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Provisioning a demand-orientated bus system for public transportation

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Abstract

Mobility needs are increasing, as well as noise emission, air pollution and congestion. Traditional mobility solutions are often no longer suitable for these challenges. New approaches for transportation, for example char sharing, are increasing in popularity and availability. Nevertheless many of these solutions are only available in urban areas. In rural or even suburban areas it is often not suitable and cost-efficient to provide public transportation with high frequency and density. Therefor many people in these areas are required to go by car to satisfy their needs. To increase the acceptance and usefulness of public transportation, especially in rural areas, a system for demand-orientated public transportation was proposed. The system was implemented in the German city of Schorndorf as a living lab, to be tested under real-world conditions. The pilot operation has started in March 2018 and the project is scheduled to be in operation till December 2018. This paper will present the challenges involved for provisioning this demand-orientated public transportation system, as well as the preliminary results.

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Keywords:public transportation; demand-oriented; Schorndorf; living lab

1. Introduction

Conventional systems for public transportation are often relatively rigid. Flexibility, for example, can be achieved by adjusting the frequency of the system or by providing vehicles with different capacities. During peak times the performance can be increased by providing larger vehicles or by increasing the frequency of trips. Nevertheless, oversupply is also not desired, because it would be cost-inefficient. However, decreasing the offer by reducing the frequency or cutting the area served makes public transportation less flexible for the customers and therefore less attractive. As a result the system is even less used and people are neglecting it for private means of transport

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(Holtermann et al., 2013). Adjusting a public transportation system and finding optimal parameters can be quite challenging. Modern transportation is subject to ever-changing requirements and therefore constant monitoring and adjustment would be required to make sure that a transportation system runs with optimal parameters. Obviously this adjustment process also costs lots of money.

To provide more flexibility for the consumer and thus increase attractiveness and acceptance, a demand-orientated system for public bus service was proposed. Ideally this system would be more efficient, because busses are only driving when and where they are needed. This would reduce energy consumption and noise pollution. The system will also provide more flexibility for the customers, because they can book the bus at will. To test the proposed system in a real-world scenario and to evaluate the costs of implementation, a living lab experiment was conducted.

A living lab is research cooperation between civil society and science. It emphasizes research and experimentation in a hands-on environment (Schneidewind, 2014) and is therefore well suited to answer these questions. The living lab was conducted in the German city of Schorndorf. The experiment started in March 2018 and is scheduled to continue till the end of December 2018.

1.1. Schorndorf

Schorndorf is a medium sized German town with a population of approximately 40,000 citizens in the year 2015. It is located 30km to the east of the city of Stuttgart, which is the capital of the federal state of Baden-Württemberg. Schorndorf is a typical example of a rural German city. A train connects the town to the federal state capital. The state capital is the place of work for many citizens from Schorndorf. During the working week, the train connection is well used by employees to go to Stuttgart to their respective workplaces. For the same reason, the line-based bus service in Schorndorf is well utilized during this time.

Opposite to that, there is not much demand of the service bus during the weekend. The citizens go by car or simply have different requirements and mobility needs. There is less demand to reach the railway station and more individual transportation.

As a result there is a large unbalance in the utilization of the public transport during the whole week. High demand during the working week is offset by low demand over the weekend. With the proposal of a demand-oriented system for the public transport, this unbalance is supposed to be mitigated.

1.2. Stakeholder

The living lab Schorndorf was conducted by a consortium of partners. Members of the consortium are the Schorndorf city administration, the VVS (Verkehrsverbund Stuttgart) as the public transport association of Baden-Württemberg, the local bus operator company Knauss and researchers from the German Aerospace Center (DLR), University Esslingen and Institute ZIRIUS.

The citizens of Schorndorf were also involved, especially in the planning phase. The citizens provided input via representatives. They were informed about the project's progress via public information events.

2. Related Work

On-demand systems for public transportation have been tested before. According to Bakker and van der Maas (1999), these so-called Demand Responsive Systems fall between regular public bus service and private car. They consider them an option only for less developed countries or certain niche markets. In the UK these systems emerged by the year 1970 as a special mode of transportation for people with mobility difficulties and where expensive to provide. However these systems do become more common by the year 2000 in multiple countries around the world.

Ultimately these systems failed for various reasons. According to Enoch et al (2006), among the reasons for failure where high-cost, insufficient commitment by political authorities and low reliability. In Schorndorf, our goal is to archive high acceptance and sustainably by integrating the on-demand system into the regular system of the transport association and by getting the citizen involved from the beginning.

3. Provision of the on-demand bus system

This section will describe the steps involved in providing the on-demand bus system. The requirements and the planning phase are briefly described, as well as the involved system components. The section will not cover the details of each task. It is meant to provide an overview and a general understanding of the challenges involved.

During the pilot operation, the on-demand bus system will replace parts of the existing timetable based public transportation during the weekend and Friday afternoon. On Friday and Saturday the people are severed with 2 busses. On Sunday and Saturday night only 1 bus is used, because much lower demand is expected. Public holidays are treated the same way as Sundays. The project was scheduled to be operational for the year 2018. The pilot operation has started in March 2018.

