OJP WHITE PAPER: IMPLEMENTATION CONSIDERATIONS FOR INTERMODAL ROUTING BASED ON OJP (FOR CLIENTS AND SERVERS) IN OJP 2.0

Systemaufgaben Kundeninformation (SKI) – Team SKI+
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Document information

Description	This document is a short introduction, how the new possibilities in OJP 2.0 can be used to get multimodal routes in an easy way. It also shows how the new types of OJP requests can be used in case a trip breaks or a change to the trip should be requested, according to travellers' choice.
Target Audience	This white paper is for implementers of OJP services and application developers using such an OJP system.
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Changes

Version	Status	Change	By	Valid from
0.5	Draft	Text borrowed from another document and improved structure and text.	Matthias Günther	23.02.2024
0.9	Draft	Small extensions, adding abbreviations, finalization.	Andreas Glauser	27.02.2024
1.0	Final	Added input from other OJP 2.0 experts.	Andreas Glauser	11.06.2024

Content

1 Introduction

Any trip begins with the wish/need of a traveller to travel from an origin to a destination, and in most cases, there are certain time constraints for the trip. Since we like to offer multiple options to bridge the distance from public transport (PT) stops to origin or destination with other modes, the trip planning faces several challenges. These challenges are:

- To check for all options, which may lead to unintentionally long response times.
- Depending on the traveller's preferences, some offers may be of interest while others may not.
- Sharing and especially demand responsive transport (DRT) add a lot of information which a routing system needs to consider when calculating a trip.
- Travelers don't know about the availability of the different modes in the requested regions. Open Journey Planning (OJP) systems should first check the availability in a circumscribed area of interest (AOI), after that, the user may choose from the given options.

1.1 Available modes of transport

There are different modes (ojp:Mode) to be considered for multimodal trips (the list isn't exhaustive):

- Public transport (PT, default)
- Demand responsive transport (DRT) [1]
- Walking
- Own bicycle
- Own car
- Rental bicycle
- Rental E-scooter
- Rental car
- Pooling[2]

1.2 Combinations

Each transportation mode may be an option at the origin of the trip, some at the end and some may be used at origin and destination. Different modes may be used for feeder (origin) and fetcher (destination). Demand responsive transport is part of PT.

Table 1 Some multimodal modes and their use in our OJP-Service according to the list above

Mode	Origin (for mode specified)	Destination	Enum OJP (Mode)	Remarks
Public Transport	Stop	Stop	(default)	Router adds walking legs, if origin or destination isn't a stop.
Walking	Any place, location or coordinate	Any place or location	Mode=walk	
Own Bicycle	Any place, location or coordinate	(makes no sense, see remark)	Mode=cycle	Routing at destination for way back home. See remark.

[1] Description of DRT: https://en.wikipedia.org/wiki/Demand-responsive_transport

[2] Pooling paper SKI+: https://www.xn--v-info-vxa.ch/sites/default/files/2024-01/vehicle_pooling_switzerland_v1.0.pdf

Own Car	Any place, location or coordinate	(makes no sense, see remark)	Mode=self-drive-car	Routing at destination for way back home. See remark.
Bicycle (sharing)	Bike station	Bike station	Mode=bicycle_rental	Router adds walking legs, if origin or destination isn't a bike station
e-Scooter (sharing)	Any free-floating e-Scooter	Any place, location or coordinate	Mode=escooter_rental	Router adds walking legs, to next e-Scooter
Car (sharing)	Parking of available Car	Parking of available Car	Mode=car_sharing	Router adds walking legs, to next car and from parking to PT or vis versa

Remark: Using your own car at the destination side of the trip implies that the car / bicycle is there. This information currently can't be transmitted. The client needs to handle this (trip to the place where the bicycle/car is parked and then a monomodal trip to the destination.

2 Description of three designated use cases

There are plenty variants of trips and possible combinations. These examples just show the basics, how to obtain a valid trip. The use of estimated TripRequests (TR) is crucial for two reasons. Firstly, it gives the traveller some options to choose from without an extra-long waiting time and secondly, it doesn't waste calculation resources for trips the traveller may not be interested in.
To handle the given examples, three different kinds of OJP 2.0 (CEN/TS 17118:2024) requests are used:

1. The TripRequest (TR).
2. The TripRefinementRequest (TRR) which is derived from the TRIAS protocol[3] and adds further information details to a trip.
3. The TripChangeRequest (TCR) which adds some additional information to the trip including changes to some legs.

The descriptions of the following use cases explain how to use the requests in proper order.

Firstly, we present a legend to explain the presentation of the trips and the meaning of the leg colours.

