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D1.3: Graphical analysis interface of travel demand flows

Project acronym: TRANS-FORM

Project title: Smart transfers through unravelling urban form and travel flow dynamics

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Contents

1 Introduction

1.1 Deliverable and task objectives

This deliverable is the final outcome of Task 1.3. Visualizing the evolution of travel flows within WP1 Unravelling Form and Flow Dynamics. In the framework of this task, a graphical analysis tool is developed to enable the visualization of travel flows at different network layers and analyse how they evolve. Moreover, a live map will display a range of travel flow characteristics and produce statistics and graphs through a user interface. The graphical tool will be instrumental for understanding system dynamics, support researchers in scenario design and discussions with stakeholders by conveying current conditions and the implications of alternative scenarios.

1.2 Background

There was an initial approach of the graphic tool at the beginning of task 1.3 (more detailed info available at Appendix section of this deliverable), that is to say, before IBM partner withdrawal of the consortium on the 29th August 2017. IBM decided to withdraw from the project consortium when its main researcher left the company. Then, ETRA team analysed the situation and the status of the API developed by IBM and prepared a comprehensive report, explaining what ETRA could do with it in order to successfully achieve the project objectives. Among other issues reported, an important one was that the server was placed at the facilities of a partner that is not in the consortium anymore, on an infrastructure on which no partner has control nor the possibility to handle and solve incidences. Furthermore, there was no possibility to batch-insert data or pre-process it. To that end, ETRA assumed the responsibility of the takeover of the analytics and visualization tool as a whole, as agreed in a consortium meeting (The Hague, 24th October 2017). Thus, this deliverable describes the Graphical Analytics Tool designed and developed by ETRA according to that agreed approach.

1.3 Tool Stakeholders

The main stakeholders of the graphical tool will be transport researchers and public transport operators or authorities; and their professional profile could be either a Transport Expert or a Transport Corporate Manager.

1.4 Tool Users

The graphical tool counts with different user profiles, such as the Tool Manager (the one who will configure the tool according to user requirements) and the Tool Operator (the one who will operate it in a normal basis).

1.5 Tool Scope

The Graphical Analytics Tool is an interactive graphic tool. The tool enables the upload of passenger and transport network data from other sources (with a structured format), represents geographically the data in a live map, transforms this data into OD Matrices, represents other types of graphs, and finally exports the resulting data and data representation.