3.1. Requirements and constraints

One of the most important requirements is that the bus should guarantee the connection to the city train. The city train connects Schorndorf with the city of Stuttgart and is of much importance for the mobility of the citizen. It is regularly used by commuters, working in Stuttgart. Similar to the regular bus lines, which are replaced by the on-demand bus system, the railway station should be starting and end point for each bus tour. Because the city train has a frequency of 30 minutes and the connection to it should be guaranteed, the time for one bus tour is limited to approximately 25 minutes.

As already described, the on-demand bus system is available from Friday afternoon till Sunday night. This timeframe was chosen to test the system in different scenarios. On Friday the bus is mainly used by commuters who arrive in Schorndorf by train and want to get home. This leads to peeks of high usage, therefore the Friday is served with 2 busses. The Saturday is a balanced scenario. The bus is equally used to travel to the city center and to the outer areas, generating many different trip requests. The Saturday is also served with 2 busses. Saturday night and Sunday are low occupancy scenarios. A lower number of requests were expected and therefore only 1 bus is in operation. The bus is also available on public holidays, but these holidays are treated the same way as Sundays and have no special handling otherwise.

A further necessary requirement is that not all passengers can be picked up at their doorstep and dropped off exactly at the requested destination. No door-to-door service can be installed for several reasons. To increase throughput, the passenger request should be clustered. Furthermore the busses are not allowed to pass and stop on all streets. The acceptable distance for the passengers to go by foot was determined via a public survey. Nevertheless it was expected that many of the parameter, like the maximum distance to the pickup location, would be refined during the course of the project.

Usually customers were required to book the bus in advance. However the railway station provides passengers with the possibility to use the bus without booking it beforehand. Tourist and travelers from outside of Schorndorf are likely not aware of the new bus system. As a result they would not have booked the bus prior to their arrival. The bus is allowed to pick up these not booked passengers at the railway station if their destination would not change the planned bus route that is defined by the booked requests. Passengers without reservation can only use the stops already planned. They can keep track of the planned route by using a tablet screen inside the bus.

To reduce the barrier for using the new bus service, the system should be integrated into the existing infrastructure of the transport association of Baden-Württemberg (VVS). This means that information regarding the bus should be available via the regular web platform of the transport association, as well as in the existing apps for Android and iOS.

3.2. Planning phase

This section briefly covers the steps involved in the planning phase of the project. The tasks which had to be considered before proving the on-demand bus system are presented.

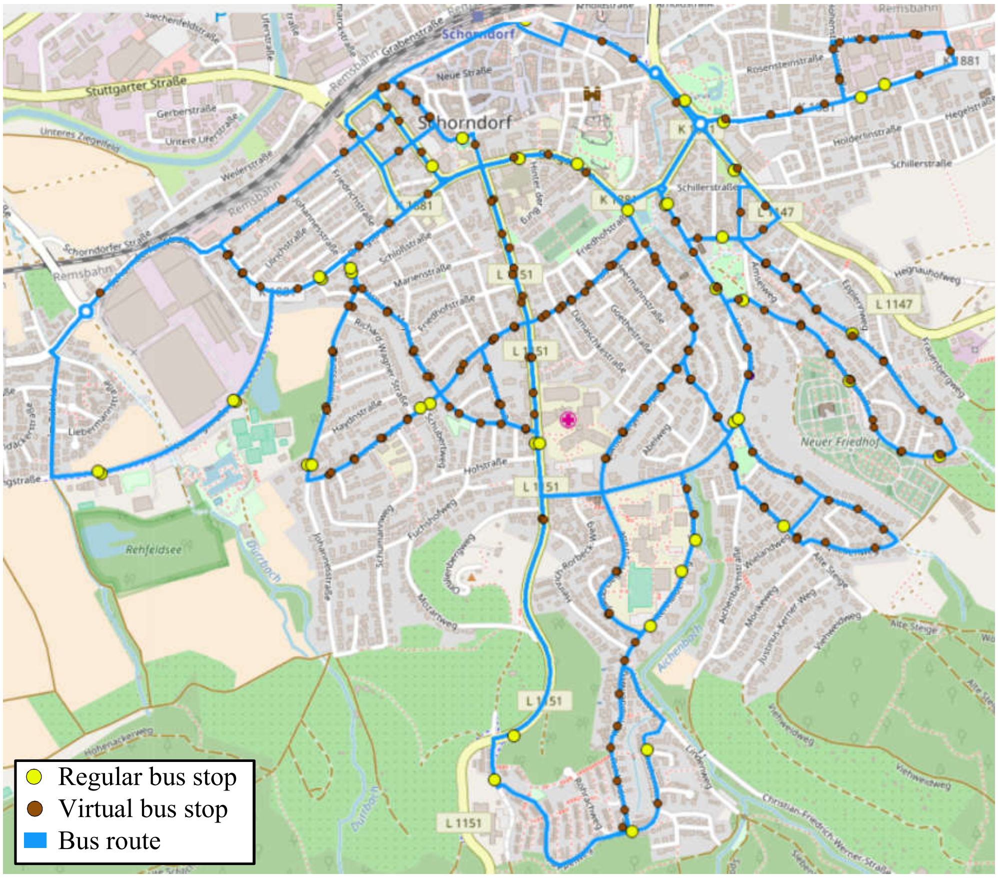

Fig. 1. Virtual and regular bus stops in Schorndorf, visualized with Openstreetmap under CC-BY-SA 2.0.