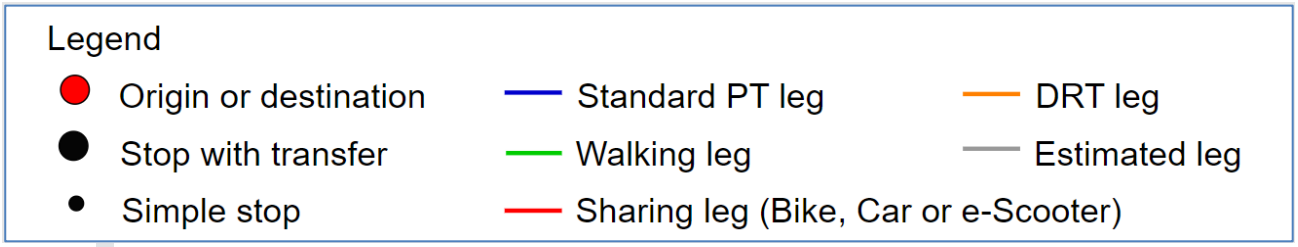

Figure 1 Legend for the trip element modelling

[3] https://www.vdv.de/projekt-ip-kom-oev-ekap.aspx

2.1 Use Case 1: Normal PT Trip

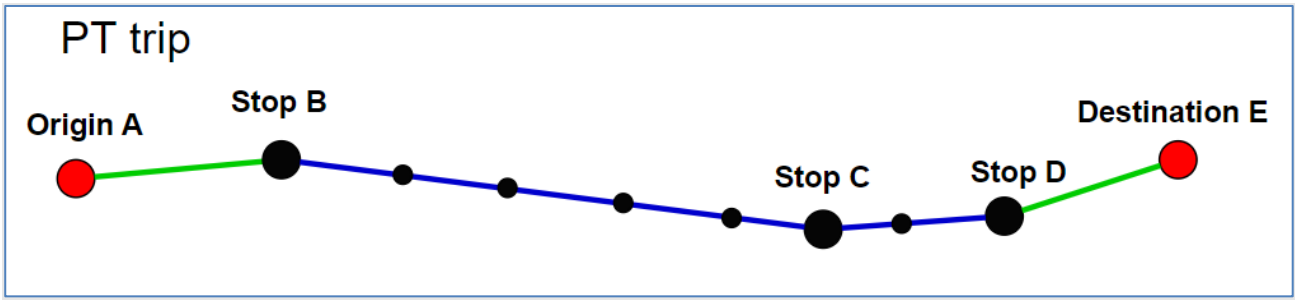

Figure 2 First step: Search with only PT

Steps to request a PT trip:

1. The traveller selects "Origin A" and "Destination E" for which a Location Information Requests (LIR) will be sent.
2. When searching the trip, a TR will be sent with no further multi modal transportation options. A trip with PT stops and, if required, a walking leg to the next PT stop and to the destination will be added by the router. In this example the PT trip starts at "Stop B", has a transfer at "Stop C" and ends at "Stop D".

2.2 Use Case 2: Trip with sharing legs included

Steps to request a trip with sharing legs at origin and destination:

1. The traveller selects "Origin A" and "Destination E" with options for sharing at both ends.
2. Starting the search with an estimated TR as shown in figure 3. Reason: To not waste calculation time on router side for detailed calculations of trips with all the sharing legs, where the traveller afterwards chooses only one from the responded list of trips.
3. The traveller selects his favourite trip and sharing provider from the list, which then launches two TCR where first the legs from points "Origin A" over "A'" to "Stop B" and second "Stop D" over "D'" to "E'" are changed to get a valid trip chain with reliable timing and detailed routing for walking and riding like in figure 4.

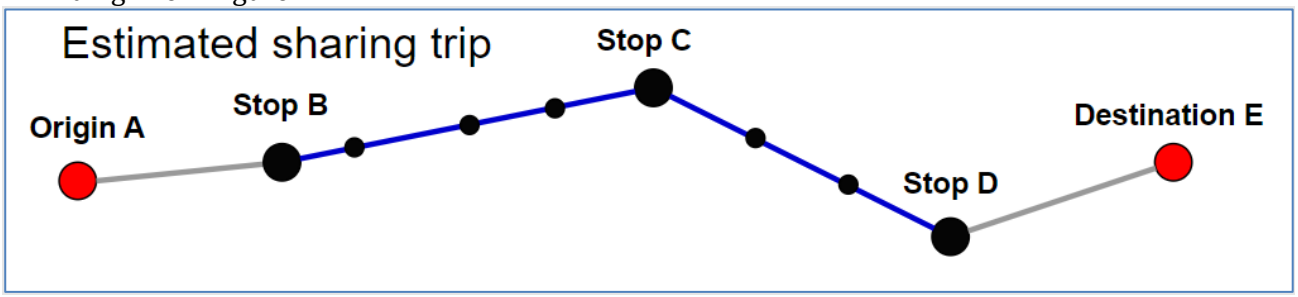

Figure 3 Trip includes sharing, estimated and trip result with selected provider.

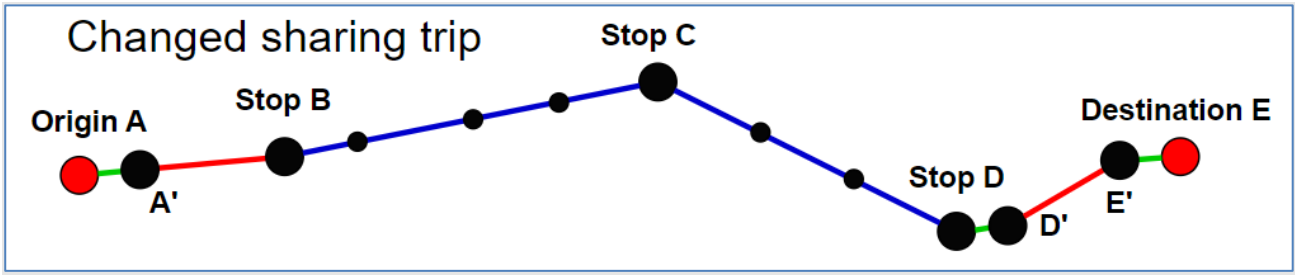

Figure 4 Trip changed, now with calculated sharing legs at origin and destination.

