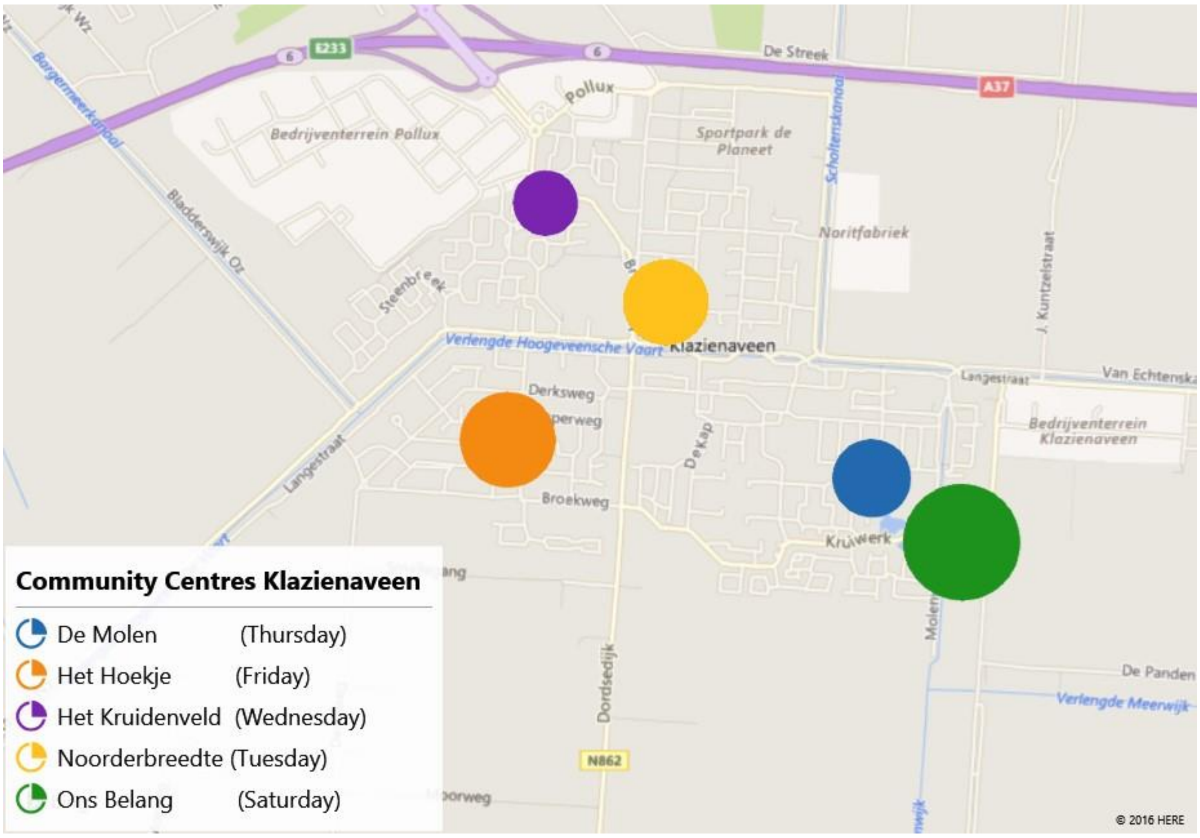

Figure 22: Community Centres in Klazienaveen by the amount of yearly trips

Interviews with chairmen of the community centres revealed the reason for transport to their locations: Bingo. A game of bingo is organized every week between 7 and 9 pm at each of the community centres, with the exception of one where bingo is played every other week. The community centres are given in Table 10, along with the day on which the game of bingo takes place. The trips correspond to the total amount of trips to (and not from) the community centres. This way, the amount of trips per day gives a good idea of the amount of people that use WMO transport to travel to the various bingo sites. To recall, the period of analysis spans from the first of January 2014 to the end of May 2015.

Community Centre	**Address**	**Trips**	**Days**	**Trips/day**
Noorderbreedte (Tuesday)	Meteoor 3, Klazienaveen	319	28	11.4
Het Kruidenveld (Wednesday)	Akkerdistel 100, Klazienaveen	183	65	2.8
De Molen (Thursday)	Lange Spruitstraat 73, Klazienaveen	265	65	4.1
Het Hoekje (Friday)	De Lauden 17, Klazienaveen	399	69	5.8
Ons Belang (Saturday)	Kruiwerk 40, Klazienaveen	589	64	9.2

Table 10: Community centres Klazienaveen

The total amount of trips to and from the community centres in Klazienaveen is given in Table 11, along with their reported distances in kilometres. Given a commercial pick-up fee of €5.60 and a price of €1.40 per kilometre, including taxes, the total costs are calculated accordingly.

	Total (from January 2014 to May 2015)			**Yearly total**		
	Trips	**Distance (km)**	**Cost (€)**	**Trips**	**Distance (km)**	**Cost (€)**
To	1755	8447	21654	1239	5963	15285
From	1787	9069	22704	1261	6402	16026
Total	3542	17516	44358	2500	12364	31311

Table 11: Numbers involved in the transport to and from community centres in Klazienaveen

In Table 12, we analysed the frequency at which people travel to and from the community centres. There are 83 elderly and people with disabilities that use WMO transport to travel to the community centres. Only 38 of those people are responsible for 95% of the trips. As can be seen, some people participate in three different bingo games every week, on average. To illustrate, these 38 people require 95% of €31,311, in other words €783 per person per year to participate regularly in a game of bingo. In terms of membership fee, this can be considered a lot of money, money that might be spent otherwise.

In the current situation, people request for transport individually. According to chairmen and volunteers at the respective community centres, the people requiring WMO transport rarely arrive in the same taxi bus. With little time in between, multiple taxi buses stop before the entrance of the community centre, dropping of single passengers most of the time. After the bingo game, similar events can be witnessed when the people requiring WMO transport are picked up again to bring them to their respective homes. According to the people we have spoken to, often, people who they know of that they live in the same street, are picked up at the same time by different taxi buses. This happens for no particular reason other than the instructions that are given by the taxi company to the taxi bus drivers. Most of our interviewees share the opinion that transport of elderly and people with disabilities can be organized much more efficiently in these situations.

total (83 people of whom 38 are responsible for 95% of 3557 trips)						
wmo_id	to	from	total	to/week	from/week	total/week
1	215	203	418	3.2	3.1	6.3
2	192	190	382	3	3	6
3	96	96	192	1.5	1.5	3
4	98	88	186	1.5	1.3	2.8
5	89	88	177	1.4	1.4	2.8
6	74	75	149	1.1	1.2	2.3
7	59	61	120	0.9	0.9	1.8
8	57	57	114	0.9	0.9	1.8
9	55	55	110	0.9	0.9	1.8
10	52	52	104	0.8	0.8	1.6
11	53	50	103	0.8	0.8	1.6
12	46	47	93	0.7	0.7	1.4
13	37	35	72	0.6	0.6	1.2
14	34	34	68	0.5	0.5	1
15	14	51	65	0.2	0.8	1
16	32	32	64	0.5	0.5	1
17	28	27	55	1	1	2
18	28	25	53	1	0.9	1.9
19	27	26	53	1	0.9	1.9
20	26	25	51	0.9	0.9	1.8
21	26	25	51	0.9	0.9	1.8
22	26	25	51	0.9	0.9	1.8
23	25	25	50	0.9	0.9	1.8
24	25	25	50	0.9	0.9	1.8
25	25	25	50	0.4	0.4	0.8
26	25	24	49	0.9	0.9	1.8
27	24	24	48	0.9	0.9	1.8
28	5	42	47	0	0.6	0.6
29	22	23	45	0.3	0.3	0.6
30	21	21	42	0.3	0.3	0.6
31	21	21	42	0.3	0.3	0.6
32	21	20	41	0.3	0.2	0.5
33	18	18	36	0.6	0.6	1.2
34	9	27	36	0.1	0.4	0.5
35	18	17	35	0.4	0.4	0.8
36	13	14	27	0.2	0.2	0.4
37	12	11	23	0.2	0.2	0.4
38	10	10	20	0.2	0.2	0.4
39	11	9	20	0.2	0.1	0.3
40	9	9	18	0.1	0.1	0.2
41	7	5	12	0.1	0	0.1
42	5	6	11	0.1	0.1	0.2
43	5	5	10	0.2	0.2	0.4
44	5	4	9	0.2	0.1	0.3
45	5	4	9	0.2	0.1	0.3
46	5	4	9	0.1	0.1	0.2
47	4	4	8	0.1	0.1	0.2
48	4	4	8	0.1	0.1	0.2
49	4	4	8	0.1	0.1	0.2
50	3	3	6	0	0	0
…	…	…	…	…	…	…
…	…	…	…	…	…	…
…	…	…	…	…	…	…

Table 12: Average trips/week of people to/from community centres in Klazienaveen

5.2 Case analysis

In order to assess whether vehicles can be deployed more efficiently in the transport of elderly and people with disabilities to and from the community centres in Klazienaveen, we need to know where people travel from. First, we look at the transport to the 5 community centres in Klazienaveen together, see Figure 23.

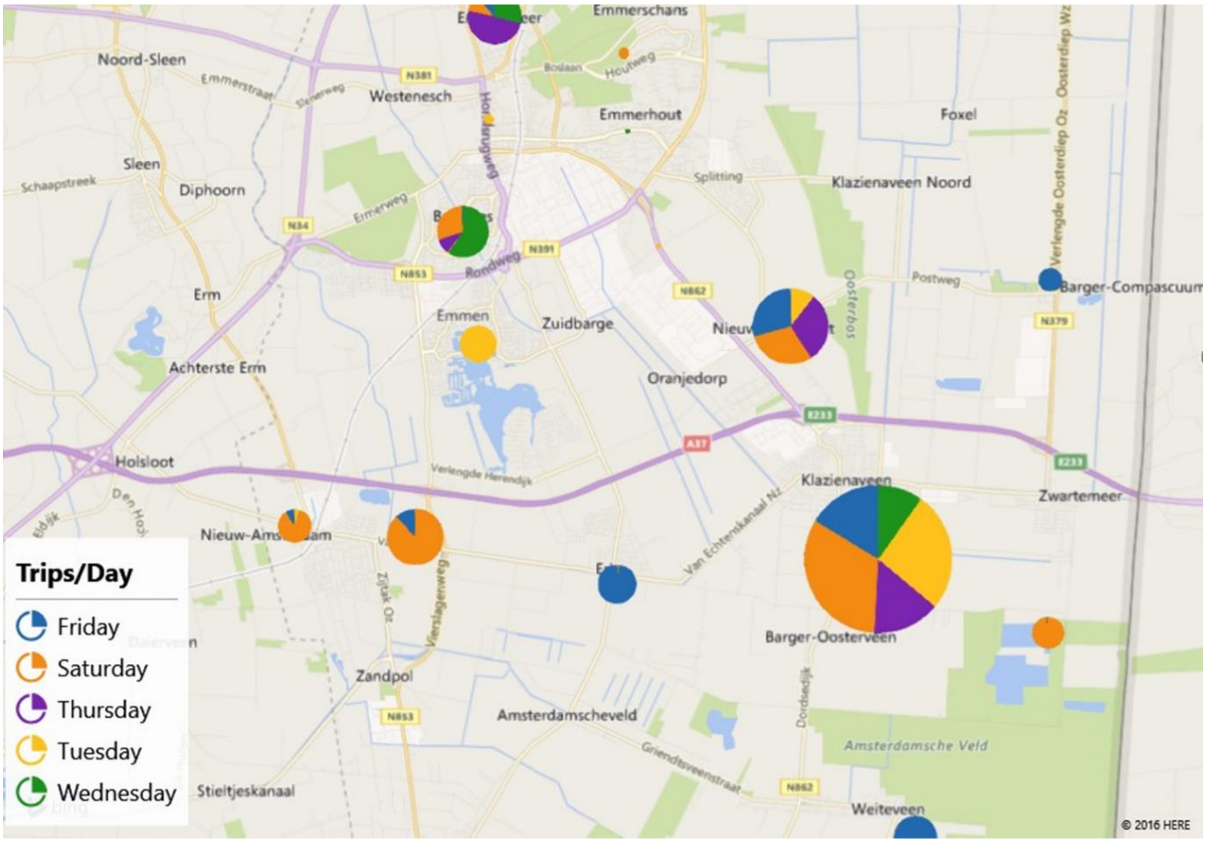

Figure 23: Origins of transport to the community centres in Klazienaveen by day of the week

Here, we see the origins of transport to the community centres in Klazienaveen on different days. The surface of the circles is related to the total amount of trips. Each circle represents a zip code area. Most of the trips originate from Klazienaveen itself. The rest of the trips originates from zip code areas between Emmen and Klazienaveen. However, the origins of trips clearly depend on the day of transport, or more specifically the community centre where the bingo event takes place. Apparently, the customer base of each community centre is different. Therefore, the routes that are driven by the taxi bus drivers to bring the people to the bingo event are also different for each day of the week. In order to capture the specific characteristics of each day of transport, we analyse the transport to the community centres in Klazienaveen, individually.

In Figure 24, we see the visitor pattern of the first community centre that we analyse. The numbers correspond to the average numbers of trips that are executed on that specific hour of the week. For example, there are on average 4.1 trips that start between 6 and 7 pm on Tuesday, see Figure 24. As bingo events at community centre Noorderbreedte are held only every other week, we further analysed trip frequency on the days that bingo events are held, see Figure 25. We observe that on most bingo events, about 10 or 11 people use WMO transport to travel to the community centre. To determine where these people travel from, we displayed the origins of transport on a map in Figure 26. Each circle represents a zip code area. The surface of the circles is related to the total amount of trips from that zip code area to the community centre. The amount of trips that each circle represents can be read from Table 13. The colours in Figure 26 represent the share of individual people that request for the transport. The share of each person can be read from Table 14.

Noorderbreedte - Meteoor 3, Klazienaveen														
To								From						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	**Hour**	Mon	Tue	Wed	Thu	Fri	Sat	Sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0.1	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0	0	0
0	0.2	0	0	0	0	0	**17**	0	0	0	0	0	0	0
0	4.1	0	0	0	0	0	**18**	0	0	0	0	0	0	0
0	0.2	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	2.9	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	1.2	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0.1	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Figure 24: Visitor pattern of cummunity centre Noorderbreedte

28 Tuesdays	Occurrence	
#Trips	To	From
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
< >		
22		
23		
24		

Figure 25: Amount of trips to community centre Noorderbreedte on bingo events

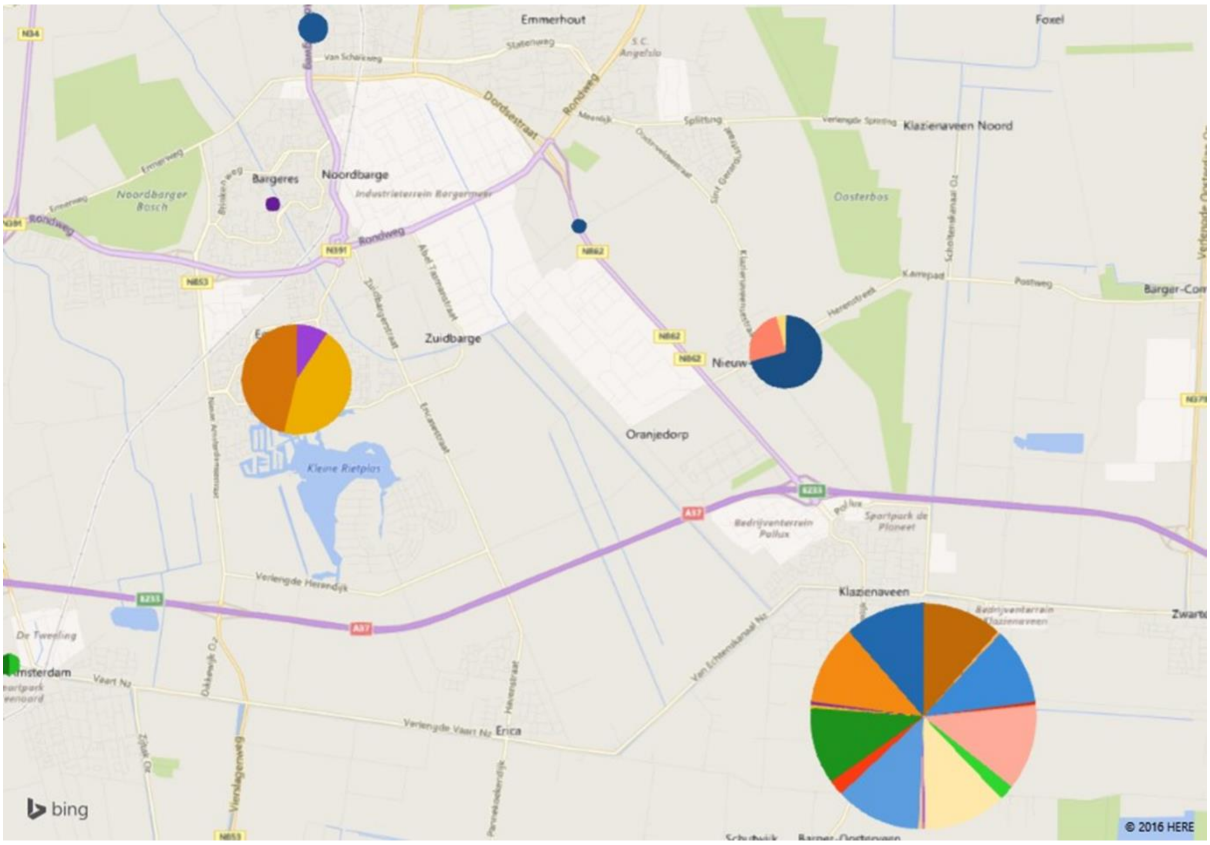

Figure 26: Origins of transport to community centre Noorderbreedte

Zip code	Trips	Trips/day
7891	227	8.1
7827	54	1.9
7885	24	0.9
7741	6	0.2
7811	4	0.1
7844	2	0.1
7825	1	0.0
7812	1	0.0