As described before, the on-demand bus does not cover door-to-door service. Furthermore the bus should not be restrained to regular bus stops. Nevertheless the bus could not pick up passengers everywhere. Certain streets, for example dead ends, could not be used by the bus. Parking prohibitions can prevent the bus from stopping at some areas. Furthermore some curves and junctions are not suitable for the bus, because of an acute angle. Not only street topology, but also points of interest, likes schools or hospital and the available resources were taken into consideration, (Brost et al., 2017). As a result, it was decided that the area of operation shall be the southern downtown area of Schorndorf. To further refine the operation area, especially the possible pickup locations, so-called virtual bus stops where introduced. The stops where selected by hand to ensure that they are suitable for the used busses.

Figure 1 shows the distribution of virtual stops in Schorndorf and the area of operation. The yellow points symbolize regular bus stops, which were incorporated into the on-demand bus system. The brown points symbolize the new virtual stops. Useable street network for the used busses are represented by the blue line. With the beginning of pilot operation, the on-demand bus system starts providing a denser network of possible stops and it will cover areas which were not served before. The aim is to increase attractiveness, acceptance and usage of the system.

The acceptance of the project by the citizens of Schorndorf was identified as a key factor for the success of the project. Therefore the citizens where involved in the requirement analysis step of the project from the very beginning. Furthermore multiple public information events where conducted to make the citizens familiar with the on-demand bus and to demonstrated the usage and benefits to them.

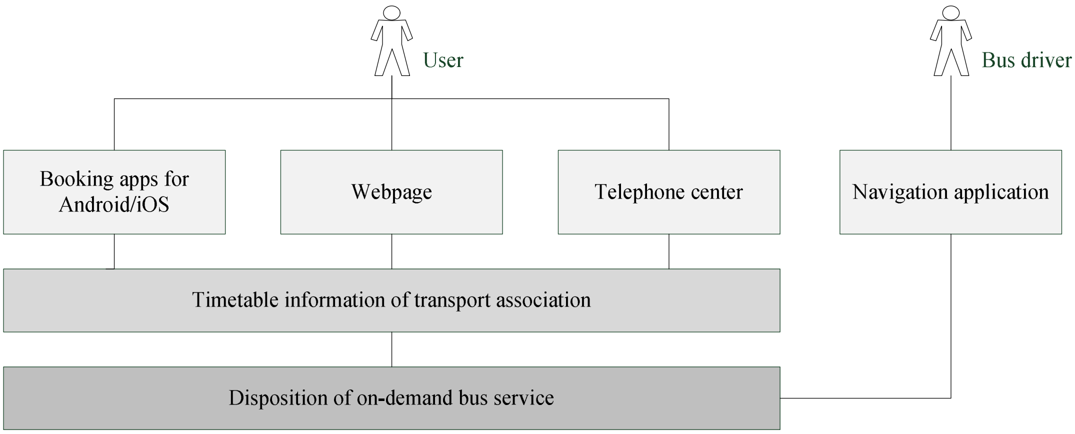

Fig. 2. System Overview.

During the first few weeks of the project, the busses were also accompanied by guides to help the passengers with booking, to support the bus drivers and to receive feedback.

3.3. System overview

The new system for provisioning the on-demand bus service was integrated into the existing system of the public transport association of Baden-Württemberg (VVS). This was necessary, to ensure that the experience for the passengers is as seamless as possible. For example the new system needs to be compatible with the existing travel ticket system.

Figure 2 shows the involved system components. Customers are able to order the bus by using either a smartphone application, the regular webpage of the transport association or by calling a telephone center. Each channel queries the timetable information of the regular transport association for available connections. From the timetable's point-of-view, the on-demand bus is still a conventional bus line, operating every half hour. This was one of the required trade-offs to map the on-demand bus with the given system.

After a customer has selected a connection, the disposition of the on-demand bus is queried for the actual trip information. Details of the disposition algorithm are presented in the next section. After the trip request was added to the currently planned route, the user is informed about his pickup and drop-off location and estimated departure time. The location can be up to 300 meters away from his originally requested location, because the disposition algorithm tries to merge the new request with the already booked connections on this route to increase throughput. By taking the currently planned route into consideration, the user also gets his estimated departure and arrival times. However, the departure time may change, because of additional requests being merged into the planned route. The departure time can vary from the first estimation in a range of +/- 5 minutes. Therefore passengers are requested to be at their pickup location 5 minutes before their departure time or to check their bookings shorty before their trip starts. The planned arrival time can also change. The only restriction on the arrival time is the guaranteed connection to the city train. As a result the user's arrival time may change if the route is altered to serve additional requests, but he will always be able to catch the next metro train. It is planned, that not only the departure time, but also the pickup location can be changed by the disposition algorithm to obtain a better pooling of requests. Currently the departure location is only set during the initial booking. It may initially be merged with an already planned stop, but it remains fixed after that.