The example in figure 4 shows a first walk (to “A’”) to a free-floating sharing device, e.g., an eScooter, which the traveller can take right into “Stop B” where he transfers to a public transport. The subsequent PT trip ends at “Stop D” where a walk connects the PT stop with the bike rental station from where the traveller drives to the place “E’” to drop off the rented bike to finally walk to “Destination E”.

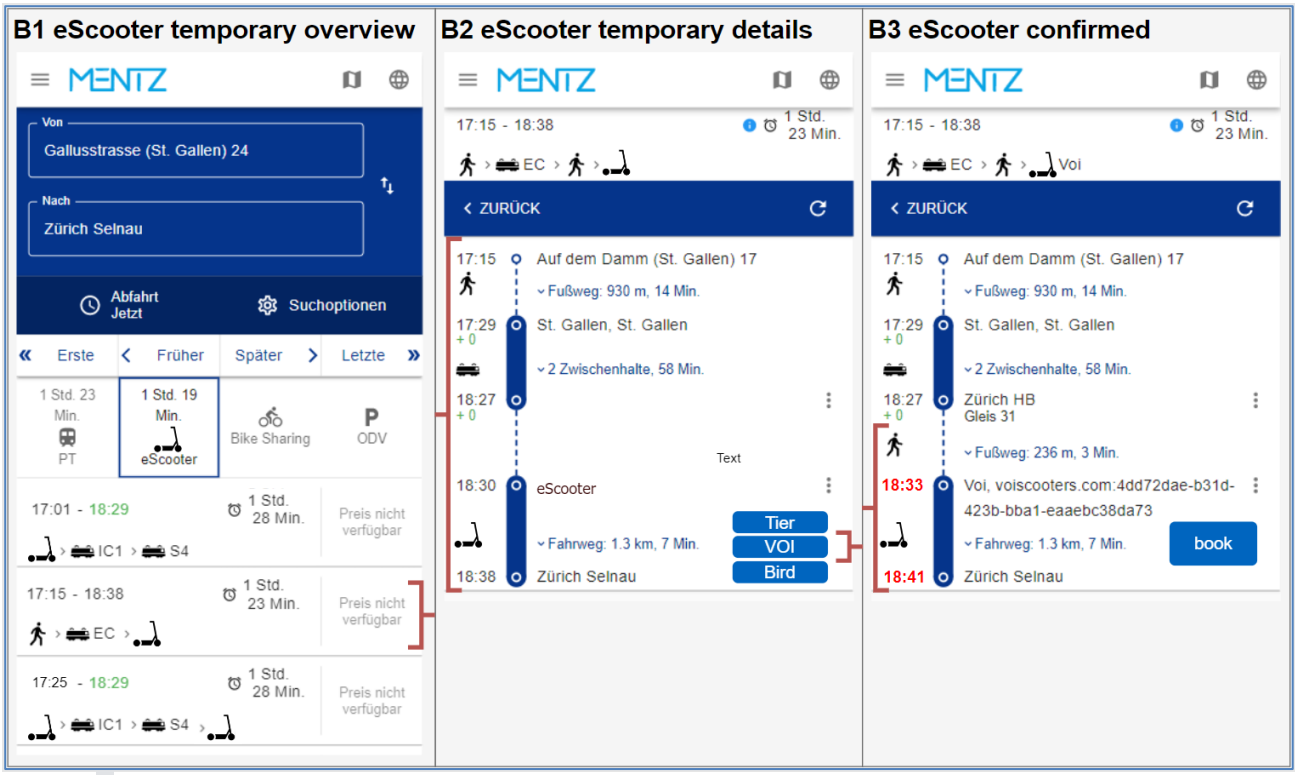

Figure 5 App mock-up about sharing by MENTZ (Copyright MENTZ)

The Mock-up design in figure 5 above shows how the refining of a trip could look like from the user perspective. The process is as follows: first, the user of the app selects origin and destination and chooses afterwards one of the proposed and estimated trips. After selecting one of the trips in the list, he can see the details of the proposed trip, where he then can choose one of the available sharing providers. With the following TCR, the trip legs will be definitively calculated with vehicles from selected operators, and the availability of eScooter will be verified. The TCR may result in a response that the chosen sharing provider cannot offer a suitable shared vehicle for the trip leg. In this case, the traveller may need to choose a different sharing provider or choose a different trip from the results of the previous TR. Maybe some information in the trip may change and needs to be updated. This information can be obtained with a TRR.

2.3 Use Case 3: Trip with demand responsive transport (DRT) legs

Steps to request a trip with a DRT leg at destination:

1. The traveller selects “Origin A” and “Destination E” with options for DRT at the destination.
2. Starting the search with an estimated TR request in figure 6, where the routing system estimates DRT legs at the end of a trip, based on its information about the DRT services and its pickup points.
3. The user chooses one of the given options in the list.
4. Then the client application may confirm the DRT availability (potentially done by OJP availability request at DRT provider). After the positive answer from the DRT provider, all legs of the trip are defined as seen in figure 7, and he can start to travel. The DRT provider may also not be able to respond with suitable offers and the trip may break. In this occasion, the traveller may choose a different trip from the results of the previous TR.