Table 13: Number of trips by zip code area

WMO ID	To	From	WMO ID	To	From
1	1.0	1.0	9	0.9	0.9
2	1.0	0.9	10	0.9	0.9
3	1.0	0.9	11	0.6	0.6
4	0.9	0.9	12	0.2	0.2
5	0.9	0.9	13	0.2	0.2
6	0.9	0.9	14	0.2	0.1
7	0.9	0.9	15	0.2	0.1
8	0.9	0.9	16	0.1	0.1

Table 14: Number of trips to and from community centre Noorderbreedte, by WMO ID

Analyses of the other community centres can be found in Appendix 3. We conclude that each community centre has a fairly consistent customer base of people who use WMO transport to travel to their locations. The customers of different community centres live in various districts and therefore travel from different places. However, the variety of districts that people travel from is small and usually adds up to only four or five zip code areas. Other areas are often further away from Klazienaveen and house people that only sporadically visit a bingo event. These are people that are less familiar to the community and they should not be targeted initially. On the other hand, the few districts with regular customers that remain, can easily be incorporated in the route of a taxi bus, passing each district to pick up people and drop them off at the community centre. A typical taxi bus for WMO transport in Drenthe, The Netherlands, offers place to 6 people and 2 additional places for people in a wheel chair and such alike. Looking at the frequency of occurrence of trips per bingo event at each of the community centres, a lot is possible in terms of capacity. On Wednesdays and Thursdays, a single taxi bus could be tasked to pick up everyone, as well as on most Fridays. On Tuesdays and Saturdays, at least one additional route is needed to serve all transport requests. Deployment of a single bus or two buses is potentially more efficient than the large numbers of vehicles that are currently being deployed to drop off elderly and people with disabilities at the various bingo events. To assess whether and how this is attainable in practice, we discuss a business case in Section 5.3.

5.3 Business case: Bingo bus

In this section, we explore the viability of a bingo bus, a single taxi bus that is dedicated to the transport of people who normally use WMO transport to reach one of the five community centres in Klazienaveen. Among others, The Department for Transport in the UK recognises that the community sector can provide efficient transport to suit the needs of specific groups or individuals. They encourage local authorities to embrace voluntary services in the development of local transport solutions (DfT, 2011). Volunteers and employees of day care centres in Emmen are already tasked with picking up their own customers with buses that are similar to the taxi buses that are used in WMO transport. These volunteers know their passengers and their conditions, making the transport a more comfortable experience for both driver and passenger. In the case of the bingo games in Klazienaveen, resources can be shared across the various community centres, for each requires transport on a different day of the week. Therefore, each community centre can be tasked with the provision of a volunteer driver for the bingo bus on the evening of their respective bingo event. Ideally, the bus is used in coordination with other organizations during the day.

To assess whether the bingo bus is a viable alternative for WMO transport, we construct a realistic set of routes for the bingo bus on different days of the week, based on the regular customer base of each community centre that we assessed in Section 5.2. Distances between each customer in a route are based on the average reported distance of trips in the data between zip code areas. These average reported distances are calculated in a distance matrix of the zip code areas in the vicinity of Klazienaveen, see Table 15. The zip code areas are presented geographically on a map in Appendix 4. Each route starts and ends at the zip code area of Klazienaveen: 7891. Furthermore, the speed of the bingo bus is assumed to be 40 km/h when driving between different zip code areas and 25 km/h when picking up two or more consecutive passengers in the same district. To take into account transfer time, we assume it takes 2 minutes to pick up a passenger, based on the average 4 minutes transfer time of all the trips in the data. At the end of a route, we further assume it takes 5 minutes in total to drop off all passengers at the community centre. Last but not least we consider constraints on capacity of a typical WMO taxi bus and (extra) ride times of passengers.

Zip code	7741	7765	7811	7812	7815	7823	7824	7825	7827	7833	7844	7884	7885	7887	7891	7894
7741	1.6	19.4	18.9	18.1	20.3	23.1	20.6	21.9	17.1	12.4	12.7	27.6	22.5	16.7	21.3	24.6
7765	19.3	2.1	17.6	17.4	18.8	17.2	16.1	14.8	14.0	11.9	12.0	14.6	10.8	8.7	7.6	10.7
7811	19.0	17.7	1.2	3.2	2.4	3.9	2.6	5.1	5.2	10.4	10.7	13.0	7.5	10.5	10.7	14.3
7812	18.2	17.4	3.2	1.3	5.0	7.1	4.4	6.5	4.2	7.9	8.5	13.9	9.1	9.1	11.9	15.0
7815	20.3	18.8	2.3	5.0	0.9	4.6	3.6	6.1	6.9	12.2	11.4	14.8	9.5	13.8	12.1	16.0
7823	23.0	17.4	4.0	7.0	4.6	1.1	3.7	3.2	8.4	13.9	14.3	10.8	6.6	13.1	10.3	14.2
7824	20.5	16.1	2.5	4.4	3.6	3.7	1.7	3.6	6.4	11.4	11.5	11.7	6.2	10.3	9.4	12.9
7825	22.1	14.8	5.1	6.6	6.2	3.2	3.5	5.3	6.5	12.9	13.4	9.8	5.6	9.1	8.6	12.9
7827	17.1	13.9	5.1	4.1	6.8	8.4	6.2	6.5	1.6	5.5	7.1	12.9	6.7	7.8	9.4	13.5
7833	12.4	11.9	10.4	7.9	12.1	13.9	11.5	12.8	5.3	1.9	1.4	15.7	10.7	5.7	10.1	13.9
7844	12.7	12.0	10.7	8.5	11.4	14.3	11.5	13.4	7.5	1.4	0.4	16.9	11.9	6.4	11.2	15.0
7884	27.7	14.6	12.9	14.0	14.8	11.3	11.5	9.9	12.9	15.6	16.9	0.6	6.0	11.6	6.9	5.4
7885	22.4	10.8	7.5	9.1	9.6	6.6	6.2	5.6	6.7	10.8	12.3	6.0	1.5	6.4	4.2	7.7
7887	16.5	8.3	10.6	9.2	14.0	13.1	10.3	9.1	7.4	5.5	6.4	11.6	6.9	1.0	5.3	9.3
7891	21.4	7.6	10.7	11.9	12.2	10.3	9.4	8.7	9.3	10.1	11.2	6.9	4.2	5.3	2.5	5.0
7894	24.6	10.7	14.3	15.2	15.9	14.2	12.8	12.8	13.5	13.9	15.0	5.4	7.7	9.4	5.0	0.9

Table 15: Matrix of distances in kilometres between zip code areas in the vicinity of Klazienaveen

On every other Tuesday, bingo takes place at community centre Noorderbreedte. A relatively large group of people using WMO transport visits this event on a regular basis. These are primarily people who live in Klazienaveen. Only three other people from outside this area visit this community centre frequently, two of whom living in the same zip code area. For the exact numbers, we refer to the analyses in Appendix 3. The eleven people of frequent visitors cannot travel together in a single bus. Therefore, we propose two different routes which are driven subsequently. For convenience of the passengers, it is not desired to pick up a passenger in Klazienaveen first. Rather, the first pick-up occurs at the upper left district, depicted in Figure 27.

Figure 27: Two different routes on every other Tuesday

The details of the two routes can be found in Table 16. We deliberately separate the first pick-up from the rest, as the related travel distance and time do not concern passengers, since the vehicle is still empty. The second stop refers to the pick-up of a passenger that lives in the same district. Therefore, the travel time is based on an average speed of 25 km/h in this segment. The bus then proceeds to the district at the upper right of Figure 27 at a speed of 40 km/h. On the way back to Klazienaveen, two more passengers are picked up in Klazienaveen before drop-off at the community centre. At drop-off, no passengers are picked up, so the number of passengers is 0. The drop-off takes a total of 5 minutes after which the bus proceeds to execute the second route, which solely comprises the pick-up of passengers in Klazienaveen, presented by the black circle at the bottom right of Figure 27.

	Noorderbreedte (every other Tuesday)						
	From	**To**	**Distance (km)**	**Passengers**	**Transfer (min)**	**Travel (min)**	**Total (min)**
To first pick-up	7891	7827	9.3	1	2	13.9	13.9
Route 1	7827	7827	1.6	1	2	4.8	8.8
	7827	7885	6.7	1	2	10.1	12.1
	7885	7891	4.2	1	2	6.3	8.3
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	0	5	6.0	11.0
Totals route 1:			**20**	**6**	**17**	**39**	**56**
Route 2:	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	0	5	6.0	11.0
Totals route 2:			**15**	**5**	**15**	**36**	**51**
Route 1 + 2			**35**	**11**	**32**	**75**	**107**
Incl. first pick-up			**44**	**11**	**32**	**89**	**121**

Table 16: Routing details for every other Tuesday

The first route takes 56 minutes from the first pick-up to the community centre. The average reported distance from the first pick-up district to Klazienaveen is 9.4 kilometres, see Table 15. If we again assume an average speed of 40 km/h and a transfer time of 4 minutes, the passenger of the first pick-up would take 18 minutes to reach the community centre using WMO transport, without detours. Considering WMO regulations in Drenthe, The Netherlands, a driver is allowed to make a detour of 30 minutes to pick-up other passengers, allowing for a total travel time of 48 minutes. However, this restriction is only violated for the first passenger. The second route takes 51 minutes, adding up to a total of 107 minutes, measured from the first pick-up. The bus departs 14 minutes early from Klazienaveen, giving the driver approximately two hours of work.

On Wednesday, community centre Kruidenveld is visited regularly by 4 people that use WMO transport. These people live in only 2 districts other than Klazienaveen, enabling the construction of a fixed route through these areas. Only half of the time, someone is picked up at the district recognizable by the red circle in Figure 28. However, because there are no clear violations of capacity to fear of in this case, we choose to incorporate this district in our route anyway. The total time to complete the route, starting at the first pick-up, adds up to 50 minutes. The routing details can be viewed in Table 17.

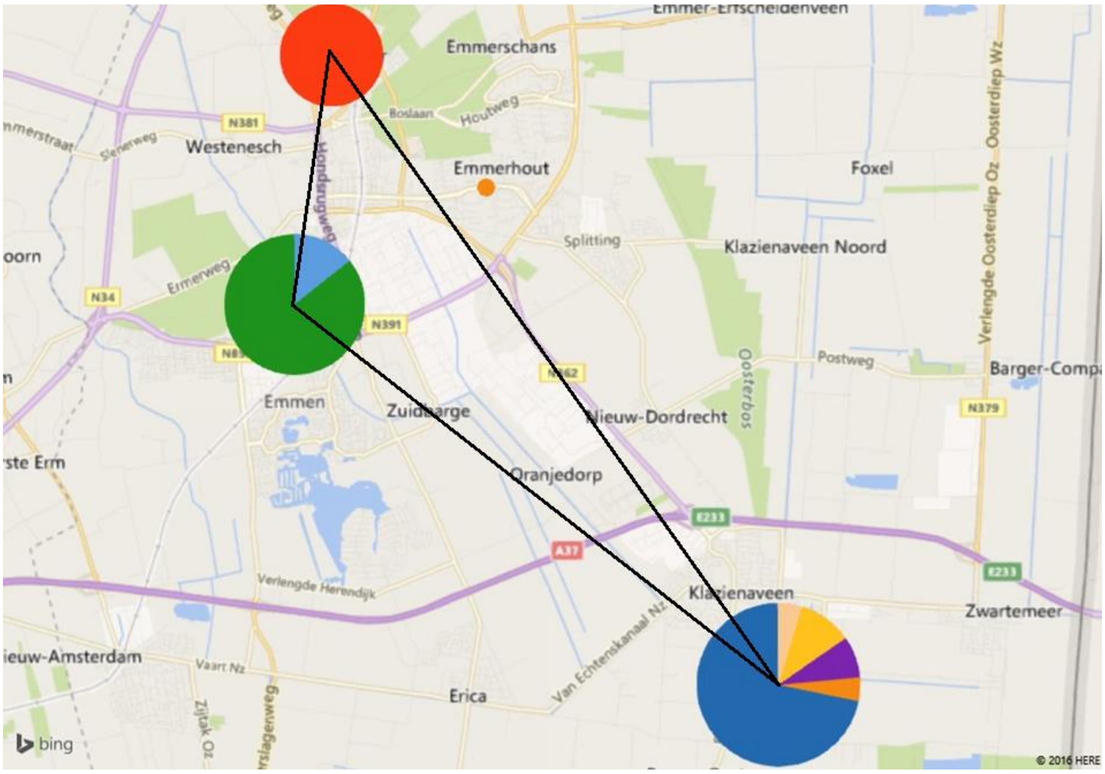

Figure 28: One route on every Wednesday

	Kruidenveld (every Wednesday)						
	From	To	Distance (km)	Passengers	Transfer (min)	Travel (min)	Total (min)
To first pick-up	7891	7815	12.2	1	2	18.3	18.3
Route	7815	7812	5.0	1	2	7.4	11.4
	7812	7891	11.9	1	2	17.8	19.8
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	0	5	6.0	11.0
Route totals:			**22**	**4**	**13**	**37**	**50**
Incl. first pick-up			**34**	**4**	**13**	**56**	**69**

Table 17: Routing details for every Wednesday

	De Molen (every Thursday)						
	From	To	Distance (km)	Passengers	Transfer (min)	Travel (min)	Total (min)
To first pick-up	7891	7815	12.2	1	2	18.3	18.3
Route	7815	7885	9.5	1	2	14.3	18.3
	7885	7891	4.2	1	2	6.3	8.3
	7891	7891	2.5	1	2	6.0	8
	7891	7891	2.5	1	2	6.0	8
	7891	7891	2.5	0	5	6.0	11
Route totals:			**19**	**5**	**15**	**39**	**54**
Incl. first pick-up			**33**	**5**	**15**	**57**	**72**

Table 18: Routing details for every Thursday

On Thursday we see a similar situation, with 2 regular customers living outside of Klazienaveen in separate districts. The other 3 customers live in Klazienaveen and visit community centre De Molen almost every Thursday, see Figure 29. We construct a single route, starting at the farthest district, which adds up to 54 minutes. See Table 18 for more details.