The bus driver also needs to be informed about the planned tour of his bus. For the duration of the pilot operation, he uses an Android application to obtain the planned route. The bus driver must retrieve his route, shortly before his departure at the railway station, to make sure he has all the latest booking requests. The application itself runs on prepared tablets inside bus. It displays the planned trips and stops, as well as the number of passengers getting on or off the bus.

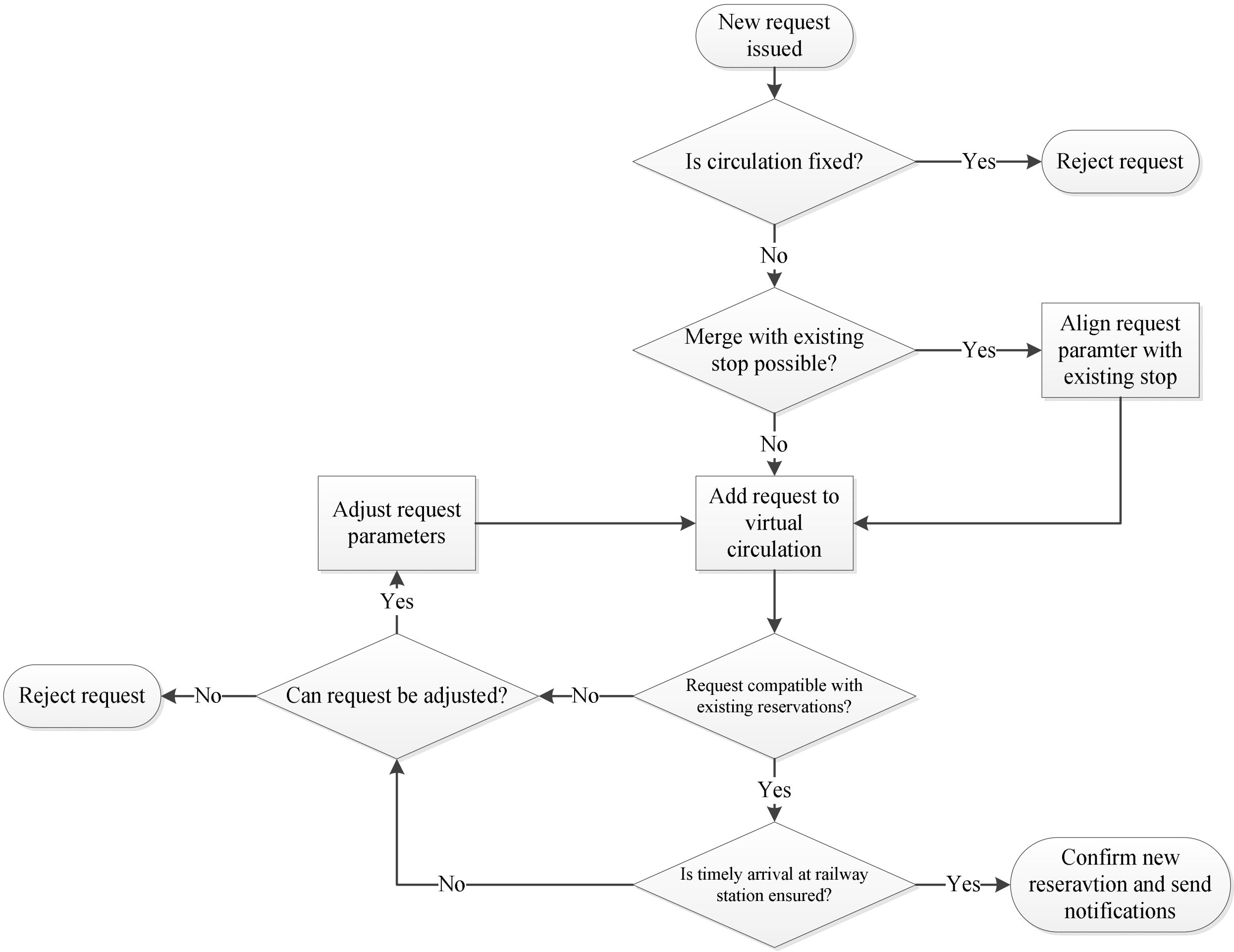

Fig. 3. Decision tree of disposition algorithm.

The disposition system and algorithm, as well as the smart phone applications were new developments by the service provider of the public transport association (VVS). The time table information and the webpage were part of the existing infrastructure of the transport association. The telephone center is an entirely new entity which was created for the project.

3.4. Disposition algorithm

This section will describe the working principle of the disposition algorithm. The disposition algorithm has 2 use cases. It is used to integrate new connection requests in a planned bus circulation and to verify that all planned requests can be fulfilled within the allowed parameters. Its second use case is to merge the requested stop with an already planned stop to increase throughput.