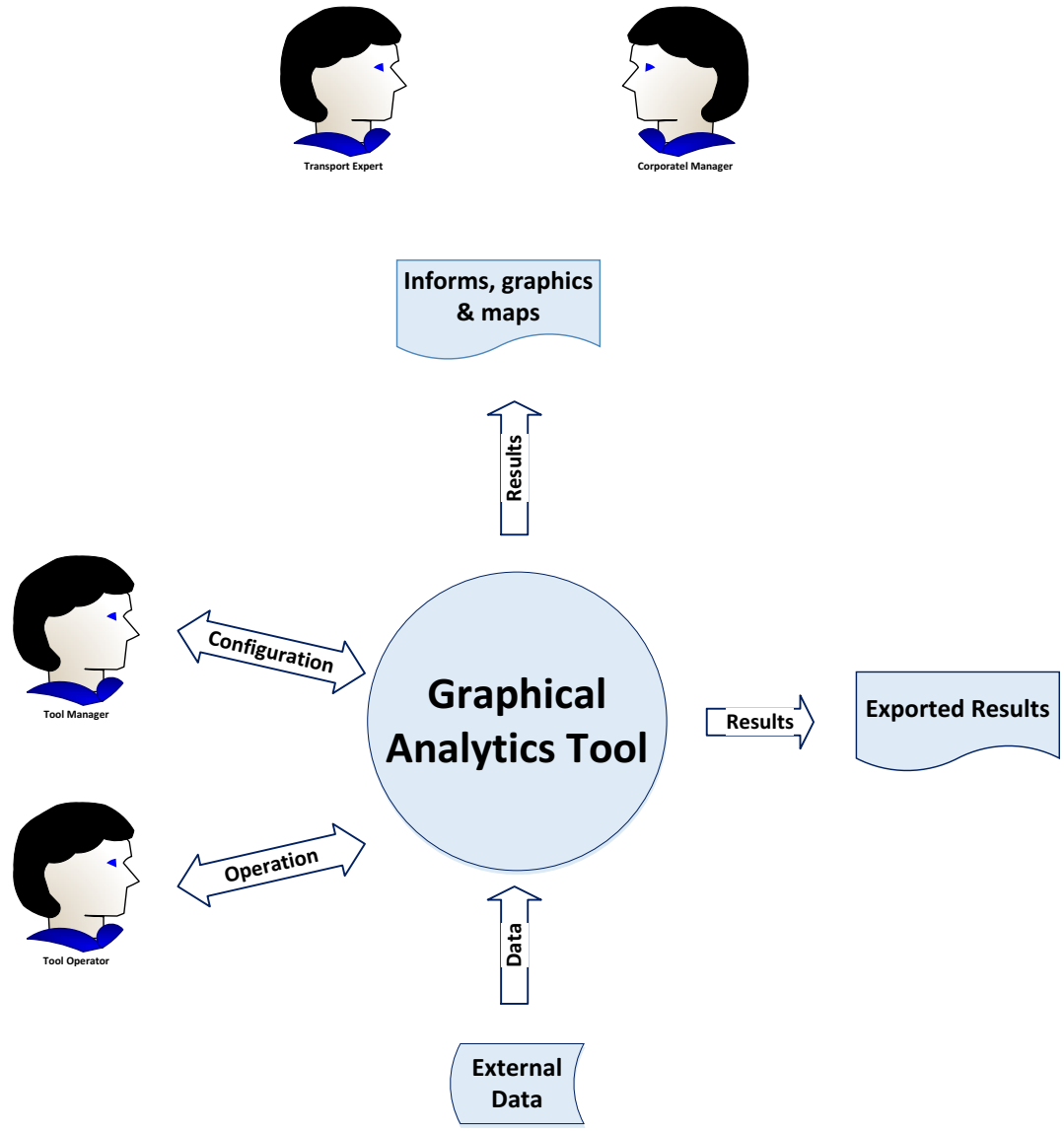

Figure 1. Scope of the tool

There are two kinds of user role: Tool Manager and Tool Operator. Tool Manager manages users and tool configuration. Tool operator works with the tool according to users' configuration.

1.6 Conceptual Model

The Graphical Analytics Tool imports passenger data from external applications. This data is transformed in a common Data Model and stored in a Data Base.