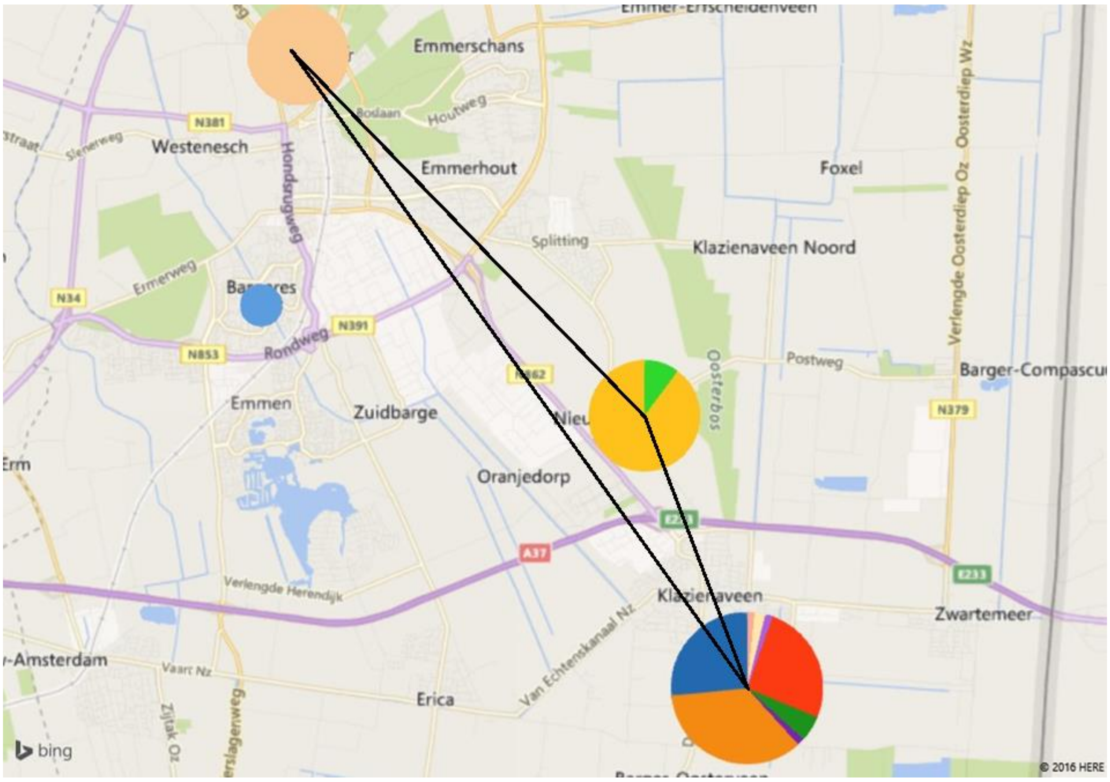

Figure 29: One route on every Thursday

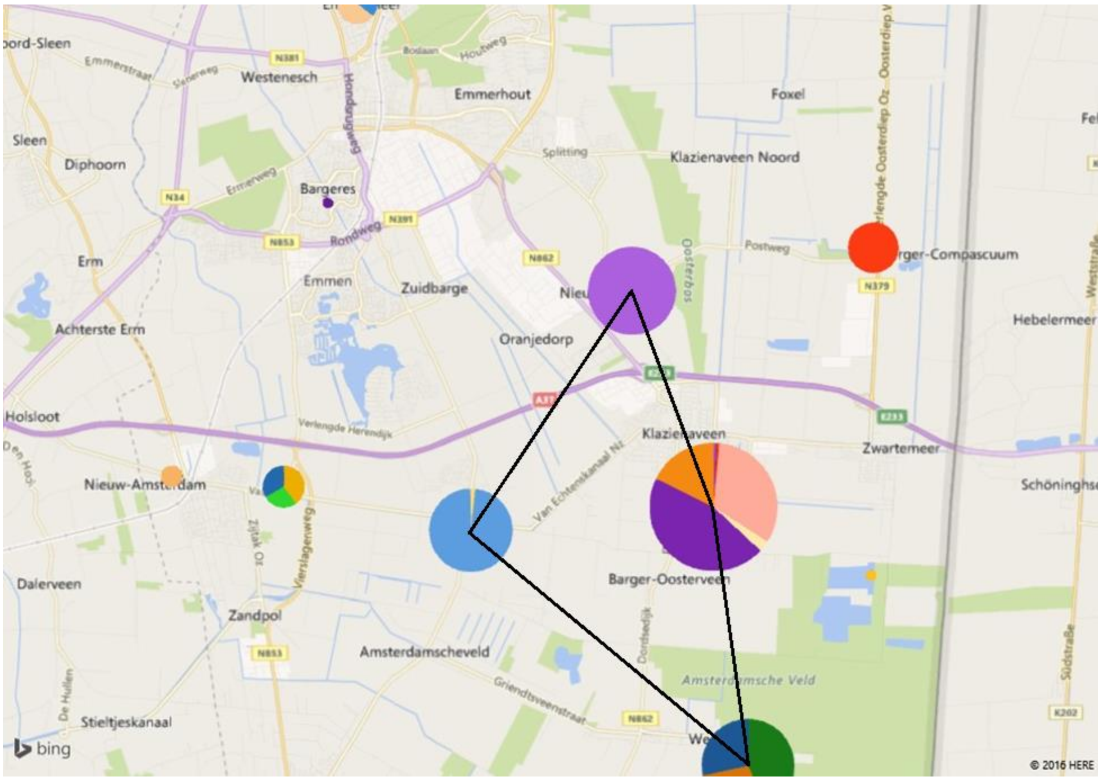

Figure 30: One route on every Friday

On Friday, the situation becomes a little more complex as customers are dispersed over a greater variety of districts. However, the single customer represented by the red circle in Figure 30 for example, visits the community centre Het Hoekje less than once every three bingo events. Therefore, it is best not to incorporate this district in our route. Starting from the zip code area that is located south of Klazienaveen, see Figure 30, on average, we pick up 1 passenger. However, the situation where 2 people are picked up in this district is one we have to account for. We continue to pick up one passenger in the light blue district and one in the light purple district. The last 2 passengers are picked up in Klazienaveen. In total this route adds up to 64 minutes. More details can be found in Table 19.

	Het Hoekje (every Friday)						
	From	**To**	**Distance (km)**	**Passengers**	**Transfer (min)**	**Travel (min)**	**Total (min)**
To first pick-up	7891	7765	7.6	1	2	11.3	11.3
Route	7765	7765	2.1	1	2	5.0	9.0
	7765	7887	8.7	1	2	13.0	15.0
	7887	7885	6.9	1	2	10.3	12.3
	7885	7891	4.2	1	2	6.3	8.3
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	0	5	6.0	11.0
Route totals:			**27**	**6**	**17**	**47**	**64**
Incl. first pick-up			**34**	**6**	**17**	**58**	**75**

Table 19: Routing details for every Friday

	Ons Belang (every Saturday)						
	From	**To**	**Distanc (km)**	**Passengers**	**Transfer (min)**	**Travel (min)**	**Total (min)**
To first pick-up	7891	7885	4.2	1	2	6.3	6.3
Route 1	7885	7812	9.1	1	2	13.7	17.7
	7812	7844	8.5	1	2	12.7	14.7
	7844	7833	1.4	1	2	3.4	5.4
	7833	7833	1.9	1	2	4.6	6.6
	7833	7891	10	0	5	15.2	20.2
Totals route 1:			**31**	**5**	**15**	**50**	**65**
Route 2	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	1	2	6.0	8.0
	7891	7891	2.5	0	5	6.0	11.0
Totals route 2:			**15**	**5**	**15**	**36**	**51**
Route 1 + 2			**46**	**10**	**30**	**86**	**116**
Incl. first pick-up			**50**	**10**	**30**	**92**	**122**

Table 20: Routing details for every Saturday

The last day for which we have to develop an operating plan for the bingo bus is Saturday. Looking at Figure 31, the situation becomes a little more troublesome as the regular customers of community centre Ons Belang are dispersed over a large geographic area. A single route to pick up customers both west and east of Klazienaveen is not really an option in terms of dwell times of people on board of the bingo bus. Furthermore, a second route is needed to pick up all the people in Klazienaveen, which is represented by the black circle in Figure 31. Routing details may be found in Table 20. The first route goes counter clockwise to maximize the distance to the first pick-up. This route takes 65 minutes from the first pick-up. The second route is executed by the same driver, after passengers along the first route have been dropped off at the community centre. The second route takes 51 minutes from the first pick-up. In total, this adds up to 116 minutes and it takes approximately two hours for the driver to pick up 10 passengers. We choose not to incorporate the pick-up of the person at the dark blue circle in Figure 31 in our schedule. It would take too much extra time to fit the pick-up of this person into any schedule with the same number of passengers.

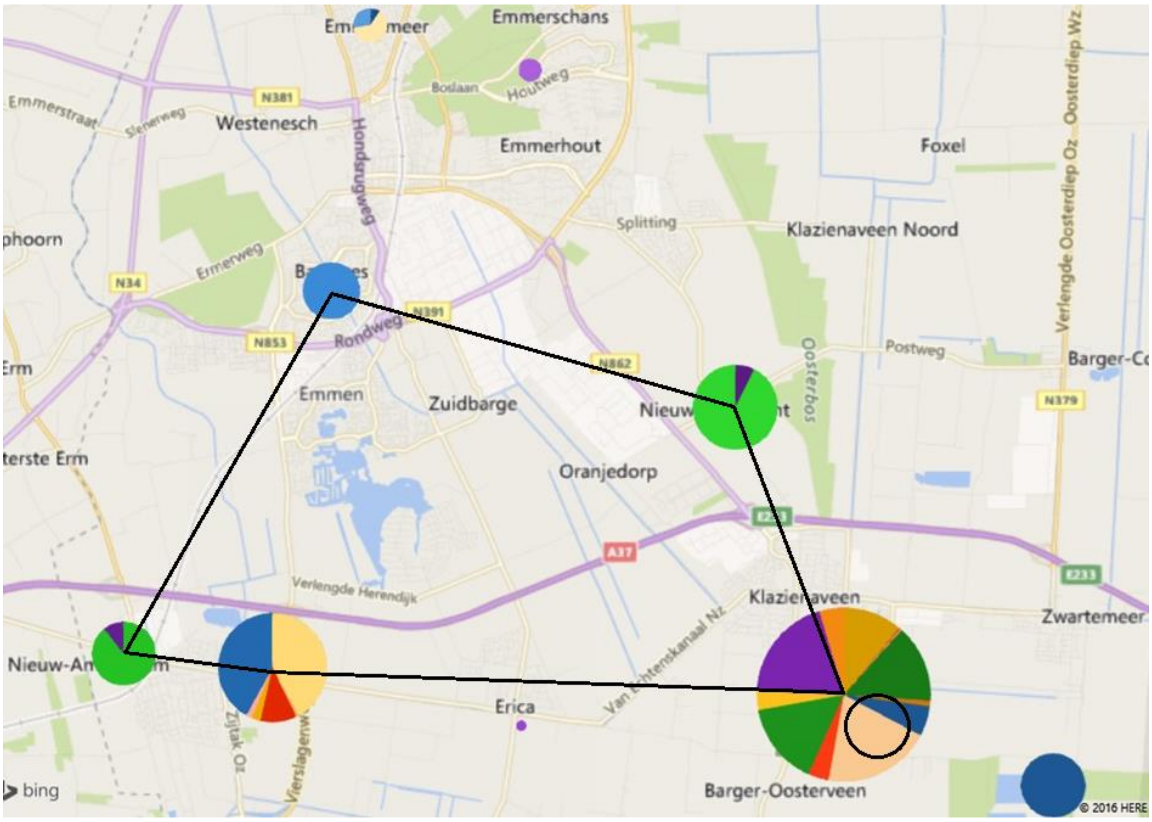

Figure 31: Two different routes on every Saturday

The totals of the weekly bingo bus routes together have been summarized in Table 21. Comparison to the current totals in Table 11 reveals that the yearly distance number of transport to the community centres remains almost exactly the same, even though the amount of trips is higher. The higher number of trips in our designed schedules is the result of rounding fractional averages. For example, in our design, we sometimes choose to pick up a person that visits a community centre on average 0.6 times, instead of 1.0 times. Actually, distances in Table 11 and Table 21 cannot be compared one to one, as the current distances (in Table 11) are merely reported distances based on the shortest path from pick-up to destination. In reality, taxi bus drivers make a lot of empty kilometres between drop-off of one passenger and pick-up of another one. These distances are not accounted for in the totals of Table 11, which would make a huge difference, since picking up multiple passengers along a route is currently the exception, rather than the rule.

Weekday	Events	Trips	Distance (km)	Total trips	Total distance (km)
Tuesday	28	11	35	308	980
Wednesday	66	4	22	264	1452
Thursday	65	5	19	325	1235
Friday	69	6	27	414	1863
Saturday	64	10	46	640	2944
Total to				**1951**	**8474**
Yearly to				**1377**	**5982**
Yearly to + from				**2754**	**11963**

Table 21: Totals bingo bus

Another advantage in terms of efficiency of transport between the bingo bus and the current situation, is the amount of resources needed to serve the same amount of trips. From interviews with members of the community, we conclude that a minimum of 4 buses is deployed every day for transport of elderly and people with disabilities to the community centres. Several people even claimed to have seen lines of taxi buses in front of the community centre. Analysis of vehicle occupation in Chapter 2, from which we concluded that the occupation of a vehicle rarely exceeds 2 passengers at a time, supports these findings. In contrast, the bingo bus can be driven each day by a single volunteer, fulfilling almost every transport request, apart from the few irregular trips, which can still be served by WMO transport.

Still, some marginal notes have to be considered. As discussed before, the regulation that a driver is only allowed to make a detour of at most 30 minutes is often violated for the first passenger in every route. Furthermore, during execution of a second route to pick up remaining passengers, the passengers of the first route have to wait at the community centre for the other passengers to arrive. The passenger of the first pick-up of the first route might have to spend a total of 2 hours between pick-up and start of the bingo event. The sequence of passengers along a route might be changed to reduce the discomfort of these passengers, if the schedule permits it. However, since the purpose of their visit is social, we can expect that most elderly and people with disabilities would not mind to spend some extra time chatting with others, in the bus or at the community centre, as they travel and wait together. Furthermore, from analysis of trips to each community centre, we know that some people are already picked up close to 5 pm, even though the bingo does not start until 7 pm. Therefore, in the current situation, some people already arrive one hour early, possibly because of the social aspects that we mentioned before. In the case of the bingo bus, these people can now travel and wait together. Besides, the bingo bus allows for tighter adherence to time intervals, as the schedule of the bus can be communicated explicitly to the regular customers, and updated based on daily experience of the drivers. It is not unrealistic to assume that the times needed to execute the various routes will decrease when both driver and passengers get accustomed to a fixed schedule. Additionally, assumptions on speeds and transfers might have to be revisited. For example, some of the people in Klazienaveen travel from the exact same address. These people can easily be picked up simultaneously without the need for additional travel and transfer time in between. On the other hand, practice might reveal that some routes are not really efficient. For example, it takes a lot of additional time to pick up a customer in the light blue district in Figure 31. Experience must indicate whether this route must be adjusted to meet the requirements of other passengers. The community can potentially arrange for the people that cannot efficiently be served by the bingo bus to be picked up by other members of the community.

In the end, an additional bingo bus might be needed to meet the ride time requirements of all the passengers. In terms of distances, this should not matter much, as each route starts and ends in Klazienaveen. However, an additional vehicle and driver has to be provided on the days on which it is needed. The cost of the current service is €31,311 per year, see Table 11. Assuming that the bingo bus fulfils at least 90% of all the current transport requests, the bingo bus service can cost at most €28,180 to break even. The total distance of the bingo bus routes to and from the community centres in Klazienaveen, including empty kilometres to the first pick-ups, adds up to 15,765 km per year. - An important note: More trips are served driving these kilometres compared to the current situation, even though we assume to fulfil only 90% of current transport requests. - This comes down to an expense of €1.79 per kilometre driven by the bingo bus, which should be more than enough to cover depreciation costs of the vehicle, maintenance and repair costs. To put into perspective, the commercial cost of WMO transport is €1.40 per reported kilometre, not even counting the €5.60 that is charged at the start of every trip. Since each reported kilometre probably coincides with an additional empty kilometre in the current situation, the operating cost of WMO transport in the current situation is probably less than €0.70 per kilometre driven. Of course, a large taxi company has some advantages over a small service as the bingo bus that only operates 4 hours per day. For example, the cost of a vehicle breakdown is covered by an entire fleet of vehicles. However, since our solution is based on the cooperative effort of volunteers, we do not have to account for wages of personnel, which usually constitute the foremost driver of expenditures. Altogether, the cost of service can probably be decreased by a large factor, whether a single or perhaps two bingo buses are provided to the community.