Figure 3 shows the decision tree of the disposition algorithm. The algorithm undergoes the decision tree each time a new request is issued. A request is always issued for a certain bus circulation. If this circulation is already fixed then the request is rejected. A circulation is fixed 5 minutes before the corresponding bus departures at the railway station and no more stops can be added to the fixed circulation.

To reduce the number of stops, the algorithm tries to merge each new request with the stops already planned. Reducing the number of required stops will minimize performance losses. The algorithm searches for stops in a vicinity of 300 meters from the requested departure location. The request is the merged with an already existing stop, if this stop is in suitable vicinity and the departure time deviates at most 10 minutes from the requested departure time. The maximum allowed time difference is 10 minutes, because the departure time of both the existing stop and the requested stop can be adjusted for at most 5 minutes.

During the next step, the algorithm adds the new request to a virtual bus circulation and checks if all constrains are ensured. The algorithm verifies that the departure times of all already planned stops can be archived with a deviation of maximum 5 minutes. The algorithm does not check the arrival times, because the arrival time is allowed to be flexible within the whole bus circulation. The algorithm also verifies that the timely arrival at the railway station is possible, because the on-demand bus system is supposed to guarantee the connection to metro train. If any of these constrains is violated, the algorithm adjusts the requested departure time within its allowed boundaries and the check is performed again. If the stop was newly added to the bus circulation, the algorithm can adjust the departure time by +-5 minutes. If the stop was merged with an already planned stop, the algorithm must respect both the original departure time and the newly requested departure time. Neither time may differ by more than 5 minutes. This is an iterative process until all contains are fulfilled or no more adjustments for the request are available.

If it was not possible to match the new request with the existing stops, the request is rejected. If a derivation of the request was found that ensures all constrains on the stops already planned, the request is accepted. The adjusted request is added to the route as being reserved. The user receives the adjusted request and he has the opportunity to book the request within 5 minutes, otherwise it is removed again. Each other user on the circulation whose departure or arrival time is affected by the new stop is notified via the smartphone application.

3.5. Challenges

This section will cover some of the challenges we encountered during the planning and operation phase of the project.

One of the first major challenges of the project was the analysis of the served area. It was necessary to capture all suitable roads for the bus, as well as all possible pickup locations for the passengers. Some roads are too narrow to be reasonable traveled on with busses. Furthermore not each possible location is suitable to pick up passengers. Stopping restrictions and no-parking zones must be taken into consideration as well. This task was further complicated by the lack of digital data on the street topologies, especially the position and type of traffic signs. Furthermore some parts of the data, already available were not up to date. As a result is was necessary to collect the required information manually by examining the served area on-site. Obviously this was a quite expensive task and it is therefore unsuitable for larger or urban areas. Profound digital data on street topology is an important requirement for on-demand routing.

As described in the planning phase section, the system uses a combination of virtual stops and conventional stops for passenger to be picked up and dropped off. However it was challenging to communicate the virtual stop to the passengers, because passengers were used look for bus stop signs. Without signs the user had to be described exactly where and on which side of the road he would be picked up. During the first weeks of the pilot operation, many passengers were especially confused by the lack of signs. It was observed, that they used regular stopping points, instead of the actual communicated pickup location.

A low barrier for customers was considered to be an important factor for the acceptance of the system. To achieve a seamless experience, information regarding the new system should be available via the regular timetable information of the public traffic association. However the existing system was designed for conventional line-based services. Mapping the on-demand bus service with the given system did result in certain shortcomings.

In Germany the public transportation system is also required to be barrier-free. People without access to a smartphone or a computer would not be able to use the booking application or the webpage. These people can use the telephone center to book the bus. However, as explained in the previous section, the planned route is fixed shortly before departure of the bus. Customers who used the smartphone application or the webpage for booking are requested to check the details of their booking, because departure time may change. This feedback channel does not exist if the booking was done with the telephone center. Therefore it would be difficult to inform the customers on changes in the time schedule. As a result, passengers who have booked via the telephone center have to be at their pickup location 5 minutes before their estimated departure time, because the final departure time may change within that time frame. In worst case situation the user has to wait for 10 minutes for his booked bus trip.