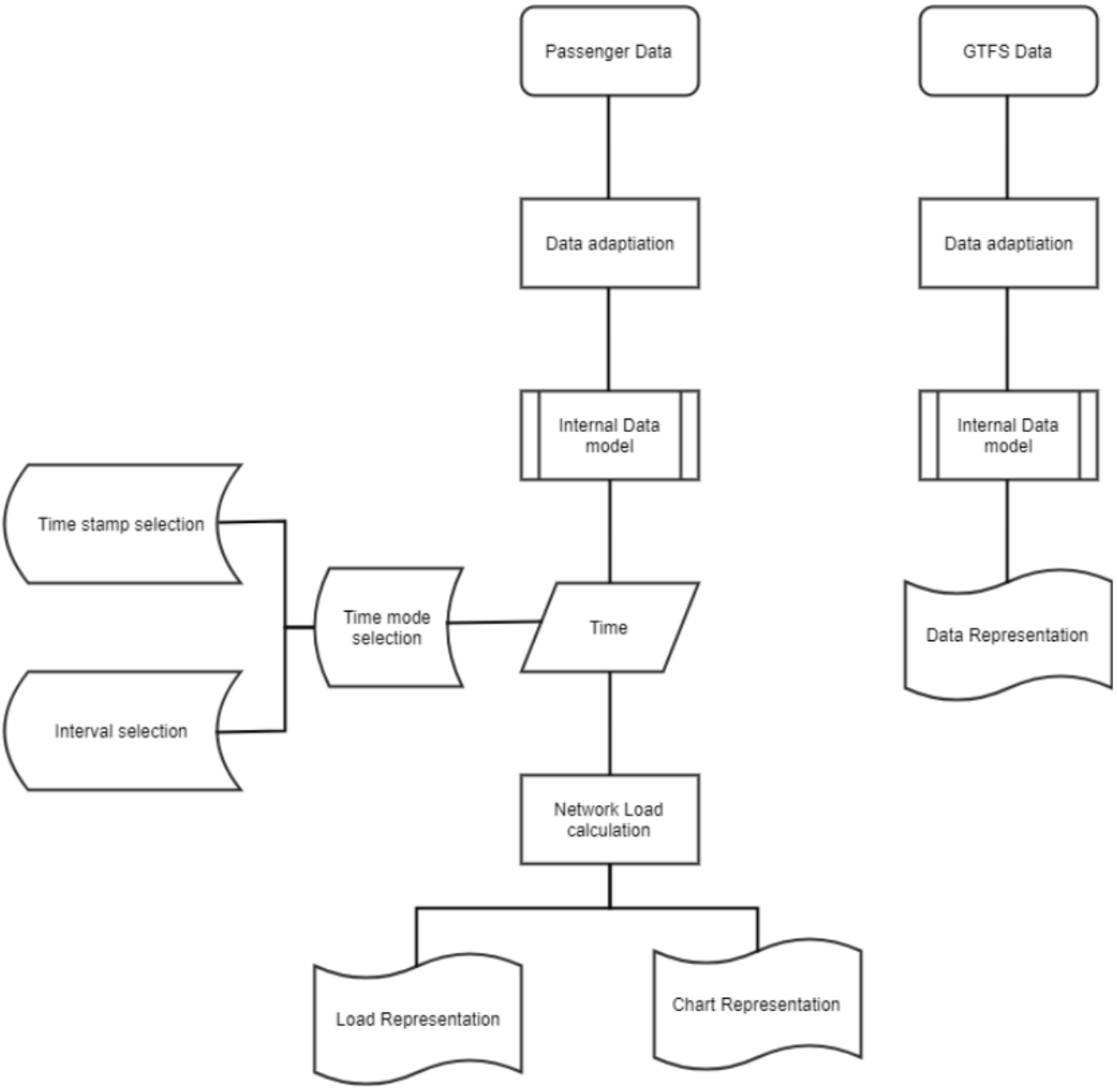

Figure 2 Work Flow Diagram

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2 User requirements and use cases

2.1 Methodology

The process to derive the user requirements and then get the use cases for the Graphical Analytics Tool was structured as explained below.
First, the objectives set for the tool were discussed among the project partners, based on the description of Task 1.3. Visualizing the evolution of travel flows.
Then, an open discussion process was initiated with the three different leaders of the study cases within the project, in order to derive a primary set of high level requirements for the tool to be designed and developed by ETRA, but according to their different needs and particularities in each level (hub, urban and regional), always bearing in mind the public transport operator perspective.
Last but not least, a list of use cases for the tool was elaborated in order to fulfil the user requirements collected during the previous step. The use cases were classified according to their features, that is to say, they were codified and clustered.

In the next subsection, the outcome of this process is showed with detail.

2.2 Outcome

Below one can find the different use cases for the Graphical Analytics Tool (19 in total), with useful information such as: the cluster they belong, the use case description, the actors involved, pre and post-condition for the use case and the priority of the use case.

M.P01	***User moves map dragging with the mouse and with keyboard arrows***
Cluster	*Map*
Classification	*Primary use-case*
Description	*The user can move around the map dragging with the mouse and pressing the arrow keys. Everything loads accordingly.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	*A user needs to move his/ her focus of interest to another area of the map*
Pre-condition	*System loaded*
Post-condition	*All layers reload accordingly.*
Priority	*High*

M.P02	*User select the layers to be shown*
Cluster	*Map*
Classification	*Primary use-case*
Description	*The user can select which layers to be shown among routes, trips, stops, load segments, hubs and feeds*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	*A user needs to stablish the layer to be shown in the map*
Pre-condition	*System loaded, layer to choose is inbounds.*
Post-condition	*The layer is shown or hidden when clicked.*
Priority	*High*