5.4 Summary and conclusions

Based on the classification of various types of organizations that are frequently visited by elderly and people with disabilities, we consider a potential case in this chapter. This is a case in which efficiency of transport can be improved by shifting transport requests from the passengers to the organizations that these passengers visit. As community centres are identified to be one of the most appropriate types of organizations to facilitate in such efforts, we selected the case of 5 community centres in Klazienaveen, each hosting a bingo event between 7 and 9 pm on different days of the week. Analysis revealed that each community centre has a fairly consistent customer base of regular visitors. A group of 38 people is responsible for 95% of the trips to these community centres. As each of those people live in various districts in and around Klazienaveen, the transport characteristics of each community centre were evaluated separately. Next, a business case was constructed for the bingo bus. Routes along districts of regular customers were designed for each day of the week, taking into account capacity of a typical WMO taxi bus and dwell times of passengers in and outside of the vehicle. The regulation of at most 30 minutes detour was often violated for the first passenger in a route. However, experience from practice must determine whether this is really the case and whether it is in fact perceived as an issue. Under the assumption that at least 90% of current transport requests can be fulfilled by the bingo bus, the bingo service is allowed to cost at least €1.79 per driven kilometre (including empty kilometers), to break even compared to the current situation. As the operating cost of each driven kilometre in the current situation is estimated to be less than €0.70, which should also cover the wages of personnel, the actual operating costs of the bingo bus are expected to be much lower than that. The profit easily justifies the deployment of an additional bingo bus, if it is needed. Even then, the amount of vehicles used to fulfil all the transport request is much lower than in the present situation, giving this alternative means of transport an overall advantage. This answers our question to what extent the efficiency of transport can be improved by shifting transportation requests from the passengers to the organizations. Through analysis of similar cases in this or in other geographic areas, efficient transport schemes can be developed and implemented gradually to accommodate the transport of elderly and people with disabilities.

Summary and conclusions

The research in this document has been focussed on the efficient transportation of elderly and people with disabilities. To allow for these frail groups of society to equally engage in social environments, demand-responsive transportation (DRT) systems have been tailored to service specific user requests. One such DRT system is subsidized by several municipalities in the southeast region of Drenthe, The Netherlands. This system is meant to serve people who are not self-reliant enough to use conventional public transport. Since the beginning of 2014, the municipalities of Borger-Odoorn, Coevorden and Emmen (BOCE) have been joining forces to put effort into improving the transportation system of elderly and people with disabilities.

The current system provides around 6,000 people with door-to-door service whenever they need it, but only half of them use this so called WMO transport more than once a month. In total, more than 200,000 trips are driven each year, which adds up to 1.8 million kilometres. An average trip spans a distance of 8.5 kilometres and lasts 23 minutes between pick-up at one location and drop-off at another location. The price of each trip starts at €5.60 and another €1.40 is charged for every kilometre. This adds up to €17.50 for an average trip, which is almost completely charged to the respective municipality. Based on a number of substantiated assumptions, we concluded that the occupation of a typical WMO taxi bus rarely exceeds 2 passengers during busy hours. Within BOCE, there is a need to explore the potential of involving service facilities in the planning and execution of WMO transport. This way, the BOCE communities aim to improve the quality of service for elderly and people with disabilities, while at the same time making the transport system more efficient. The goal of this thesis was to investigate in which way and to what degree the efficiency of transport can be improved by shifting transportation requests from the passengers to the organizations that these passengers visit.

First, we established which organizations are visited frequently in the transport of elderly and people with disabilities in Drenthe, the Netherlands. In the process, we had to solve the observed geocoding problem, which is caused by a variety of address notations in the data. In effect, trips and distances are linked to different notations, even though they refer to similar addresses. To solve this problem, we devised a method in which addresses are compared on the basis of a known string similarity measure, which is the longest common substring algorithm. Our method is unique with respect to the preparation procedure, splitting common prefixes and suffixes from street entries, enabling us to compare only the differentiating middle part of a street entry. The structure of our method can easily be adapted to fit data from other geographic areas. The adjustments that the method makes can be verified and corrected if needed.

Based on a list of unique address notations, we were able to construct a top 50 of organizations in the transport of elderly and people with disabilities in Drenthe, The Netherlands. Remarkably, this small selection of organizations turns out to be responsible for roughly 50% of all transport in terms of trips, distance and travel time. Some of these organizations are more suitable for a shift of transportation requests than others. Therefore, we introduced a set of criteria on which to evaluate each organization in our top 50. Based on these evaluations, we classified various types of organizations that show potential to engage in the transportation process. Most types of organizations can be found in every transportation system for elderly and people with disabilities across the globe. The types of organizations that have the highest potential are day care centres, community centres and other facilities for day care activities. Requests for transport to these organizations often share the same purpose and schedule and both passenger and organization share a common interest.

To asses to what degree the efficiency of transport can be improved by shifting transportation requests from the passengers to the organizations that these passengers visit, we identified the case of 5 community centres in Klazienaven, each hosting a game of bingo between 7 and 9 pm on different days of the week. Based on the idea that communities can play an important role in the transport of elderly and people with disabilities, we introduced the concept of a bingo bus. For each day of the week, we designed efficient routes along which regular customers of the respective community centre are to be picked up and dropped off again at the end of the evening. These routes take into account the capacity of a typical WMO taxi bus and the dwell times of passengers both inside and outside the vehicle. The proposed set of routes accounts for more trips compared to the current situation, even though the travelled distance stays the same. However, the current distance numbers do not account for empty distances travelled between drop-off of one passenger and pick-up of another. This is where the bingo bus takes the advantage. In the present system, multiple different vehicles are deployed, each serving a single passenger. The bingo bus can potentially serve more than 90% of all current transport requests on its own. To break even, the bingo bus service is allowed to cost €1.79 per driven kilometre, which easily justifies the provision of an additional vehicle, should experience from practice require it. Even then, the amount of vehicles used to fulfil all the transport request is much lower than in the present situation, giving this alternative means of transport an overall advantage. This answers our question to what extent the efficiency of transport can be improved by shifting transportation requests from the passengers to the organizations. Through analysis of similar cases in this or in other geographic areas, efficient transport schemes can be developed and implemented gradually to accommodate the transport of elderly and people with disabilities.

Recommendations

This thesis showed how the efficiency of transport of elderly and people with disabilities can be improved in this and in similar cases. Especially when resources can be shared across organizations, the ability to shift transportation requests from the passengers to the organizations becomes more apparent. This potential can be increased when activities and schedules are coordinated within and between organizations of similar types. The power of the community should not be underestimated. Voluntary services should be embraced as the community is often closely concerned with the well-being of elderly and people with disabilities. Furthermore, volunteers know the conditions of the people they are involved with, making transport a more comfortable experience. The business case we explored is based on voluntary services being employed to cater a new means of transport. However, the concept of analysing visitor patterns in the design of efficient routes and schedules could easily be applied to improve the current means of transport. In that case, the execution of transport would still reside with the taxi company. However, requests for transportation are coordinated by the organizations.

Demand-responsive systems have largely proven to be sustainable in terms of the environment and social needs requirements. However, economic viability is still a big issue. Given that a large proportion of the operating cost of transport services such as DRT is based on the wages of drivers and personnel, a future of driverless vehicles and automated communications opens up a spectrum of options. In the meantime, the involvement of social enterprise operators and voluntary services should be investigated further to decrease costs. Funding from different sources that recognise the benefits of DRT to their particular environment should be explored in order to relieve the pressure on local government budgets.

Last but not least, the power of data analysis should be recognized by local governments. As currently transport data of elderly and people with disabilities in Drenthe is only gathered for accounting purposes, trips are registered based on single requests for transport. This ultimately makes it hard to analyse the occupancy of vehicles at a given time, since multiple transport requests might be fulfilled by the same driver. To facilitate accurate analysis of the transport system, we recommend the implementation of additional identification numbers. One number identifies trips that start with the same vehicle at the same time and location. Another number identifies trips that end with the same vehicle at the same time and location. This provides valuable information relating to the occupancy of vehicles. Furthermore, the current number of fellow travellers within a transport request cannot be verified, even though the municipality pays for the transport of these people. This can potentially induce fraud. Complete and accurate registration of trips is the key to improvement.

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Appendix 1.1: Longest common substring algorithm

```
'Longest common substring(lcs) algorithm
Public Function lcs(ByVal s1 As String, ByVal s2 As String) As Integer

'Initialization
Dim a As Integer
Dim b As Integer
a = Len(s1)                                 'The length of the first string
b = Len(s2)                                 'The length of the second string
Dim c(0 To 25, 0 To 25) As Integer          'Initialize the matrix
Dim d As Integer                            'Initialize counter of maximum
d = 0                                       'The current maximum is equal to 0
Dim i As Integer
Dim j As Integer

For i = 0 To a
    c(i, 0) = 0                             'Fill zeroth row of matrix with zeros
Next i
For j = 1 To b                              'Fill zeroth column of matrix with zeros
    c(0, j) = 0
Next j

'Compare each character to each character of the other string
For i = 1 To a
    For j = 1 To b
        If Mid(s1, i, 1) = Mid(s2, j, 1) Then
            c(i, j) = c(i - 1, j - 1) + 1   'If there is a match, add 1
            If c(i, j) > d Then
                d = c(i, j)                 'If higher than current max, change max
            End If
        Else
            c(i, j) = 0                     'Otherwise the element becomes 0
        End If
    Next j
Next i

lcs = d                                     'The lcs is the current max
End Function



'Compare strings using the longest common substring (lcs) algorithm
Public Function compare(ByVal s1 As String, ByVal s2 As String) As Double

'Initialization
Dim a As Integer
Dim b As Integer
Dim c As Integer
a = Len(s1)                                  'The length of the first string
b = Len(s2)                                  'The length of the second string
c = lcs(s1, s2)                              'The length of the lcs of both strings

'If both strings are empty, they are the same (this also avoids errors)
If a = 0 And b = 0 Then
    compare = 1
'Otherwise the lcs is scored relative to the string lenghts
Else
    compare = 2 * c / (a + b)
End If
End Function
```

Appendix 1.2: Preparation Procedure

```
'Method to prepare addresses for comparison by means of...
'Correcting numbers, writing abbreviations in full...
'Splitting prefixes and suffixes from street names
Sub prepare_addresses()
Dim a As Long

For a = 2 To ActiveSheet.Rows.Count
    If ActiveSheet.Cells(a, 1) <> "" Then
        'Copy street for processing to preserve the original
        Cells(a, 5) = Cells(a, 2)

        'Remove numbers from street names
        If IsNumeric(Left(Right(Cells(a, 5), 4), 1)) Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 4)
        ElseIf IsNumeric(Left(Right(Cells(a, 5), 3), 1)) Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 3)
        ElseIf IsNumeric(Left(Right(Cells(a, 5), 2), 1)) Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2)
        ElseIf IsNumeric(Left(Right(Cells(a, 5), 1), 1)) Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 1)
        End If

        'Assure that numbers are positive
        If Cells(a, 3) < 0 Then
            Cells(a, 3) = Cells(a, 3) * -1
        End If

        'Write suffix abbreviations in full
        If Right(Cells(a, 5), 4) = "SNGL" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 4) & "SINGEL"
        ElseIf Right(Cells(a, 5), 2) = "WG" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2) & "WEG"
        ElseIf Right(Cells(a, 5), 5) = "DWSTR" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 5) & "DWARSSTRAAT"
        ElseIf Right(Cells(a, 5), 4) = "DWLN" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 4) & "DWARSLAAN"
        ElseIf Right(Cells(a, 5), 3) = "STR" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 3) & "STRAAT"
        ElseIf Right(Cells(a, 5), 2) = "LN" And Not Right(Cells(a, 2), 3) = "PLN" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2) & "LAAN"
        ElseIf Right(Cells(a, 5), 2) = "DK" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2) & "DYK"
        ElseIf Right(Cells(a, 5), 2) = "PD" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2) & "PAD"
        ElseIf Right(Cells(a, 5), 2) = "DR" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2) & "DRIFT"
        ElseIf Right(Cells(a, 5), 2) = "KD" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2) & "KADE"
        ElseIf Left(Right(Cells(a, 5), 2), 1) = " " And Right(Cells(a, 5), 1) = "N" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 1) & "NOORD"
        ElseIf Left(Right(Cells(a, 5), 2), 1) = " " And Right(Cells(a, 5), 1) = "O" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 1) & "OOST"
        ElseIf Left(Right(Cells(a, 5), 2), 1) = " " And Right(Cells(a, 5), 1) = "Z" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 1) & "ZUID"
        ElseIf Left(Right(Cells(a, 5), 2), 1) = " " And Right(Cells(a, 5), 1) = "W" Then
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 1) & "WEST"
        End If
```

Appendix 1.2: Preparation Procedure (2)

```
'Write prefix abbreviations in full
If Left(Cells(a, 5), 3) = "LN " Then
    Cells(a, 5) = "LAAN " & Right(Cells(a, 5), Len(Cells(a, 5)) - 3)
ElseIf Left(Cells(a, 5), 4) = "KAN " Then
    Cells(a, 5) = "KANAAL " & Right(Cells(a, 5), Len(Cells(a, 5)) - 4)
ElseIf Left(Cells(a, 5), 5) = "VERL " Then
    Cells(a, 5) = "VERLENGDE " & Right(Cells(a, 5), Len(Cells(a, 5)) - 5)
ElseIf Left(Cells(a, 5), 5) = "VERK " Then
    Cells(a, 5) = "VERKORTE " & Right(Cells(a, 5), Len(Cells(a, 5)) - 5)
ElseIf Left(Cells(a, 5), 3) = "MR " Then
    Cells(a, 5) = "MEESTER " & Right(Cells(a, 5), Len(Cells(a, 5)) - 3)
ElseIf Left(Cells(a, 5), 3) = "PR " Then
    Cells(a, 5) = "PRINS " & Right(Cells(a, 5), Len(Cells(a, 5)) - 3)
ElseIf Left(Cells(a, 5), 2) = "NW" Then
    Cells(a, 5) = "NIEUW" & Right(Cells(a, 5), Len(Cells(a, 5)) - 2)
End If

'Split suffixes from street names
If Left(Right(Cells(a, 5), 3), 1) = " " _
And (Right(Cells(a, 5), 1) = "N" Or Right(Cells(a, 5), 1) = "O" _
     Or Right(Cells(a, 5), 1) = "Z" Or Right(Cells(a, 5), 1) = "W") Then
        Cells(a, 6) = Right(Cells(a, 5), 2)
        Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 2)
ElseIf Right(Cells(a, 5), 11) = "DWARSSTRAAT" Then
    Cells(a, 6) = Right(Cells(a, 5), 11)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 11)
ElseIf Right(Cells(a, 5), 9) = "DWARSLAAN" Then
    Cells(a, 6) = Right(Cells(a, 5), 9)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 9)
ElseIf Right(Cells(a, 5), 3) = "DYK" Or Right(Cells(a, 5), 3) = "PAD" _
Or Right(Cells(a, 5), 3) = "WEG" Or Right(Cells(a, 5), 3) = "HOF" _
Or Right(Cells(a, 5), 3) = "BOS" Then
    Cells(a, 6) = Right(Cells(a, 5), 3)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 3)
ElseIf Right(Cells(a, 5), 4) = "OOST" Or Right(Cells(a, 5), 4) = "ZUID" _
Or Right(Cells(a, 5), 4) = "WEST" Or Right(Cells(a, 5), 4) = "LAAN" _
Or Right(Cells(a, 5), 4) = "KAMP" Or Right(Cells(a, 5), 4) = "VELD" _
Or Right(Cells(a, 5), 4) = "HAGE" Or Right(Cells(a, 5), 4) = "SLAG" _
Or Right(Cells(a, 5), 4) = "CAMP" Or Right(Cells(a, 5), 4) = "KADE" Then
    Cells(a, 6) = Right(Cells(a, 5), 4)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 4)
ElseIf Right(Cells(a, 5), 5) = "NOORD" Or Right(Cells(a, 5), 5) = "BRINK" _
Or Right(Cells(a, 5), 5) = "DREEF" Or Right(Cells(a, 5), 5) = "VAART" _
Or Right(Cells(a, 5), 5) = "DRIFT" Or Right(Cells(a, 5), 5) = "AKKER" Then
    Cells(a, 6) = Right(Cells(a, 5), 5)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 5)
ElseIf Right(Cells(a, 5), 6) = "SINGEL" Or Right(Cells(a, 5), 6) = "STRAAT" _
Or Right(Cells(a, 5), 6) = "KAMPEN" Or Right(Cells(a, 5), 6) = "ACKERS" _
Or Right(Cells(a, 5), 6) = "AKKERS" Or Right(Cells(a, 5), 6) = "BRACHT" Then
    Cells(a, 6) = Right(Cells(a, 5), 6)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 6)
ElseIf Right(Cells(a, 5), 7) = "STRASSE" Then
    Cells(a, 6) = Right(Cells(a, 5), 7)
    Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 7)
End If
```