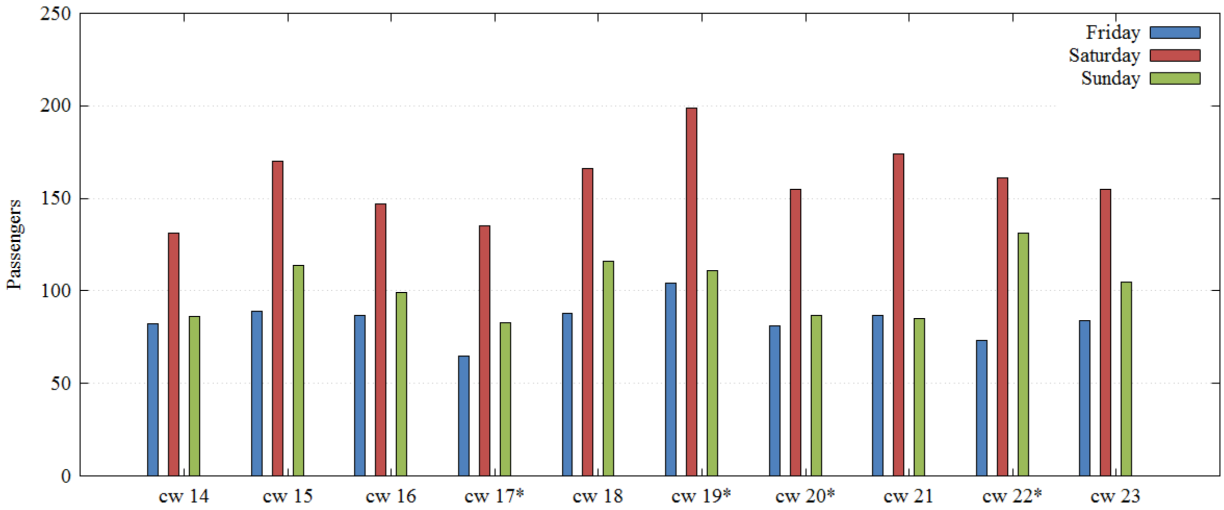

Fig. 4. Passenger figures by calendar week (cw) during the pilot operation.

Furthermore the telephone center is more expensive to maintain. Therefore it is desired that the telephone center is only used by people who depend on it. Unfortunately this was not the case, especially in the beginning of the pilot operation. Nevertheless with constant improvements of the booking apps and the incorporation of user feedback to improve usability, the share of app users could be increased.

4. Evaluation

This section is going to present some of the result and lessons learned from the pilot operation. The goal of this section is to provide overview of the system scale.

As described before, the pilot operation started in March 2018, in calendar week 10. However the first weekends were considered not representative, because many customers were not fully aware of the project and technical issues had to be resolved. Furthermore several guides were deployed to support customers and bus operators. At the beginning of April (calendar week 14), the system started to work on normal conditions and we consider the data after this date to be representative for the system. Therefore only data starting from calendar week 14 is presented in this section.

Furthermore, public holidays are also not considered in this evaluation although they are treated the same way as regular Sundays by the system. Furthermore only data from regular bookings is considered. Passengers, who departure at the railway station without a prior booking are currently not recorded in the visualized data. Unfortunately, no accurate and comprehensive data on passenger figures does exist for the time before the pilot operation of the on-demand bus. Therefore the current data cannot be easily related to original one.

4.1. Passenger figures

Figure 3 shows the development of passenger figures during the pilot operation by calendar weeks. Weeks marked with an asterisk are adjacent to 1 or more public holidays.

Overall the amount of passengers remains more or less constant, with approximately 300 passengers each weekend. We assume the stable passenger figures to be an indicator that the system has stabilized after calendar week 14. As expected the most passengers were transported each Saturday. Nevertheless the demand on Friday is lower than we had expected. However this figure does only contains the passenger numbers from regular bookings.

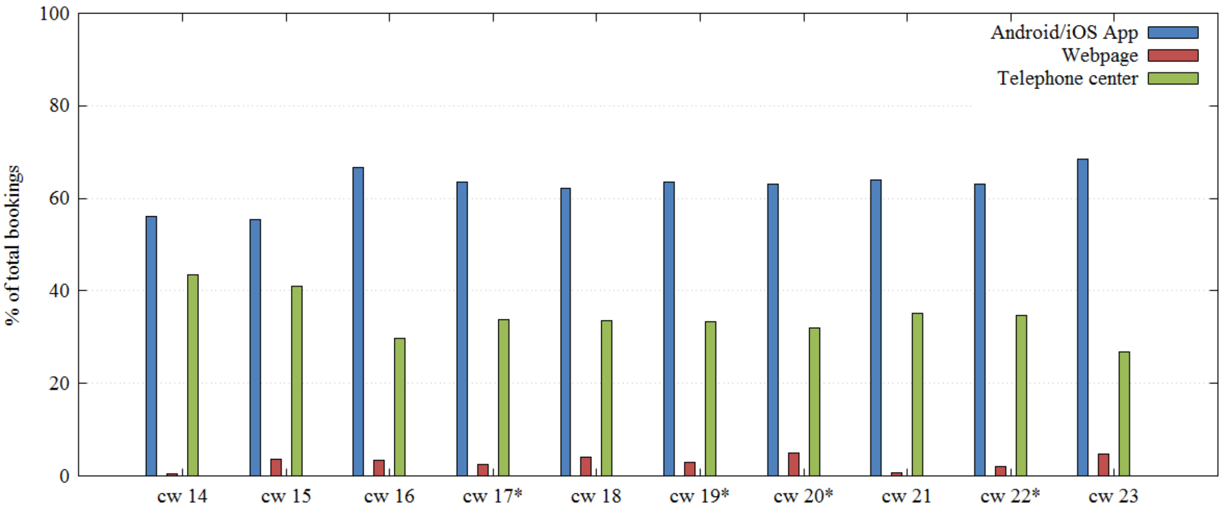

Fig. 5. Used booking channel by calendar week (cw) during the pilot operation.