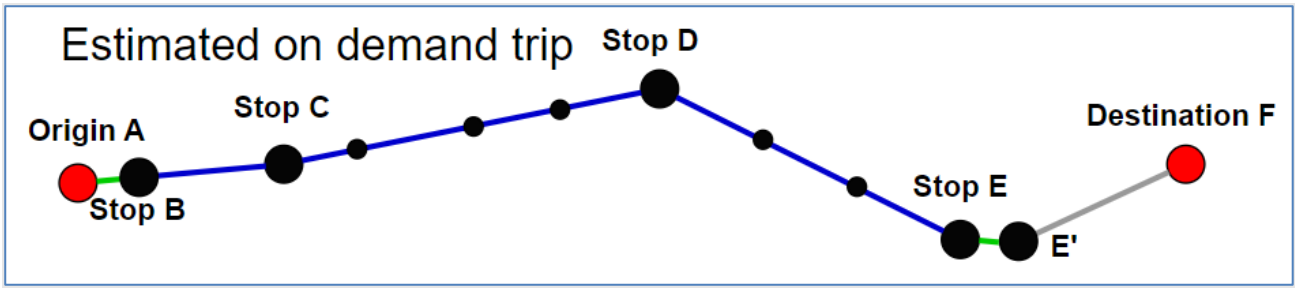

Figure 6 Estimated trip with estimated DRT leg at the end

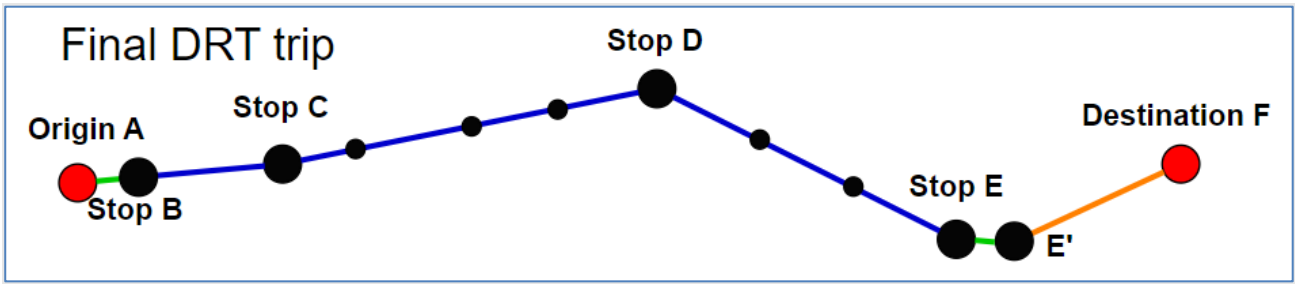

Figure 7 Finalized trip with confirmed DRT leg at the end

3 Hints to obtain trips in OJP 2.0

We present hints how a responding system and client (home system) should process a user trip search, in order that travellers need for options to choose from, can be satisfied. Additionally, the number of requests and calculation time on OJP systems side should be kept as low as possible, by following these procedures.

The proposed use of trip leg estimations is a way to facilitate a lower load on the OJP system. However, trip leg estimations are optional and OJP systems may still choose to provide already verified results to the requesting systems.

3.1 How to obtain multimodal trips with OJP 2.0

Steps in the process as seen in figure 8 to obtain a trip with different selections in the trip refining process:

1. After the traveller selection of origin and destination, the available modes in these regions can be requested with a LIR.
2. With the first request we show a PT trip and optional estimations for possible multimodal trips.
3. With this information the traveller can select the desired mode. A new TCR for the estimated trip legs is sent.
4. Refinement requests may be performed to get updated information for certain legs and a reliable timeline for the whole trip chain.