Appendix 1.2: Preparation Procedure (3)

```
        'Correct for other suffixes
        If Right(Cells(a, 5), 4) = "MEER" Or Right(Cells(a, 5), 4) = "ZAND" Then
            Cells(a, 6) = Right(Cells(a, 5), 4) & Cells(a, 6)
            Cells(a, 5) = Left(Cells(a, 5), Len(Cells(a, 5)) - 4)
        End If

        'Split prefixes from street names
        If Left(Cells(a, 5), 3) = "DE " Then
            Cells(a, 4) = Left(Cells(a, 5), 3)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 3)
        ElseIf Left(Cells(a, 5), 4) = "HET " Or Left(Cells(a, 5), 4) = "VAN " _
        Or Left(Cells(a, 5), 4) = "HLT " Or Left(Cells(a, 5), 4) = "RIET" _
        Or Left(Cells(a, 5), 4) = "OOST" Or Left(Cells(a, 5), 4) = "ZUID" _
        Or Left(Cells(a, 5), 4) = "WEST" Then
            Cells(a, 4) = Left(Cells(a, 5), 4)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 4)
        ElseIf Left(Cells(a, 5), 5) = "LAAN " Or Left(Cells(a, 5), 5) = "PRINS" _
        Or Left(Cells(a, 5), 5) = "NOORD" Then
            Cells(a, 4) = Left(Cells(a, 5), 5)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 5)
        ElseIf Left(Cells(a, 5), 6) = "BOVEN " Or Left(Cells(a, 5), 6) = "SNEEUW" Then
            Cells(a, 4) = Left(Cells(a, 5), 6)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 6)
        ElseIf Left(Cells(a, 5), 7) = "KANAAL " Or Left(Cells(a, 5), 7) = "STATION" Then
            Cells(a, 4) = Left(Cells(a, 5), 7)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 7)
        ElseIf Left(Cells(a, 5), 8) = "MEESTER " Or Left(Cells(a, 5), 8) = "BENEDEN " Then
            Cells(a, 4) = Left(Cells(a, 5), 8)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 8)
        ElseIf Left(Cells(a, 5), 9) = "VERKORTE " Then
            Cells(a, 4) = Left(Cells(a, 5), 9)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 9)
        ElseIf Left(Cells(a, 5), 10) = "VERLENGDE " Then
            Cells(a, 4) = Left(Cells(a, 5), 10)
            Cells(a, 5) = Right(Cells(a, 5), Len(Cells(a, 5)) - 10)
        End If
    Else
        Exit For
    End If
Next a
End Sub
```

Appendix 1.3: Method to sort cities based on similarity

```
'Method to sort cities based on similarity
Sub CitySort()

'Track the time needed to perform this method and switch off screen updating for speed
Dim StartTime As Date
StartTime = Now()
Application.ScreenUpdating = False

'Initialize columns and variables
Range("J1") = "Similarity"
Dim k As Long
Dim i As Long
Dim j As Integer
k = 2                                                    'Start with first address

With ActiveSheet
    Do While k < .Rows.Count                             'Go through each address...
        If .Cells(k, 1) <> "" Then                       '...until the last address
            For i = k + 1 To .Rows.Count                 'Compare to the next address...
                If .Cells(i, 1) <> "" Then               '...until the last address
                    'Calculate similarity between cities based on the lcs algorithm
                    Cells(i, 10) = compare(Cells(i, 1), Cells(k, 1))
                Else
                    Exit For
                End If
            Next i

            'Sort the addresses on the similarity scores of cities and cities by alphabet
            j = k + 1                                    'Don't sort address that we compare to
            i = i - 1                                    'Last address
            Myrange1 = Cells(j, 1).Address               'Upper left cell in sort range
            Myrange2 = Cells(i, 10).Address              'Bottom right cell in sort range
            Myrange3 = Cells(j, 10).Address              'Range of similarity scores
            Range(Myrange1 & ":" & Myrange2).Sort _
            key1:=Range(Myrange3), order1:=xlDescending, _
            key2:=Range(Myrange1), order2:=xlAscending

            'As long as city is the same, no further comparison or sorting is needed
            Do While Cells(j, 1) = Cells(k, 1)
            j = j + 1
            Loop
            k = j                                        'Go to the first city that is different
        Else
            Exit Do
        End If
    Loop
End With

'Update the screen
Application.ScreenUpdating = True
'Display the amount of seconds needed to perform the method
MsgBox Round((Now() - StartTime) * 24 * 3600, 0)
End Sub
```

Appendix 1.4: Method to change street names

```
'Method to sort and change streets based on similarities
Sub StreetSort()

'Track the time needed to perform this method and switch off screen updating for speed
Dim StartTime As Date
StartTime = Now()
Application.ScreenUpdating = False

'Initialize columns and variables
Range("J1") = "Similarity"
Range("K1") = "City"
Range("L1") = "Old Street"
Range("M1") = "New Street"
Dim k As Long
Dim i As Long
Dim j As Integer
Dim z As Integer
k = 2                                                           'Start at first address
z = 1                                                           'Counter for the changes made

Do While k < ActiveSheet.Rows.Count                             'Go through each address...
    If ActiveSheet.Cells(k, 1) <> "" Then                       '...until the last address
        i = k + 1                                               'Compare to the next address
        Do While Cells(i, 1) = Cells(k, 1)                      'As long as city is the same...
            '...Check if prefix, suffix and first character of the middle part are the same
            If Cells(i, 4) = Cells(k, 4) _
            And Cells(i, 6) = Cells(k, 6) _
            And Left(Cells(i, 5), 1) = Left(Cells(k, 5), 1) Then
                'Calculate similarity between middle parts based on the lcs algorithm
                Cells(i, 10) = compare(Cells(i, 5), Cells(k, 5))
                'If similarity score >= 60%, we assume similarity
                If Cells(i, 10) >= 0.6 And Cells(i, 10) < 1 Then
                    z = z + 1
                    Cells(z, 11) = Cells(i, 1)                            'City
                    Cells(z, 12) = Cells(i, 4) & Cells(i, 5) & Cells(i, 6)  'Old street
                    Cells(i, 5) = Cells(k, 5)                             'Change middle part
                    Cells(i, 10) = 1                                      'Change similarity
                    Cells(z, 13) = Cells(i, 4) & Cells(i, 5) & Cells(i, 6)  'New Street
                End If
            End If
            i = i + 1
        Loop

        'Sort the addresses on similarity score of the middle part of the streets
        i = i - 1                                              'Last address of the same city
        j = k + 1                                              'Don't sort address we compare to
        If i > j Then                                          'Don't sort if 0 or 1 street
            Myrange1 = Cells(j, 1).Address                     'Upper left cell in sort range
            Myrange2 = Cells(i, 10).Address                    'Bottom right cell in sort range
            Myrange3 = Cells(j, 10).Address                    'Range of similarity scores
            Range(Myrange1 & ":" & Myrange2).Sort key1:=Range(Myrange3), order1:=xlDescending
        End If
        Columns(10).ClearContents                              'Do not disrupt the next sort

        'As long as city and street are the same, no further comparison or sorting is needed
        Do While Cells(j, 1) = Cells(k, 1) _
        And Cells(j, 4) = Cells(k, 4) _
        And Cells(j, 5) = Cells(k, 5) _
        And Cells(j, 6) = Cells(k, 6)
            j = j + 1
        Loop
        k = j
    Else
        Exit Do
    End If
Loop

'Update the screen
Application.ScreenUpdating = True
'Display the amount of seconds needed to perform the method
MsgBox Round((Now() - StartTime) * 24 * 3600, 0)
End Sub
```

Appendix 2: Visitor patterns of organizations

(1): Hospitals

scheper ziekenhuis emmen														
			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0.1
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0.1	0	0	0	0
0.4	0.3	0.2	0.1	0.2	0	0	**6**	0	0	0	0	0	0	0.1
2.4	3.2	3.6	2.7	2.5	0.1	0	**7**	0.1	0.1	0	0	0	0	0
7.2	11.9	8.8	7.7	7.8	0.1	0.1	**8**	0.5	0.4	0.5	0.4	0.5	0.1	0
7.7	10.2	8.2	8.5	6.6	0.2	0.1	**9**	2.2	2.9	3.5	2.4	2.4	0.1	0.1
7.3	8.3	7	8.4	5.9	0.3	0.2	**10**	5.6	7.5	7	6.4	5.2	0.2	0.1
3.4	3	2.3	2.5	2.4	0.1	0.1	**11**	7.4	12.7	8.1	8.6	8.2	0.4	0.1
10.9	10.8	8.6	10	5.9	1.5	1.6	**12**	6.3	8	5.6	7	5.2	0.3	0.1
9.9	9.6	7.5	8.8	5.6	0.7	0.7	**13**	4.6	4.5	3.5	4	2.9	0.3	0.1
4.7	6	4.4	5.6	2.9	0.1	0.2	**14**	9.5	8.8	8	9	5.7	1.2	1.1
1.4	1.9	1.2	1.1	0.6	0.2	0.1	**15**	9.5	9.9	8.2	8.8	5.5	0.7	0.9
0.2	1	0.2	0.4	0.3	0.2	0.2	**16**	5.8	6.8	4.7	5.9	2.7	0.2	0.2
1.1	1.5	1.3	1.1	1.1	1.1	0.9	**17**	1.6	1.7	1.1	1.4	0.6	0.1	0.1
0.5	0.3	0.3	0.3	0.2	0.1	0.3	**18**	0.3	1.2	0.2	0.3	0.2	0.1	0.2
0	0.1	0.1	0.1	0	0.1	0.1	**19**	1.4	1.5	1.1	1.2	1	1	0.8
0.1	0	0.1	0	0.1	0.1	0.2	**20**	0.5	0.3	0.4	0.2	0.3	0.4	0.3
0	0	0	0.1	0	0.1	0	**21**	0.1	0.1	0.1	0.1	0.1	0.1	0
0	0	0	0.1	0	0	0	**22**	0	0.1	0.1	0.1	0.1	0.1	0
0	0	0	0	0	0	0	**23**	0	0.1	0	0.1	0	0.1	0

röpcke-zweers ziekenhuis hardenberg														
			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0.1	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0.1	0.2	0.3	0.1	0.2	0	0	**7**	0	0	0	0	0	0	0
0.3	0.3	0.4	0.3	0.3	0	0	**8**	0	0	0.1	0	0	0	0
0.4	0.3	0.4	0.3	0.3	0	0	**9**	0	0	0.1	0.1	0	0	0
0.2	0.3	0.2	0.3	0.2	0	0.1	**10**	0.3	0.3	0.2	0.2	0.3	0	0
0.1	0.1	0.2	0.2	0	0	0	**11**	0.3	0.3	0.4	0.4	0.2	0	0
0.3	0.2	0.3	0.2	0.1	0	0	**12**	0.2	0.3	0.2	0.3	0.2	0.1	0
0.5	0.2	0.4	0.3	0.1	0	0	**13**	0.3	0.2	0.2	0.1	0.1	0	0
0.3	0.2	0.4	0.3	0.2	0.1	0	**14**	0.2	0.1	0.2	0.2	0.1	0	0
0	0.1	0.1	0	0	0	0	**15**	0.3	0.3	0.4	0.1	0.1	0	0
0	0	0	0	0	0	0	**16**	0.4	0.3	0.2	0.4	0.3	0.1	0
0	0.1	0	0	0	0	0	**17**	0.2	0.1	0.2	0.1	0.1	0	0
0.1	0	0	0.1	0	0	0	**18**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0.1	0.1	0.1	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (2): Train Stations

Station Emmen

to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0.1	0	0	0	0.1	**0**	0.4	0.6	0.7	0.7	0.8	1	0.6
0	0	0	0	0	0.1	0	**1**	0	0.1	0.1	0.2	0.1	0.3	0.4
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0.1	0.1
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0.1	0.1
0	0.1	0.1	0	0.1	0	0	**4**	0	0	0	0	0	0	0.1
0	0	0.1	0.1	0.1	0.1	0	**5**	0	0	0	0	0	0	0.1
0	0	0	0.1	0.1	0.5	0	**6**	0	0	0	0	0	0	0.2
0.1	0	0.1	0.1	0.1	0.7	0.4	**7**	0.1	0.1	0.1	0	0.1	0.1	0.1
0.1	0.3	0.4	0.2	0.4	0.3	0.5	**8**	0.5	0.3	0.5	0.4	0.4	0.1	0.1
0.3	0.2	0.2	0.2	0.2	0.2	0.3	**9**	0.2	0.2	0.2	0.3	0.1	0.1	0
0.3	0.3	0.4	0.1	0.4	0.2	0.3	**10**	0.3	0.2	0.2	0.2	0.2	0.1	0.1
0.2	0.2	0.2	0.1	0.3	0.1	0.3	**11**	0.3	0.2	0.2	0.1	0.2	0.1	0.1
0.3	0.3	0.2	0.3	0.4	0.2	0.2	**12**	0.2	0.3	0.1	0.1	0.2	0.1	0.1
0.3	0.2	0.3	0.2	0.2	0.1	0.2	**13**	0.4	0.2	0.1	0.1	0.2	0.1	0.1
0.4	0.3	0.2	0.3	0.2	0.1	0.1	**14**	0.1	0.1	0.2	0.1	0.2	0	0.2
0.2	0.2	0.1	0.2	0.2	0.1	0.3	**15**	0.2	0.2	0.2	0.2	0.2	0.1	0.2
0.1	0.2	0.1	0.2	0.2	0.1	0.2	**16**	0.1	0.4	0.2	0.3	0.2	0.2	0.3
0.1	0.2	0.1	0.3	0.2	0.1	0.1	**17**	0.2	0.2	0.3	0.2	0.3	0.2	0.4
0.1	0.1	0.1	0.1	0.1	0.1	0.2	**18**	0.2	0.2	0.1	0.1	0.1	0.5	0.4
0.1	0.1	0.1	0	0	0.1	0.1	**19**	0.2	0.3	0.1	0.2	0.3	0.4	0.6
0	0	0	0	0.1	0.1	0.2	**20**	0.3	0.3	0.2	0.3	0.4	0.5	0.9
0.1	0	0	0	0.1	0	0	**21**	0.3	0.3	0.2	0.4	0.3	0.4	0.4
0	0	0	0	0.1	0.1	0	**22**	0.4	0.4	0.4	0.6	0.4	0.4	0.5
0	0	0	0	0.1	0.1	0	**23**	0.6	0.9	0.8	0.8	0.7	0.6	0.8

Station Coevorden

to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0.1	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0.1	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0.1	0	**5**	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0.1	0	0.1	0	0	0.1	0	**7**	0	0	0	0	0	0	0
0	0.1	0.1	0	0.1	0.1	0	**8**	0	0	0	0.1	0	0	0
0.1	0.1	0.1	0.1	0.1	0.1	0.1	**9**	0.1	0.1	0	0	0.1	0.1	0.1
0.2	0.1	0.1	0.1	0.2	0.1	0.1	**10**	0.1	0.1	0	0.1	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.2	0.2	0	**11**	0.2	0	0	0.1	0.1	0.2	0
0.1	0.3	0.1	0.2	0.1	0.3	0	**12**	0.1	0.1	0	0	0.1	0.1	0
0.2	0.1	0.2	0.2	0.1	0.2	0.1	**13**	0.2	0.1	0.1	0	0.1	0.1	0
0.1	0.1	0.1	0.2	0.1	0.2	0.1	**14**	0.2	0.1	0.1	0.1	0.1	0.1	0.1
0	0.1	0.2	0.2	0.1	0.1	0.1	**15**	0.2	0	0.2	0.1	0.1	0.1	0.1
0.1	0	0	0.1	0	0	0.1	**16**	0.2	0.2	0.1	0.1	0.1	0.2	0.1
0	0	0	0	0	0	0	**17**	0.2	0.4	0.1	0.1	0.1	0.3	0.1
0	0.1	0	0	0.1	0.1	0	**18**	0.1	0.1	0	0	0.1	0	0.1
0	0	0	0	0.1	0	0.1	**19**	0	0.1	0.1	0	0.1	0.1	0.1
0	0	0	0	0	0.1	0.1	**20**	0	0.2	0	0	0.1	0.1	0.1
0	0	0	0	0.1	0.1	0	**21**	0	0.2	0	0	0.1	0	0.1
0	0	0	0	0	0	0	**22**	0.1	0	0	0	0.1	0	0
0	0	0	0	0	0	0	**23**	0.1	0.1	0	0	0.1	0.6	0