As described before, passengers are able to use the on-demand bus without a prior booking if they depart at the railway station. We assume that many commuters used this opportunity. The share of passengers without bookings is not calculated yet. Passenger counting and surveys will be conducted to acquire an estimation of the actual scale.

Passenger figures are obviously influenced by adjacent public holidays. There has been a noticeable decrease in calendar week 17. We assume the reason is major public holidays, shortly after the weekend. Likely many people used this for vacation, which resulted in reduced demand.

4.2. Used booking channels

Figure 4 shows the trend in used booking channels during the pilot operation by calendar weeks. Weeks marked with an asterisk are adjacent to 1 or more public holidays. There are 3 different booking channels, which can be used to booking the on-demand bus. These channels are the mobile smartphone application, the webpage of the transport association and the telephone center. The figure does not distinguish between the Android application and the iOS application, both are summed up. The figure displays the share of bookings, received from each of the 3 channels for each calendar week. As explained before, only data after calendar week 14 is displayed.

The primary used booking channel is the mobile application. This was expected, considering the importance of smartphone applications nowadays. Approximately 60 percent of all bookings were received from smartphone clients. Surprisingly, the second important booking channel was not the webpage, but the telephone center.

The purpose of the telephone center was to act as a fallback for people without a smartphone or a computer and to support customers with a handicap, especially blind passengers. The telephone center is also more expensive to maintain. Furthermore, although it is possible to cancel orders via the telephone center, it is almost never used for this. This is not surprising because the paid telephone number of the telephone center is an additional barrier for the customers. It is therefore unwanted that the telephone center is favored over the webpage. We investigated on this numbers and found out, that many information events were focused on the mobile application and the telephone center, whereas the webpage was uncared-for. As a result, lots of customers were simply not aware that they can book the bus via the regular webpage of the traffic association. Furthermore, bookings via the webpage require a registered account at the transport association of Baden-Württemberg (VVS). This may create a barrier for the users. As a first measure, more emphasis was put on the webpage in the information material. However the results of these measures were not available for time writing.

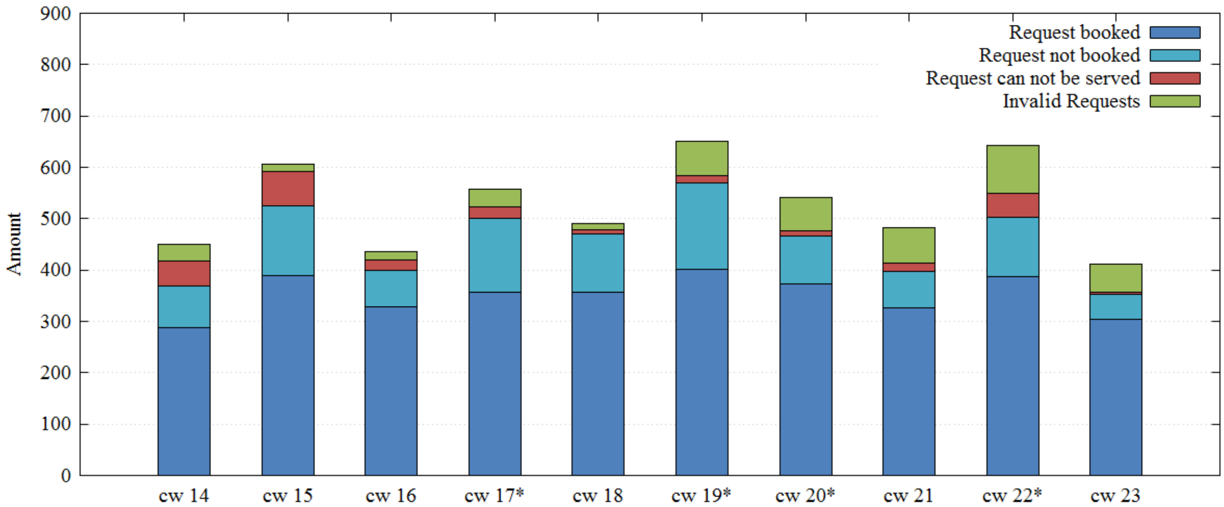

Fig. 6. Booking requests and bookings by calendar week (cw) during the pilot operation.

4.3. Booking requests

Figure 5 shows the amount of booking requests and performed bookings during the pilot operation by calendar week. Each row displays the aggregated requests and bookings, conducted during this week. Weeks marked with an asterisk are adjacent to 1 or more public holidays. It is important to consider that the on-demand bus is also in operation during holidays. Therefore calendar weeks with holidays cannot simply be compared to regular weeks. The aggregated values for the whole pilot operation for the time written are presented in table 1.

The figure displays the overall amount of booking requests and invalid requests, as well as the share of requests which could not be served and the amount of booked requests. Invalid requests are, for example, requests for off-hours or with a too early departure time. These requests can therefore never succeed and the system rejects the request. In this case the user is prompted with an according error message.