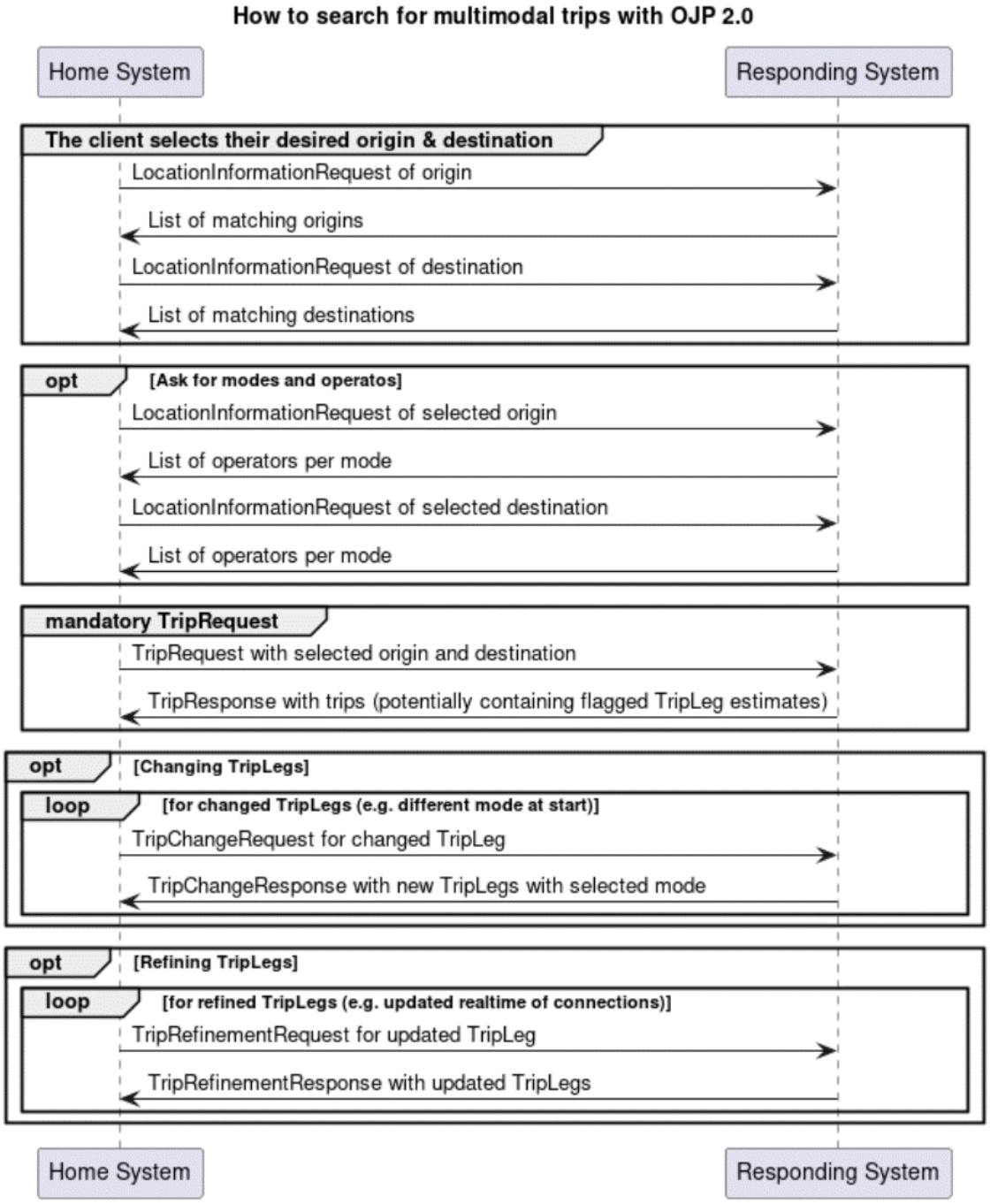

Figure 8 Sequence for a generic trip search in OJP including optional Trip Refinement Request (TRR) and Trip Change Request (TCR)

As seen in the diagram a search has up to five different elements, where some are optional[4] and changing and refining trip legs is probably requested several times on the same trips. If the origin, the destination or date and time is changing, the trip requests need to be done again, starting at the top of the process.

3.2 Process description for a trip search

We show how a fully customized trip from origin to destination can be requested. In some of the following examples a trip with origin "Bern, Zytglogge" and destination "Thun, Strandbad" is used. This description is not complete in scope but is intended to illustrate the principles and functionality of TCR

[4] If using coordinates to coordinates, even the first step is optional.

and TRR using simple examples. The examples show multimodal use cases and thus also the areas of application that are improved by OJP 2.0.

3.2.1 Start with a PT search

The traveller selects the origin and destination in most cases by selecting from a list based on a LIR.
If only a PT search is considered we will get trip legs as in the following example, where we have a walking/connecting leg from the "Origin A" to the first PT "Stop B" with a PT change at "Stop C", reaching the final "Stop D" and walking to "Destination E.
A traveller enters an "Origin A" (Bern, Zytglogge) and a "Destination E" (Thun, Strandbad) and does a trip search. Following a standard PT search:

```
...<RequestTimestamp>2022-12-01T10:50:30Z</RequestTimestamp>
     <ojp:Origin>
       <ojp:PlaceRef>
         <StopPointRef>8507110</StopPointRef>
         <ojp:LocationName>
           <ojp:Text>Bern, Zytglogge (Bern)</ojp:Text>
         </ojp:LocationName>
       </ojp:PlaceRef>
       <ojp:DepArrTime>2022-12-01T15:00:00Z</ojp:DepArrTime>
     </ojp:Origin>
     <ojp:Destination>
       <ojp:PlaceRef>
         <StopPointRef>8576861</StopPointRef>
         <ojp:LocationName>
           <ojp:Text>Thun, Strandbad (Thun)</ojp:Text>
         </ojp:LocationName>
       </ojp:PlaceRef>
     </ojp:Destination>...
```