Appendix 2 (3): Nursing Homes

de horst - rondweg 97 emmen

to								from						
mon	**tue**	**wed**	**thu**	**fri**	**sat**	**sun**	**hour**	**mon**	**tue**	**wed**	**thu**	**fri**	**sat**	**sun**
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0.1	0	0	0	0	0	0
0.8	2.6	0	2.1	0.5	0	0	**8**	0.1	0.1	0.2	0.1	0.1	0	0
0.2	0.6	0.3	0.4	0.2	0.1	0	**9**	0.7	0.5	0.4	0.7	0.6	1	1
0.4	0.9	0.5	0.5	1.1	0.2	0.2	**10**	0.8	0.9	0.4	0.4	0.5	0.7	0.7
0.8	0.4	0.7	0.6	0.5	0.1	0.1	**11**	0.2	1.3	0.3	0.7	0.8	0.2	0.6
2.2	1.4	2.7	1.3	1.4	1.1	3	**12**	0.3	1	0.4	0.8	0.3	0.2	0.4
1.6	1.9	2	2	1.9	1.6	2.2	**13**	1.2	0.9	1.1	1	0.9	0.9	1.9
1.1	1	1	1	0.9	0.7	0.6	**14**	2.1	1	1.7	0.8	0.8	0.8	1.2
1.1	0.3	0.2	0.4	0.3	0.4	0.6	**15**	1.3	2	2.4	2.4	1.3	1.1	3.2
0.5	0.5	1.1	0.6	0.4	0.4	0.7	**16**	2	1.8	1.7	1.7	1.8	1.7	2.1
0.6	0.5	0.8	0.7	0.5	0.7	1.3	**17**	0.2	0.3	0.3	0.5	0.3	0.3	0.2
0.5	0.5	0.5	0.5	0.5	0.8	1.4	**18**	0.4	0.2	0.4	0.2	0.1	0.1	0.1
0.2	0.2	0.2	0.3	0.2	0.7	1.6	**19**	0.2	0.2	0.6	0.3	0.4	0.4	0.3
0.2	0	0.3	0.2	0.2	0.2	0.5	**20**	0.4	0.3	0.7	0.4	0.3	0.4	0.5
0.2	0.1	0.3	0.2	0.1	0.1	0.5	**21**	0.2	0.4	0.2	0.2	0.2	0.2	0.1
0	0	0.1	0	0.1	0.1	0.1	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0.1	0	**23**	0	0	0	0	0	0	0

veltman - ingenieur biewengaweg 42 weiteveen

to								from						
mon	**tue**	**wed**	**thu**	**fri**	**sat**	**sun**	**hour**	**mon**	**tue**	**wed**	**thu**	**fri**	**sat**	**sun**
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0.9	0.9	0.9	0.8	0.9	0.1	0
0	0	0	0	0	0	0	**8**	0.2	0.2	0.1	0.2	0.1	0.1	0.1
0	0	0.1	0	0	0.1	0	**9**	0.1	0.3	0.1	0.2	0.1	0.1	0.1
0.1	0.2	0.2	0.2	0.1	0	0	**10**	0.2	0.2	0.2	0.1	0.1	0.1	0
0.2	0.2	0.3	0.3	0.9	0	0.1	**11**	0	0.1	0.1	0.1	0.1	0.2	0.1
0.2	0.2	0.2	0.2	0.1	0.1	0.2	**12**	0.2	0.6	0.5	0.1	0.2	0.7	0.2
0.1	0.2	0.2	0.1	0.1	0.1	0.7	**13**	0.2	0.4	0.4	0.3	0.3	0.6	0.6
0.7	1	0.7	0.7	0.2	0.1	0.2	**14**	0.1	0.2	0.1	0.2	0.2	0.4	0.2
0.4	0.5	0.4	0.3	0	0.3	0.1	**15**	0.1	0.1	0.3	0.3	0.1	0.1	0.4
0.2	0.3	0.1	0.2	0.2	0.8	0.3	**16**	0.2	0.2	0.2	0.3	0.1	0.1	0.7
0.1	0.1	0	0.1	0.1	0.3	0.1	**17**	0.2	0.2	0.2	0.3	0.1	0.1	0.1
0.1	0.1	0.1	0.1	0.1	0.3	0.3	**18**	0	0	0.1	0	0.8	0.1	0.1
0.2	0.2	0.6	0.3	0.1	0.1	0.8	**19**	0	0	0.1	0	0.2	0.1	0
0.1	0.2	0.4	0.3	0.1	0.1	0.1	**20**	0	0	0	0	0	0	0
0.1	0.1	0.2	0.1	0.2	0.1	0.1	**21**	0	0	0	0	0	0	0
0.1	0	0.1	0	0.2	0.1	0.1	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (4): Day care centres

zorgboerderij de hooimijt - emmerhoutstraat 22 emmen														
			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0.7	0.8	0.5	0.9	0.7	0	0	**8**	0	0	0	0	0	0	0
7	7.1	5.4	6.3	7.7	0	0	**9**	0	0	0	0	0	0	0
0.3	0.6	0.2	0.2	0.6	0	0	**10**	0	0	0	0	0	0	0
0	0.2	0	0.1	0	0	0	**11**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0.4	0.2	0.3	0	0.4	0	0
0	0	0	0	0	0	0	**14**	1.5	1.8	1.2	1.2	1.8	0	0
0	0	0	0	0	0	0	**15**	6.8	7	5	6.5	6.6	0	0
0	0	0	0	0	0	0	**16**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**17**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

zorggroep heerendordt - klazienaveensestraat 98 nieuw dordrecht														
			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
1.7	1.5	1.6	1.5	1.4	0	0	**8**	0	0	0	0	0	0	0
2.2	2	2.2	2.3	2.2	0	0	**9**	0	0	0	0	0	0	0
0.5	0	0.7	0	0.6	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0.1	0	0.1	0.1	0	0	0
0	0	0	0	0	0	0	**12**	0.5	0	0	0.4	0	0	0
0	0	0	0	0	0	0	**13**	0.6	0.1	0.2	0.4	0.1	0	0
0	0	0	0	0	0	0	**14**	0.2	0.1	0.2	0	0.1	0	0
0	0	0	0	0	0	0	**15**	3.7	3.3	4	3.5	4.1	0	0
0	0	0	0	0	0	0	**16**	0.1	0	0.1	0	0.1	0	0
0	0	0	0	0	0	0	**17**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (5): Facilities for day care activities

manege de eekwal - heirweg 17 emmen														
			to								from			
mon	tue	wed	thu	fri	sat	sun	**hour**	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0.5	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0	0.7	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0.1	0	0	0	**10**	0	0	0	0.9	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0	0.4	0	0	0
0	0	0	0	0	0	0	**12**	0	0	0	0	0	0	0
0	0	0.1	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0	0	0
0	0	3.1	0	0	0	0	**17**	0	0	0	0	0	0	0
0	0	2.5	0	0	0	0	**18**	0	0	1.2	0	0	0	0
0	0	1.9	0	0	0	0	**19**	0	0	3.1	0	0	0	0
0	0	0.2	0	0	0	0	**20**	0	0	1.8	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	1.2	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

golfslagbad aquarena - angelsloërdijk 31 emmen														
			to								from			
mon	tue	wed	thu	fri	sat	sun	**hour**	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0.2	0	0	0	0	**8**	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	**9**	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	**10**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**11**	0.1	0	0	0	0	0	0
0	0	0	0	0	0	0	**12**	0.1	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0	0	0
0	0.1	0	0	0	0	0	**17**	0	0	0	0	0	0	0
5	0	0	0	0	0	0	**18**	0	0	0	0	0	0	0
5.9	0	0	1	0	0	0	**19**	0	0.1	0	0	0	0	0
0	0	0	0	0	0	0	**20**	7.8	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	2.6	0	0	1.6	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (6): Social employment facilities

training & diagnosis centre - abel tasmanstraat 7 emmen														
to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0.2	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0.8	1.3	1.3	1	0.8	0	0	**6**	0	0	0	0	0	0	0
1.2	0.9	1.1	1.3	0.9	0	0	**7**	0	0	0	0	0	0	0
0.2	0.1	0.1	0.1	0.1	0	0	**8**	0	0	0	0	0	0	0
0.1	0.1	0.1	0.1	0.2	0	0	**9**	0.1	0.1	0.1	0.1	0	0	0
0.2	0.1	0.1	0.1	0.1	0.1	0	**10**	0.1	0.1	0	0.1	0.1	0	0
0.1	0.1	0	0.1	0	0.1	0	**11**	1.2	0.9	1.4	0.7	0.7	0	0
0.1	0.2	0.1	0.1	0	0.2	0	**12**	0.4	0.8	0.5	0.5	0.3	0	0
0	0.1	0	0.1	0	0.1	0	**13**	0.1	0	0.1	0.1	0.2	0	0
0	0.1	0.1	0	0.1	0	0	**14**	0.2	0.2	0.4	0.3	0.1	0.2	0
0	0	0	0	0	0	0	**15**	0.3	0.3	0.3	0.2	0.1	0.1	0
0	0	0	0	0	0	0	**16**	1.2	0.9	0.9	1	0.4	0	0
0	0	0	0	0	0	0	**17**	0	0	0	0	0	0	0
0	0	0	0	0.8	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0.4	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0.2	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0.8	0	0

park maintenance - de kwakel 6 klazienaveen														
to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
3.5	3.9	3.3	2.7	1.2	0	0	**6**	0	0	0	0	0	0	0
1.1	1	1	0.5	0.1	0	0	**7**	0	0	0	0	0	0	0
0.1	0	0.1	0.1	0	0	0	**8**	0	0	0	0	0	0	0
0	0.1	0	0	0.1	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	2.3	2.2	2.1	2	0.9	0	0
0	0	0	0	0	0	0	**12**	0.2	0.4	0.6	0.4	0.3	0	0
0	0	0	0	0	0	0	**13**	0	0.1	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0.1	0.1	0.1	0.1	0.1	0	0
0	0	0	0	0	0	0	**15**	0.5	0.5	0.7	0.3	0	0	0
0	0	0	0	0	0	0	**16**	1.4	1.6	0.7	0.3	0	0	0
0	0	0	0	0	0	0	**17**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (7): Community centres

bargermeer/meerveld - de winkelakkers 2 emmen														
to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0.1
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	1.1	0	**16**	0	0	0	0	0	0	0
0	0	0	0	0	3.8	0	**17**	0	0	0	0	0	0	0
0	0	1.3	0	0.1	1.1	0	**18**	0	0	0	0	0	0.5	0
0	0	0.1	0	0	0.1	0	**19**	0	0	0	0	0	4.7	0
0	0	0	0	0	0.1	0	**20**	0	0	0	0	0	0.3	0
0	0	0	0	0	0	0	**21**	0	0	1.1	0	0	0.1	0
0	0	0	0	0	0	0	**22**	0	0	0.3	0.1	0.1	0.1	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

angelslo (de marke) - statenweg 107 emmen														
to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0.3	0.2	0.4	0.1	0.1	0.3	**8**	0	0	0	0	0	0	0
0.8	1.4	0.5	1.7	0.2	0.3	0.6	**9**	0	0	0	0	0	0	0
0.1	0.2	0.2	0.2	0.4	0.5	0	**10**	0	0.1	0	0	0.1	0.1	0
0.2	0	0.2	0.2	0.1	0.1	0	**11**	0.1	0.2	0.4	0.1	0.3	0.4	0
0.4	0.5	2.6	0.4	0.2	0.2	0	**12**	0.4	0.2	0.2	0.4	0.3	0.2	0.8
0.3	0.6	1.4	1.6	0.4	0.6	0	**13**	0.1	0.5	0.3	0.2	0.2	0	0
0.1	0.2	0.4	0.3	0.3	0.6	0	**14**	0.1	0.7	0.4	0.4	0.3	0.2	0
0.1	0	0.1	0.1	0.1	0.3	0	**15**	1.3	0.6	0.5	2.3	0.4	0.8	0
0	0	0	0.2	0.1	0.1	0	**16**	0.2	0.6	3.5	1.5	0.4	0.6	0
0	0.1	0	0.1	0	0	0	**17**	0.1	0.2	0.2	0.2	0.1	0.2	0
0	0.2	0.1	0.1	0	0	0	**18**	0	0.1	0	0.1	0	0	0
0	0	0.1	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0.1	0	0	0
0	0	0	0	0	0	0	**21**	0	0.1	0.1	0	0.1	0	0
0	0	0	0	0	0	0	**22**	0	0	0.1	0.1	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (8): Shopping areas

hema koffieshop - hoofdstraat 34 emmen

to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0.1
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0.1	0.4	0.5	0.3	2	0.2	0	**8**	0	0	0	0	0	0	0
0.1	1.8	1.1	1	5.6	1.1	0.2	**9**	0.1	0	0	0.1	0	0.1	0
0.3	1.7	1	1.1	5.3	1.5	0.3	**10**	0.1	0.3	0.2	0.2	0.4	0.3	0
0.3	0.9	0.5	0.7	1.9	1	0.4	**11**	0.1	0.7	0.5	0.5	1.5	0.4	0
1.1	1.2	0.7	0.9	1.8	1.6	0.7	**12**	0.2	1.1	1.1	0.9	4.7	1.1	0
1.8	2	2	2	1.8	2.7	0.7	**13**	0.3	1.2	0.9	1.1	4.8	0.7	0
0.4	0.7	1.4	0.6	0.7	1.9	0.4	**14**	0.9	1.8	1.2	1.1	4.1	1.2	0.3
0.1	0.2	0.2	0.3	0.2	0.2	0.1	**15**	1	2	1.7	1.3	2.4	2.4	0.7
0.1	0.1	0.1	0.2	0.3	0.1	0	**16**	2.1	3.4	3.1	2.9	3.1	3.7	1.1
0	0	0.5	0.1	0.1	0	0.1	**17**	0.6	1.5	1	1.1	1.1	0.9	0.4
0	0	0.1	0.2	0	0.1	0	**18**	0.1	0.9	0.1	0.8	0.1	0.1	0
0	0	0	0	0	0	0	**19**	0	0.1	0.1	0.4	0	0	0
0	0	0	0	0	0.1	0	**20**	0	0	0	0.3	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0.1	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0.3	0	0.3	0	0	0	**23**	0	0	0	0	0	0	0

winkelcentrum zuid - wilhelminastraat emmen

to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0.1	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0.1
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0.1
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0.1
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0.1	0.1	0.1	0.1	0.2	0	0	**8**	0.1	0.5	0.1	0.1	0.2	0	0
0	0.1	0.1	0.2	0.4	0.3	0	**9**	0.1	0.2	0.2	0.2	0.4	0	0
0.1	0.6	0.2	0.2	0.7	0.3	0.1	**10**	0.1	0.3	0.3	0.2	0.2	0.1	0
0.1	0.2	0.2	0.2	0.3	0.1	0	**11**	0	0.1	0.1	0.2	0.1	0.3	0.1
0.1	0.2	0.2	0.5	0.2	0.2	0.1	**12**	0.1	0.2	0.2	0.3	0.1	0.2	0
0.2	0.2	0.3	0.3	0.1	0.2	0.1	**13**	0.2	0.3	0.2	0.5	0.2	0.2	0.4
0.2	0.2	0.3	0.4	0.2	0.1	0.1	**14**	0.2	0.3	0.6	0.6	0.3	0.4	0.2
0.1	0.2	0.1	0.3	0.2	0.3	0.2	**15**	0.2	0.2	0.1	0.3	0.3	0.1	0.1
0.3	0.4	0.4	0.5	0.2	0.2	0.2	**16**	0.1	0.1	0.2	0.5	0.3	0.1	0.1
0.1	0.1	0.1	0	0.1	0	0.2	**17**	0	0.1	0.1	0.1	0.2	0.1	0
0	0.1	0.1	0.1	0	0	0	**18**	0	0	0	0.1	0.1	0	0.1
0	0.1	0	0.1	0.1	0	0.1	**19**	0	0.1	0	0	0	0.1	0
0	0	0	0	0	0.1	0.1	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0.1	**21**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