Table 1. Aggregated booking requests and bookings during the pilot operation.

Proportion of invalid requests from all requests	8.66 %
Proportion of serviceable requests from all valid requests	94.62 %
Proportion of non-serviceable requests from all valid requests	5.38 %
Proportion of bookings of all serviceable requests	77.16 %

The system will also reject a valid request, if this request could not be served with the already planned requests. In this case the user is asked to change his request parameters. Our goal is to minimize the share of rejections by adjusting disposition parameters and improving the algorithm.

Overall figure 6 shows an improving tendency. The overall number of requests remains relatively constant, considering regular fluctuations and holidays. The number of refused valid requests has decreased. Nevertheless, there is a noticeable outlier during calendar week 22, but calendar week 22 is also subject to a local holiday. More data is needed for an accurate estimation. The exceptional large number of holidays during the pilot operation makes comparison and evaluation of the data difficult.

5. Conclusion and Future work

For the time writing, the living lab Schorndorf is still in progress and many components can still be improved and developed.

There are currently 2 major tasks for the project. The first task is to increase the success rate of requests. The second task is to improve efficiency. As displayed in Table 1, approximately 5.4 percent of all requests could not be fulfilled. The reasons for the rejection of a request are currently being investigated. The important thing is to find out if the system's capacities are sufficient to cover the demand even at peak demand. Another important goal is to improve the overall efficiency of the system. Currently trips are only merged inside a timeframe of 30 minutes. Departure and arrival time may change to combine a booking request with other stops already planned on the next matching vehicle trip, but it will never be merged with bookings from another vehicle trip. If we assume 3 bookings, each in a time shift of more than 30 minutes, then each booking will be scheduled on its own vehicle trip, which is rather inefficient. However increased flexibility for passengers was also a goal and forcing these trips to be merged will result in increased wait time. It is challenging to find a good compromise to agree on both goals.

It was observed by deployed bus guides, that especially children were not aware of the system and not familiar with the booking. Unfortunately, no information events were conducted in public schools during the preliminary stage of the pilot operation. Schools rejected the request for an information event due to the lack of resources. For future living labs, this should be taken into consideration.

As described before in section 3.4, many passengers had difficulties with finding the correct pick up location. The customers were used to conventional stopping points. One possible solution would be to select virtual stops with unique selling points, like the front of certain shops or landmarks. This would make them more visible to passengers. However it would also increase the effort to select these stops even more. To better direct the user to the correct pickup location, not only the address, but also a picture of the stop could be provided. The booking application could also be enhanced to provide navigation for pedestrians to the virtual stop. However this is future work.

Currently the telephone center is used by approximately one third of all customers. This is undesired, because the telephone center is much more expensive to maintain and was intended as a fallback for customers who depend on it. Furthermore it is less comfortable for the customers. The missing feedback channel forces them to be at the bus station in advance and a wait of up to 10 minutes can be the result. Using the telephone center also cost money, because customers have to pay for the call. Misunderstandings in the communication did result in passengers not being picked up, either because they have waited at the wrong location or the time was not correctly communicated. The barrier of making a payed call also leads to bookings not being canceled in case they are no longer required. The exact reasons for many passengers to use the telephone center are still unclear and further analysis is required. A survey may yield useful results.

As described in section 3.3, the pickup location of the passengers is currently set fixed after booking. However, more flexibility could be archived by making the location as flexible as the departure time. Admittedly this would also increase the effort of informing the passengers and would not be possible with bookings via the telephone center for the time being. It was time consuming and expensive to select virtual stops and possible pick up locations, because of the lack of useful digital data. It is therefore infeasible to setup the system in larger cities without having accurate, digital street data beforehand. Especially road signs and information on parking zones is required. However the on-demand bus system, in its current state, was not intended for urban areas at all. The designated areas of operation are suburban and rural areas.

Routing of the bus is currently rather static and neither traffic jams nor regular fluctuations of the traffic situation during the weekend are taken into consideration for the route calculation. The routes are determinate by the normal routing algorithm of the traffic association. Therefore this is unlikely to be changed, because of the resulting cost for testing and implementation. Nevertheless the capacity of the on-demand bus system would benefit from more precise routing. Furthermore, passengers could retrieve more accurate estimations for their departure time.

The bus service on Friday is used by lots of commuters, arriving via train. The current situation is that these commuters are required to book the bus each Friday. Obviously this leads to displeasure of the affected commuters. Some commuters simply do not book the bus beforehand. They use the on the fly opportunity at the railway station, described in section 3.1. The possibility of recurring postings is currently discussed. Many technical aspects are required to be considered, as well as concern regarding the loss of flexibility.

Currently, the integration in the conventional public transportation system is rather simply and inflexible. The bus simply connects to the departure times of the city train. A more sophisticated approach for intermodal routing with demand oriented public transportation system will be implemented in the upcoming project Hub Chain. Hub Chain will develop an intermodal routing service with a connection guarantee in suburban and rural areas in the federal state of Mecklenburg. The lessons learned from the living lab Schorndorf are expected to be very useful for this project.

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