Figure 9 Example for trip request with public transport only

3.2.2 Example of estimated trip chain for multimodal trips

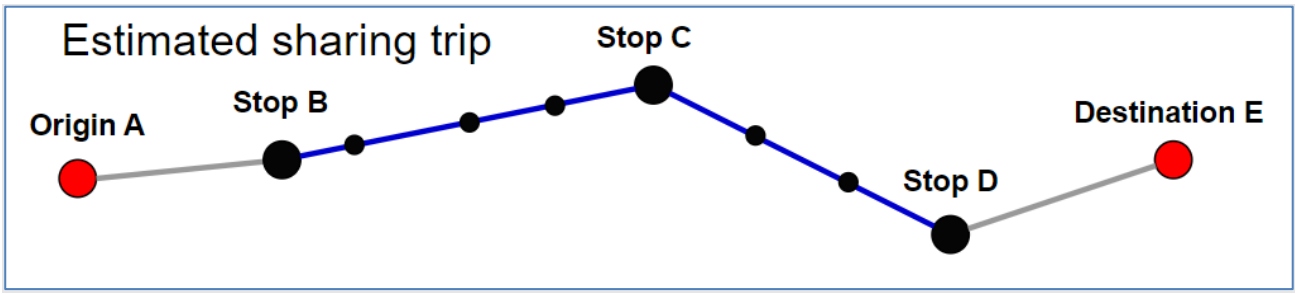

Figure 10 Example with different forms of sharing at origin and destination

The traveller needs to walk to an available free-floating scooter (in this example choosing between Voi, Tier, or Lime) and can then take it directly to the stop. At destination side the traveller must walk first to the sharing station and need to drop it at another one to finally walk to his chosen "Destination E".
The following snippet of the trip response shows details added for scooters. In the same manner other available modes can be delivered to the client. In the context the operator details will be present.

```
...<ojp:Service>
       <ojp:IndividualMode>scooter_sharing</ojp:IndividualMode>
       <ojp:OperatingDayRef/>
       <ojp:JourneyRef/>
       <siri:LineRef/>
```

```
            ...
            <ojp:PublishedServiceName>
                <ojp:Text/>
            </ojp:PublishedServiceName>
            <ojp:OperatorRefs>
                <ojp:OperatorRef>Voi</ojp:OperatorRef>
                <ojp:OperatorRef>Tier</ojp:OperatorRef>
                <ojp:OperatorRef>Lime</ojp:OperatorRef>
            </ojp:OperatorRefs>
        </ojp:Service>...
```

Figure 11 Example with one mode and several operators

Example Response of a TripRefinemenetRequest using a filter for the specific sharing provider “Voi”:

```
<OJPTripRefineRequest xmlns="http://www.vdv.de/ojp"
xmlns:siri="http://www.siri.org.uk/siri"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:schemaLoca-
tion="http://www.siri.org.uk/siri ../../../../Downloads/OJP-
changes_for_v1.1/OJP-changes_for_v1.1/OJP.xsd">
    <siri:RequestTimestamp/>
    <RefineParams>
        <OperatorFilter>
            <OperatorRef>Voi</OperatorRef>
        </OperatorFilter>
    </RefineParams>
    <TripResult>
        <Id/>
        <Trip>
            <Id/>
            <ojp:LegId>1</ojp:LegId>
            <ojp:ContinuousLeg>
                <ojp:LegStart>
                    <ojp:GeoPosition>
                        <siri:Longitude>7.47153</siri:Longitude>
                        <siri:Latitude>46.94360</siri:Latitude>
                    </ojp:GeoPosition>
                    <ojp:LocationName>
                        <ojp:Text xml:lang="de">OriginPoint</ojp:Text>
                    </ojp:LocationName>
                </ojp:LegStart>
                <ojp:LegEnd>
                    <siri:StopPointRef>8507110</siri:StopPointRef>
                    <ojp:LocationName>
                        <ojp:Text xml:lang="de"> Bern, Zytglogge
(Bern)</ojp:Text>
                    </ojp:LocationName>
                </ojp:LegEnd>
                <ojp:Service>
                    <ojp:IndividualMode>scooter_sharing</ojp:IndividualMode>
                    <ojp:OperatingDayRef/>
                    <ojp:JourneyRef/>
                    <siri:LineRef/>
                    <ojp:Mode>
                        <ojp:PtMode/>
                    </ojp:Mode>
                    <ojp:PublishedServiceName>
                        <ojp:Text/>
                    </ojp:PublishedServiceName>
                </ojp:Service>
                <ojp:TimeWindowStart>2022-12-07T13:16:10Z</ojp:TimeWin-
dowStart>
                <ojp:TimeWindowEnd>2022-12-07T13:23:53Z</ojp:TimeWindowEnd>
```

```
                <ojp:Duration>PT8M</ojp:Duration>
                <ojp:Length>1393</ojp:Length>
            </ojp:ContinuousLeg>
        </Trip>
    </TripResult>
</OJPTripRefineRequest>
```

Figure 12 Example of an operator within the context of the response

Trip Refinement

In the example below the traveller selected a trip with "Voi" as desired operator:

```
...<ojp:TripLeg>
    <ojp:LegId>1</ojp:LegId>
    <ojp:ContinuousLeg>
        <ojp:LegStart>
            <ojp:GeoPosition>
                <siri:Longitude>7.47153</siri:Longitude>
                <siri:Latitude>46.94360</siri:Latitude>
            </ojp:GeoPosition>
            <ojp:LocationName>
                <ojp:Text xml:lang="de">OriginPoint</ojp:Text>
            </ojp:LocationName>
        </ojp:LegStart>
        <ojp:LegEnd>
            <siri:StopPointRef>8507110</siri:StopPointRef>
            <ojp:LocationName>
                <ojp:Text xml:lang="de"> Bern, Zytglogge (Bern)</ojp:Text>
            </ojp:LocationName>
        </ojp:LegEnd>
        <ojp:Service>
            <ojp:IndividualMode>scooter_sharing</ojp:IndividualMode>
            <ojp:OperatingDayRef/>
            <ojp:JourneyRef/>
            <siri:LineRef/>
            <ojp:Mode>
                <ojp:PtMode/>
            </ojp:Mode>
            <ojp:PublishedServiceName>
                <ojp:Text/>
            </ojp:PublishedServiceName>
            <ojp:OperatorRefs>
                <ojp:OperatorRef>Voi</ojp:OperatorRef>
            </ojp:OperatorRefs>
        </ojp:Service>
        <ojp:TimeWindowStart>2022-12-07T13:16:10Z</ojp:TimeWindowStart>
        <ojp:TimeWindowEnd>2022-12-07T13:23:53Z</ojp:TimeWindowEnd>
        <ojp:Duration>PT8M</ojp:Duration>
        <ojp:Length>1393</ojp:Length>
    </ojp:ContinuousLeg>
</ojp:TripLeg>…
```

Figure 13 part of a response with leg details on a specific trip leg with eScooter

4 Special challenges to be addressed when planning multimodal trips

4.1 Avoiding requests without possible trip results

It may be advisable to request information around coordinates, addresses, topographic places and stops about available modes in walk distance, before requesting a multimodal trip including such modes. This should happen with LIR around the origin and destination, to avoid requests with modes that doesn't exist within the AOI.