Appendix 2 (9): Municipal office and asylum centre

gemeentehuis - raadhuisplein 1 emmen

to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0.1	0	0.1	0.1	0.5	0.1	0	**8**	0	0	0	0	0	0	0
0.2	0.4	0.3	0.3	1.4	0.2	0	**9**	0	0	0	0	0	0	0
0.1	0.4	0.5	0.4	0.9	0.1	0	**10**	0	0	0	0.1	0.5	0	0
0.1	0.2	0.2	0.1	0.4	0.1	0.1	**11**	0.1	0.1	0.1	0.1	0.6	0.1	0
0.3	0.3	0.3	0.2	0.3	0.3	0.1	**12**	0.1	0.2	0.1	0.1	0.3	0	0
0.4	0.5	0.6	0.5	0.4	0.2	0.1	**13**	0	0.1	0.2	0.1	0.3	0	0
0.2	0.2	0.2	0.3	0.1	0.1	0	**14**	0.1	0.2	0.2	0.3	0.2	0.1	0
0	0	0	0.1	0.1	0	0	**15**	0.2	0.2	0.2	0.1	0.1	0.1	0
0	0	0.1	0.1	0	0	0	**16**	0.2	0.2	0.3	0.2	0.2	0.1	0
0	0	0	0.1	0	0	0	**17**	0	0.1	0	0.1	0.1	0.1	0
0	0	0	0.1	0	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0.1	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0

azc - ter apelervenen 4 ter apel

to								from						
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0.1	0.2	0.2	0.2	0.2	0.3	0.1	**0**	0	0	0	0	0	0	0
0	0	0	0.1	0	0.1	0.1	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0.1	0.1	0.1	0.1	0.1	0.1	0	**7**	0	0	0	0	0	0	0
0.5	0.3	0.5	0.5	0.4	0.1	0	**8**	0	0	0	0	0	0	0
0.1	0.2	0.2	0.2	0.1	0	0	**9**	0	0	0	0	0	0	0
0.1	0.1	0.1	0.1	0.1	0	0	**10**	0	0	0	0	0	0	0
0.1	0.1	0.1	0.1	0.1	0	0	**11**	0	0	0	0	0	0	0
0.1	0.1	0.1	0	0	0	0	**12**	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0.1	0	0	0.1	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0.1	0.1	0	0
0	0	0	0	0	0	0	**16**	0.1	0.1	0.1	0.1	0	0	0
0	0	0	0	0	0	0	**17**	0.1	0	0	0.1	0.1	0	0
0	0	0	0	0	0	0	**18**	0.1	0.1	0.1	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0
0	0	0.1	0	0	0.1	0	**22**	0	0	0	0	0	0	0
0.2	0.3	0.3	0.3	0.1	0.1	0.3	**23**	0	0	0	0	0	0	0

Appendix 2 (10): Departments of Scheper Ziekenhuis

ggz dagcentrum

			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
0.1	0.6	0	0	0	0	0	7	0	0	0	0	0	0	0
0.5	3.6	0.5	0.8	1	0	0	8	0	0	0	0	0	0	0
0	0	0	0.1	0	0	0	9	0	0	0	0	0	0	0
0	0	0.1	0	0	0	0	10	0	0	0	0	0	0	0
0	0	0.2	0	0	0	0	11	0.3	3.4	0.4	0.4	0.9	0	0
0.3	0.9	1.3	1.1	0	0	0	12	0	0.6	0.1	0.3	0	0	0
0	0	0	0	0	0	0	13	0	0	0	0	0	0	0
0	0	0	0	0	0	0	14	0.1	0	0.1	0.1	0	0	0
0	0	0	0	0	0	0	15	0.4	0.9	1.6	1.1	0	0	0
0	0	0	0	0	0	0	16	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	17	0	0	0	0	0	0	0
0	0	0	0	0	0	0	18	0	0	0	0	0	0	0
0	0	0	0	0	0	0	19	0	0	0	0	0	0	0
0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
0	0	0	0	0	0	0	21	0	0	0	0	0	0	0
0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
0	0	0	0	0	0	0	23	0	0	0	0	0	0	0

fysio

			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
0	0	0.3	0.1	0	0	0	8	0	0	0	0	0	0	0
0.1	0.9	0.7	0.5	0.1	0	0	9	0	0.1	0	0.1	0	0	0
0.2	0.6	0.3	0.2	0.5	0	0	10	0.1	0.1	0.6	0.4	0.1	0	0
0.1	0.1	0.1	0.1	0.2	0	0	11	0.1	0.9	0.4	0.3	0.5	0	0
0.1	0.3	0.1	0.2	0.2	0	0	12	0.1	0.5	0.2	0.1	0.3	0	0
0.3	0.4	0	0.6	0.3	0	0	13	0.1	0.1	0.1	0.1	0.1	0	0
0.2	0.6	0	0.2	0.3	0	0	14	0.2	0.4	0.1	0.5	0.3	0	0
0.1	0.2	0	0.1	0.1	0	0	15	0.2	0.4	0	0.2	0.2	0	0
0	0	0	0	0	0	0	16	0.1	0.4	0	0.1	0.2	0	0
0	0	0	0	0	0	0	17	0	0	0	0	0	0	0
0	0	0	0	0	0	0	18	0	0	0	0	0	0	0
0	0	0	0	0	0	0	19	0	0	0	0	0	0	0
0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
0	0	0	0	0	0	0	21	0	0	0	0	0	0	0
0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
0	0	0	0	0	0	0	23	0	0	0	0	0	0	0

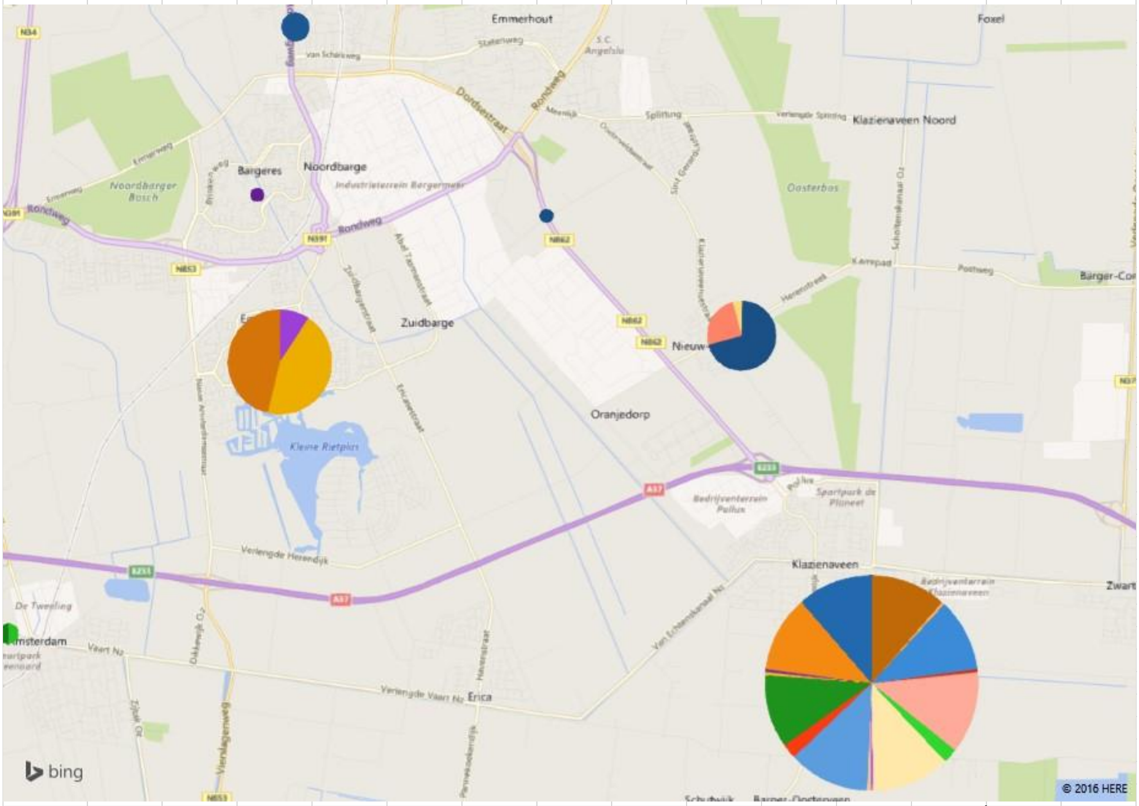
oim

			to								from			
mon	tue	wed	thu	fri	sat	sun	hour	mon	tue	wed	thu	fri	sat	sun
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
0.1	0.1	0.2	0.3	0	0	0	8	0	0	0	0	0	0	0
0.2	0.4	0.5	0.4	0.1	0	0	9	0	0	0.1	0.1	0	0	0
0.3	0.5	0.4	0.6	0.1	0	0	10	0.1	0.2	0.3	0.4	0	0	0
0.1	0.2	0.1	0.2	0	0	0	11	0.3	0.4	0.5	0.5	0.1	0	0
0.2	0.2	0.1	0.4	0.1	0	0	12	0.2	0.2	0.1	0.4	0	0	0
0.2	0.3	0.2	0.3	0.1	0	0	13	0.1	0.2	0.1	0.4	0.1	0	0
0.1	0.1	0.1	0.1	0	0	0	14	0.2	0.3	0.1	0.4	0.1	0	0
0	0	0	0	0	0	0	15	0.1	0.2	0.1	0.2	0	0	0
0	0	0	0	0	0	0	16	0.1	0.1	0	0.1	0	0	0
0	0	0	0	0	0	0	17	0	0	0	0	0	0	0
0	0	0	0	0	0	0	18	0	0	0	0	0	0	0
0	0	0	0	0	0	0	19	0	0	0	0	0	0	0
0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
0	0	0	0	0	0	0	21	0	0	0	0	0	0	0
0	0	0	0	0	0	0	22	0	0	0	0	0	0	0
0	0	0	0	0	0	0	23	0	0	0	0	0	0	0

Appendix 3: Analyses of community centres

Noorderbreedte - Meteoor 3, Klazienaveen

To								From						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0.1	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0.1	0	0	0	0
0	0	0	0	0	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0	0	0
0	0.2	0	0	0	0	0	**17**	0	0	0	0	0	0	0
0	4.1	0	0	0	0	0	**18**	0	0	0	0	0	0	0
0	0.2	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	2.9	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	1.2	0	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0.1	0	0	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0



28 Tuesdays	Occurrence	
#Trips	To	From
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
< >		
22		
23		
24		

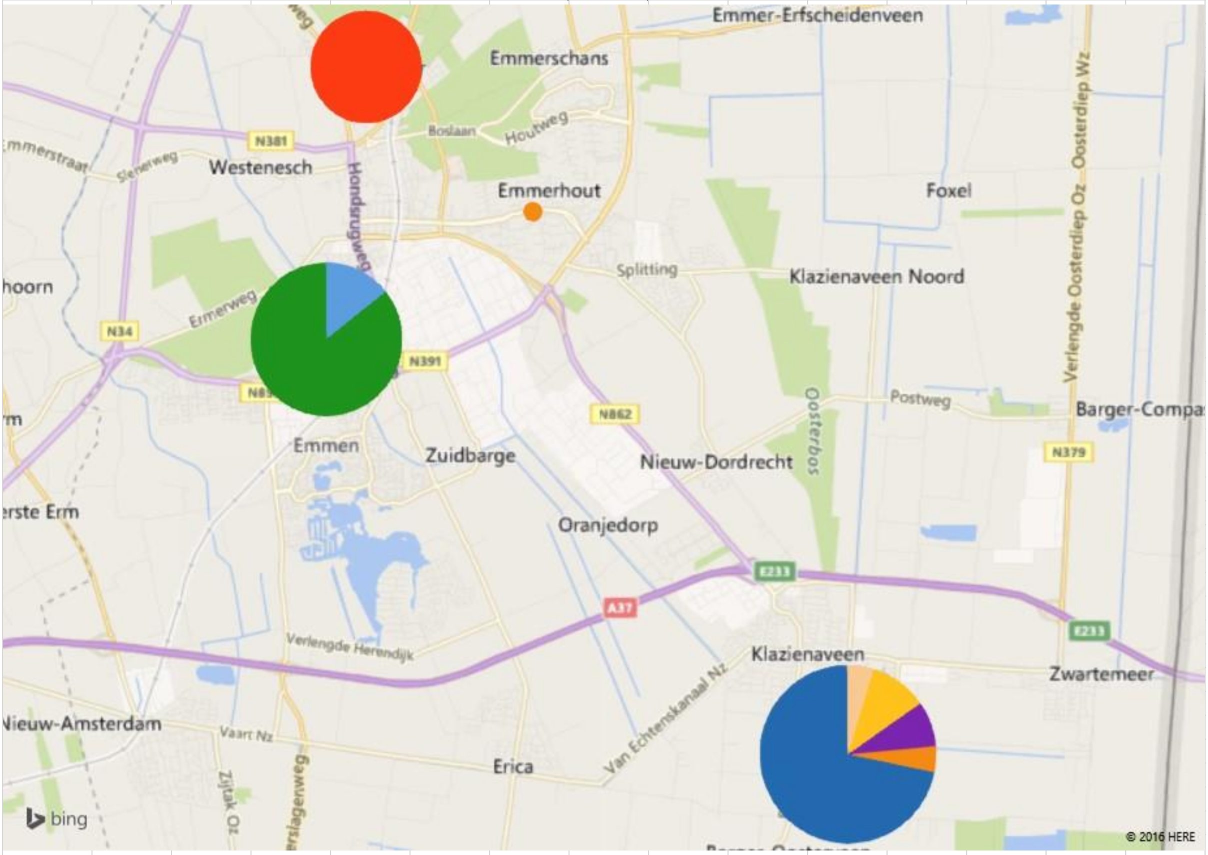
WMO_ID	To	From
1	1.0	1.0
2	1.0	0.9
3	1.0	0.9
4	0.9	0.9
5	0.9	0.9
6	0.9	0.9
7	0.9	0.9
8	0.9	0.9
9	0.9	0.9
10	0.9	0.9
11	0.6	0.6
12	0.2	0.2
13	0.2	0.2

WMO_ID	To	From
14	0.2	0.1
15	0.2	0.1
16	0.1	0.1

Zip code	Trips	Trips/day
7891	227	8.1
7827	54	1.9
7885	24	0.9
7741	6	0.2
7811	4	0.1
7844	2	0.1
7825	1	0.0
7812	1	0.0

Kruidenveld - Akkerdistel 100, Klazienaveen

To								From						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0
0	0	0	0	0.1	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0.1	0	0
0	0	0.6	0	0	0	0	**17**	0	0	0	0	0	0	0
0	0	1.8	0	0	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	1.3	0	0	0	0
0	0	0	0	0	0	0	**22**	0	0	1.4	0.1	0	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0