Figure 14 Zone around origin or destinations to search for available modes

In figure 14 on the left side all modes are within a walk distance, on the right side only bikes and a car are available. A service must not search for modes which cannot be satisfied in requested region. This prevents unnecessary waiting time and unnecessary load on the OJP servers.

4.2 Optimise search time by selection of operator

After gathering the availability, the user may select the most desired operator for his trip. This leads to faster response time and minimizes further the load on the requested OJP systems.
With a longer response time a multi modal trip can be requested right away to show the traveller his trip with the most desired transport options:

```
...<ojp:Origin>
     <ojp:PlaceRef>
       <StopPointRef>8507110</StopPointRef>
       <ojp:LocationName>
         <ojp:Text> Bern, Zytglogge (Bern)</ojp:Text>
       </ojp:LocationName>
     </ojp:PlaceRef>
     <ojp:IndividualTransportOptions>
       <ojp:Mode>scooter_sharing</ojp:Mode>
       ...
     </ojp:IndividualTransportOptions>
     <ojp:DepArrTime>2022-12-01T15:00:00Z</ojp:DepArrTime>
   </ojp:Origin>...
```

Figure 15 New trip search for the entire trip with desired mode at origin

Because in this case we may find routes which the user doesn't like to use, maybe he doesn't like it or just has not yet used the required app from the provider. To solve this issue, an approach is described above that lets the user select possible sharing operator first to narrow down and speed up the search with a following TCR.

With OJP 2.0, different modes at origin and destination can be requested. For shorter trips, a new mode option may be used to travel from origin to destination, without using any classical PT modes.

4.3 Repairing broken trip chains in case of given legs

Based on use case 3, we alternate the situation that the trip brakes, and a fix needs to be made (recalculating the trip).
The trip search starts the same after the estimation we get this trip:

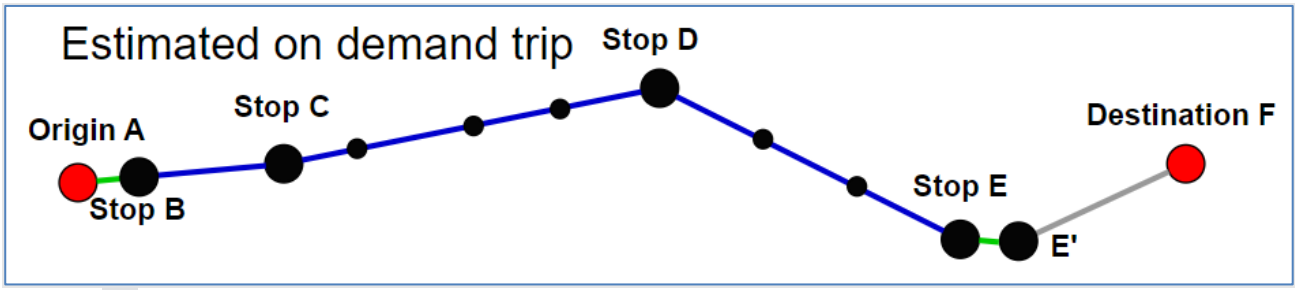

Figure 16 Estimated DRT trip

The user selects the trip out of several results, where then the estimated DRT service will be requested to make an offer. We assume that the information about the service in the OJP system was accurate, and the DRT service still offers a similar route and time information as estimated.

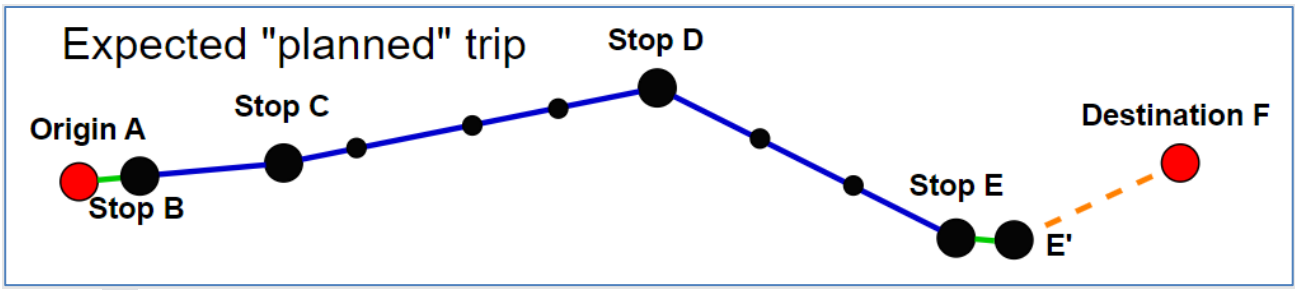

Figure 17 Refined DRT trip, not booked yet

Later the traveller starts the trip, he planned some hours ago. To start the journey, outside of OJP, he buys all the required tickets and makes a booking for the DRT leg. Now the DRT provider can no longer provide the route at the time the traveller requested an offer some time ago and therefore returns a slightly changed trip offer.

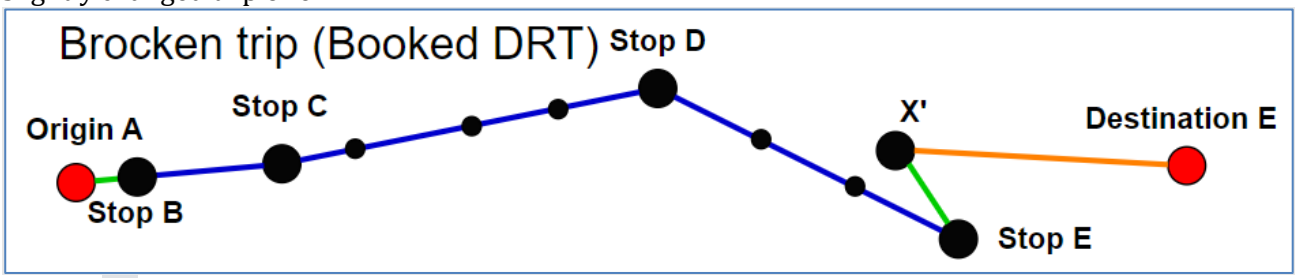

Figure 18 Broken trip by changed DRT leg

Since the walking leg from “Stop E” to the new pickup point “X’” is now much longer, the times previously calculated do not fit anymore. Therefore, the trip needs to be recalculated. The client application should now take the trip leg “X’” to “Destination E” as given and should recalculate only the rest of the trip with a TCR to fit the offer.
The whole trip has now two parts, the confirmed booking from the DRT service “X’” to “Destination E” and the part with the OJP trip information from “Origin A” over the PT stops “Stop B”, “Stop C”, “Stop D” to “Stop X” and a walking leg to connect to DRT pick-up point “X’”.
To fix the trip a recalculation “Origin A” to DRT pick-up “X’” is required. A TR will return the following:

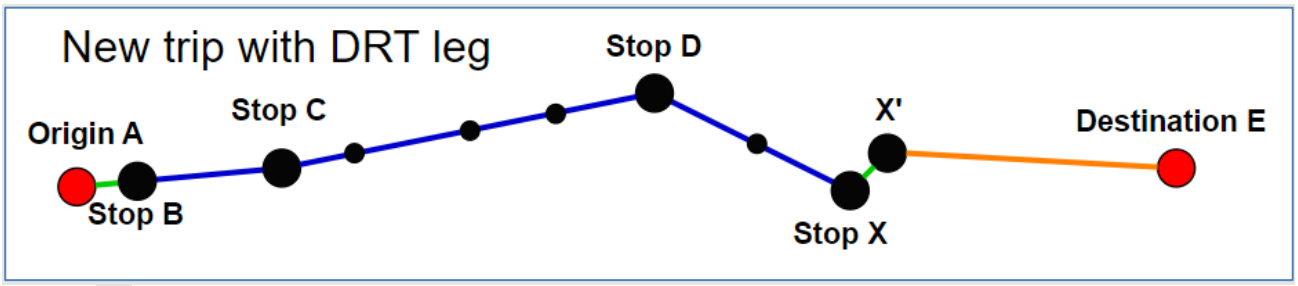

Figure 19 New DRT trip

In this example, the result changes the last stop of the PT trip to the new stop “Stop X”, which is closer to the new pick-up point “X’” from the DRT service. Now the traveller can buy the ticket and place the final booking.
This is just a simplified example, many other possible combinations can make up a whole trip, which include fixed trip legs which cannot be altered and should therefore not be part of a recalculation on a OJP service. Many other combinations and segmentation may be possible.

5 Abbreviations

A table with used abbreviations:

Abbreviation	Description
AOI	Area of interest, in this case the area to start or end the trip.
DRT	Demand responsive transport, a vehicle which can be ordered to pick-up somebody at a certain place and drop-off at another position. Depending on the organisation pick-up and drop-off may be predefined locations or any point along the road. The region of operation is predefined and DRT service can only operate inside the defined regions.
LIR	LocationInformationRequest, a OJP service which can deliver certain information about a position or a named object.
OJP	Open journey planner, is a European standard protocol for routing systems.
PT	Public transport, mostly the timetable-based modes of transport or other ways of transportation which is not based on rented or own vehicles.
TCR	TripChangeRequest, is a OJP service which allows to fix or update an existing trip with new information about transport in the first and last mile, based on a prior sent TR.
TR	The TripRequest is the OJP service to let a possible route be calculated from origin to a destination at a defined time. The time can be defined at departer or arrival.
TIR	TripInformationRequest, gives the most actual information on a PT leg depending on the JourneyReference
TRIAS	Travellers Realtime Information Advisory Standard which represent standard VDV 431 and is a predecessor of OJP.
TRR	TripRefinementRequest, to make real-time updates in a trip, without to call the router again. TIR only updates the journey with a reference and can't update any first to last-mile vehicles.
VDV	The Association of German Transport Companies (Verband Deutscher Verkehrsunternehmen VDV) is an active industry association for public transport - in dialogue with politics and business.