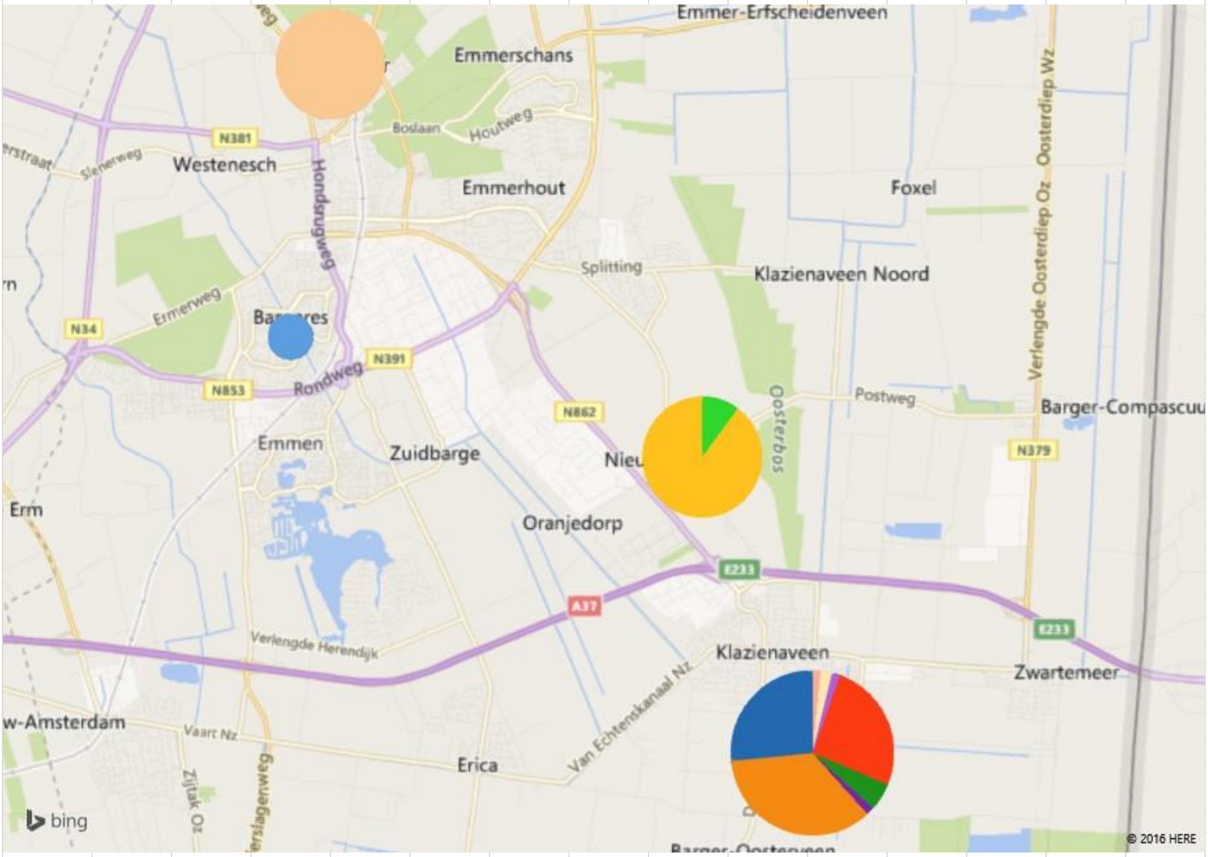
65 Wednesdays	Occurrence	
#Trips	To	From
1		
2		
3		
4		
5		

WMO_ID	To	From
1	0.9	0.9
2	0.8	0.8
3	0.5	0.5
4	0.1	0.4
5	0.1	0.1
6	0.1	0.1
7	0.1	0.1
8	0.1	0.1

Zip code	Trips	Trips/day
7891	85	1.3
7812	63	1.0
7815	34	0.5
7824	1	0.0

De Molen - Lange spruitstraat 73, Klazienaveen

To								From						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0
0	0	0	0	0.1	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0.1	0	0
0	0	0	1.7	0	0	0	**17**	0	0	0	0	0	0	0
0	0	0	1.8	0	0.2	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0.2	0.1	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	1.4	0	0	0
0	0	0	0	0	0	0	**22**	0	0	0	2	0.1	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0.1	0.2	0



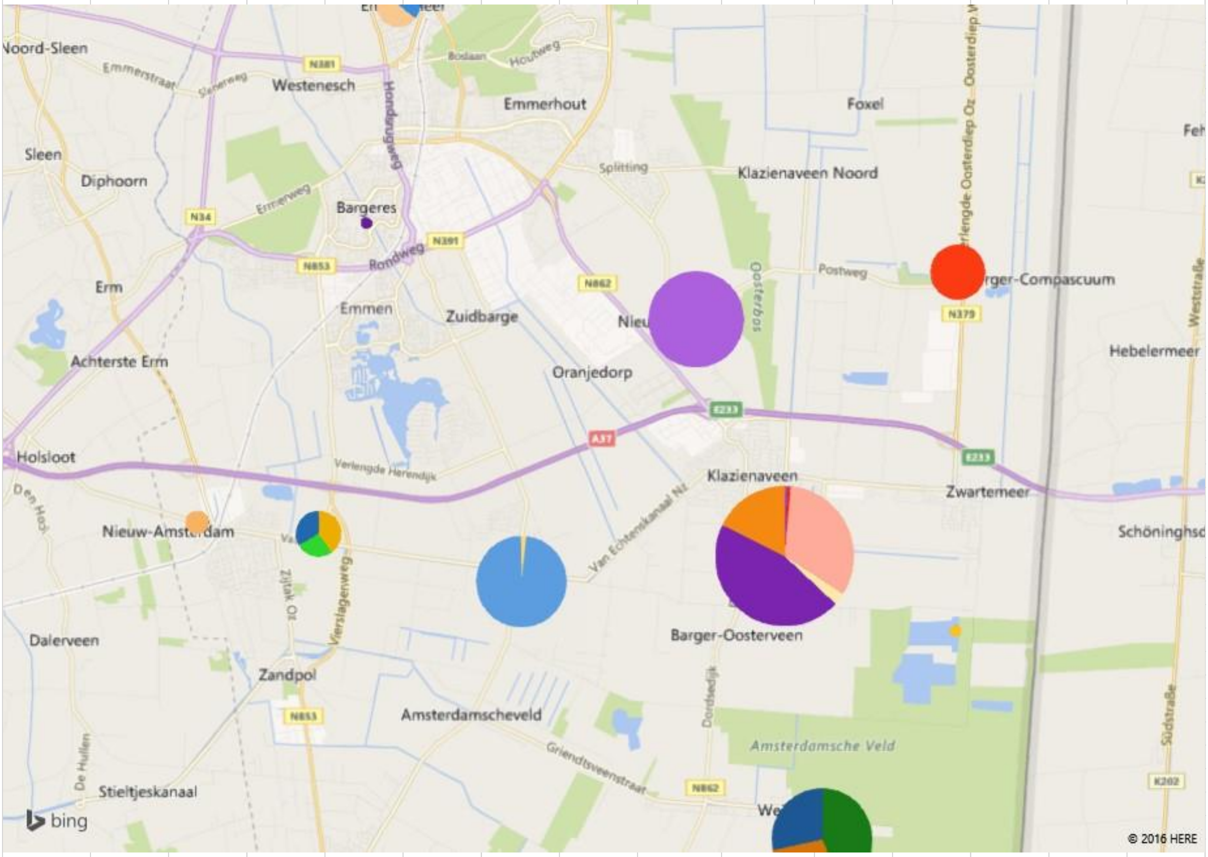
65 Thursdays	Occurrence	
#Trips	To	From
1		
2		
3		
4		
5		
6		
7		
8		

WMO_ID	To	From
1	1	1
2	0.9	0.7
3	0.7	0.7
4	0.5	0.5
5	0.5	0.4
6	0.2	0.2
7	0.1	0.1
8	0.1	0.1
9	0	0
10	0	0
11	0	0
12	0	0

Zip code	Trips	Trips/day
7891	128	2.0
7885	69	1.1
7815	58	0.9
7812	10	0.2

Het Hoekje - De lauden 17, Klazienaveen

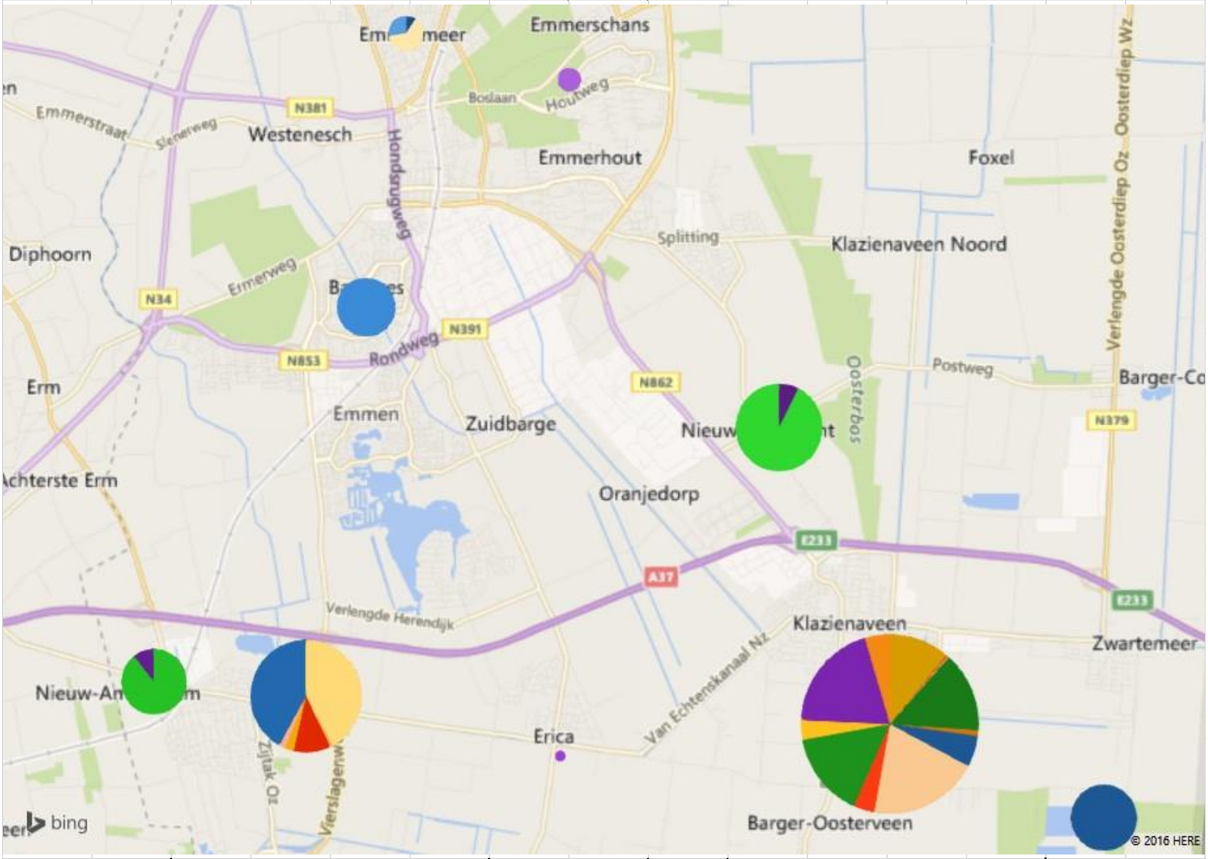
To								From						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0.1	0	0
0	0	0	0	3.2	0	0	**17**	0	0	0	0	0	0	0
0	0	0	0	2	0	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0.1	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0.6	0	0
0	0	0	0	0	0	0	**22**	0	0	0	0	4.8	0	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0



69 Fridays	Occurrence		WMO_ID	To	From	WMO_ID	To	From	Zip code	Trips	Trips/day
#Trips	To	From	1	1	1	12	0	0.1	7891	141	2.0
3			2	0.9	0.9	13	0.1	0.1	7765	74	1.1
4			3	0.9	0.9	14	0.1	0.1	7885	67	1.0
5			4	0.7	0.7	15	0.1	0.1	7887	60	0.9
6			5	0.5	0.5	16	0.1	0	7884	22	0.3
7			6	0.4	0.4	17	0.1	0	7833	15	0.2
8			7	0.3	0.3				7815	14	0.2
9			8	0.3	0.3				7844	4	0.1
10			9	0.3	0.3				7894	1	0.0
11			10	0.1	0.2				7812	1	0.0
12			11	0.1	0.1						

Ons belang - Kruiwerk 40, Klazienaveen

To								From						
Mon	Tue	Wed	Thu	Fri	Sat	Sun	**Hour**	Mon	Tue	Wed	Thu	Fri	Sat	Sun
0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**1**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**3**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**9**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0
0	0	0	0	0.1	0	0	**12**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**13**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**14**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**15**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**16**	0	0	0	0	0.1	0	0
0	0	0	0	0	5.1	0	**17**	0	0	0	0	0	0	0
0	0	0	0	0	2.9	0	**18**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**19**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**20**	0	0	0	0	0	0	0
0	0	0	0	0	0	0	**21**	0	0	0	0	0	0.6	0
0	0	0	0	0	0	0	**22**	0	0	0	0	0	8	0
0	0	0	0	0	0	0	**23**	0	0	0	0	0	0.1	0

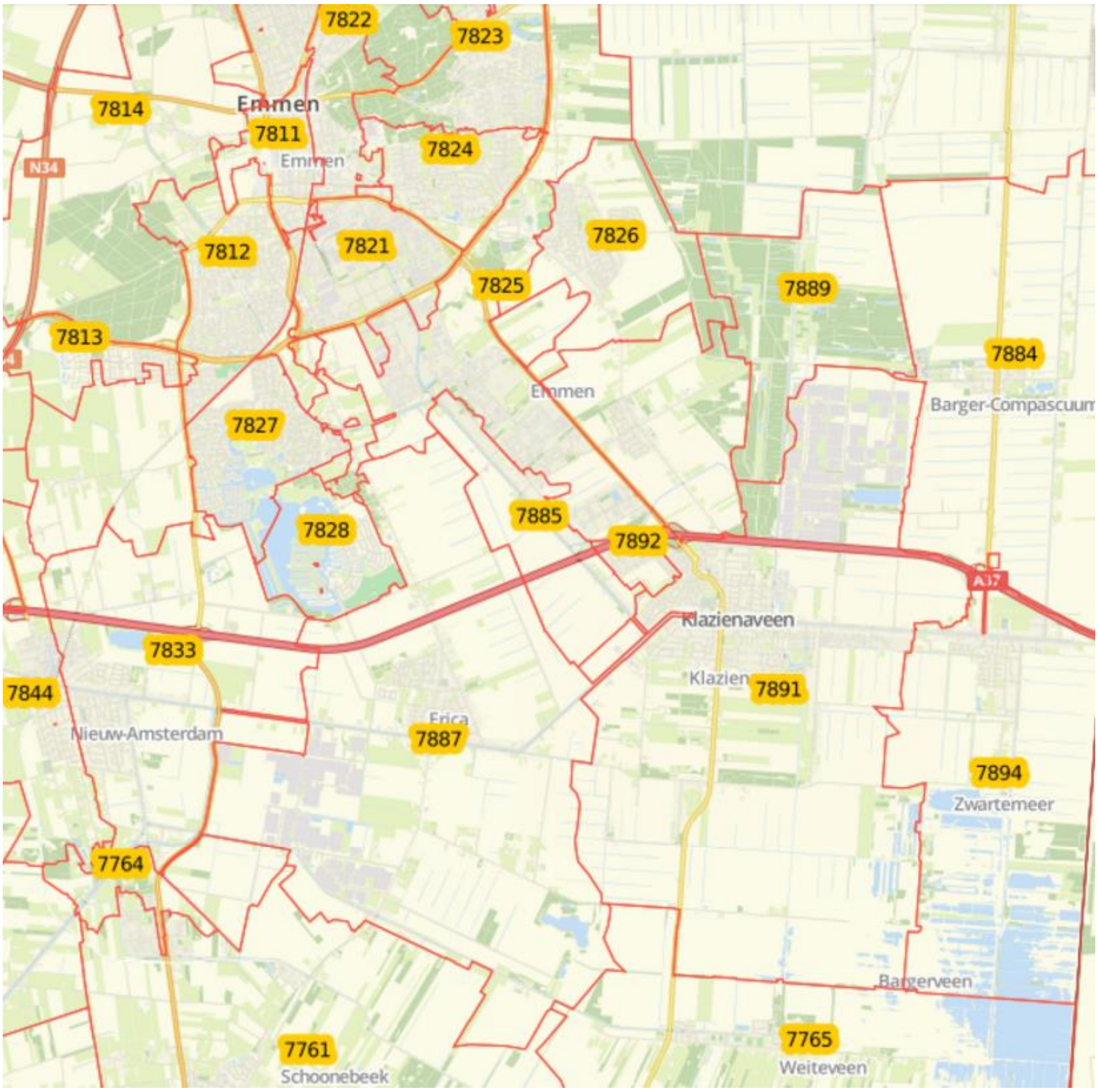


64 Saturdays	Occurrence	
#Trips	To	From
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

WMO_ID	To	From
1	1	1
2	0.9	0.9
3	0.9	0.9
4	0.9	0.9
5	0.7	0.7
6	0.7	0.7
7	0.7	0.7
8	0.6	0.7
9	0.5	0.5
10	0.5	0.5
11	0.5	0.5
12	0.1	0.6
13	0	0.5
14	0.2	0.2
15	0.2	0.2
16	0.2	0.2
17	0.2	0.1
18	0.1	0.1
19	0.1	0.1
20	0.1	0.1

Zip code	Trips	Trips/day
7891	284	4.4
7833	112	1.8
7885	68	1.1
7894	39	0.6
7844	38	0.6
7812	31	0.5
7815	11	0.2
7823	5	0.1
7887	1	0.0

Appendix 4: Zip code areas Bingo Bus



http://www.spotzi.com