M.P03	*User selects which map layout to show among multiple options*
Cluster	*Map*
Classification	*Primary use-case*
Description	*The user can select different layouts to show for the map, like traffic, light layout or others.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*System loaded*
Post-condition	*The layout changes accordingly.*
Priority	*Medium*

M.P04	*User zooms map with display buttons or mouse wheel*
Cluster	*Map*
Classification	*Primary use-case*
Description	*The user can change the map zoom with the wheel or using the +,- buttons on the display.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	*A user needs to zoom in or zoom out in the map*
Pre-condition	*System loaded, zooms are not in the limits*
Post-condition	*Map gets smaller or bigger accordingly, new layer elements load if necessary.*
Priority	*High*

M.P05	*The map shows all kinds of elements with the current status regarding the selected date and time*
Cluster	*Map*
Classification	*Primary use-case*
Description	*All the elements that are visible automatically in the bounds of the map are shown with different colours and other styles.* - *Routes* - *Trips* - *Stops* - *Load Segments* - *Hubs* - *Feeds*
Actors involved	*Tool Manager*
Triggering Event	
Pre-condition	*System loaded, elements in bounds*
Post-condition	*Elements are displayed on the map*
Priority	*High*

M.P06	*Elements are displayed only between certain zoom levels*
Cluster	*Map*
Classification	*Primary use-case*
Description	*Each of the elements have an option showing between which zoom levels the elements are displayed. If the map is not between these levels, the element is hidden and not selectable in the layer button. The element will appear if the zoom falls into the bounds.*
Actors involved	*Tool Manager*
Triggering Event	
Pre-condition	*System loaded, elements in bounds.*
Post-condition	*Elements hide if zoom out of bounds, elements appear if zoom in bounds.*
Priority	*Medium*

ME.P01	The user can set the pointer over any element to get information
Cluster	Map Elements
Classification	Primary use-case
Description	The user will get a tooltip when hovering any element (route, stop, load segment, trip, hub or feed) with information about name, domains, location, load if applicable, etc.).
Actors involved	Tool Manager, Tool Operator
Triggering Event	A user needs detailed information over one element.
Pre-condition	There are elements on screen, the mouse is over one of them.
Post-condition	A tooltip appears showing information.
Priority	High

ME.P02	The user can select any element to get information on a sidebar
Cluster	Map Elements
Classification	Primary use-case
Description	The user can click on any element and a sidebar, on the right side, will appear showing real time information until closed.
Actors involved	Tool Manager, Tool Operator
Triggering Event	A user needs more information over one element.
Pre-condition	There are elements on screen, the mouse is over one of them, the user clicks.
Post-condition	A side bar appears on the right with information.
Priority	High

SB.P01	*The sidebar shows basic information of the selected element*
Cluster	*Map Elements*
Classification	*Primary use-case*
Description	*The sidebar shows at the top part basic information, which has to match the information provided in the tooltip.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	*A user needs more information over one element.*
Pre-condition	*An element is selected and the sidebar visible.*
Post-condition	*Information is printed on the top of the sidebar.*
Priority	*High*

SB.P02	*The sidebar can be closed*
Cluster	*Map Elements*
Classification	*Primary use-case*
Description	*The sidebar has a cross to close it, which will deselect the current selected element and hide the sidebar.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An element is selected and the sidebar visible.*
Post-condition	*The selection becomes empty and the sidebar closes.*
Priority	*Medium*

SB.P03	*The sidebar shows one or more linear maps*
Cluster	*Map Elements*
Classification	*Primary use-case*
Description	*If an element with routes is selected, a linear map appears showing the position of the trip and stops in real time. Clicking on the stops or the trip will focus on the clicked element.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An element with a related route is selected and the sidebar visible.*
Post-condition	*A linear map with real time positions is displayed.*
Priority	*High*

L.P01	Segments will show the load with a green-red gradient colour
Cluster	Map Elements
Classification	Primary use-case
Description	The routes are divided in segments between stops. This segments have a colour between green and red that shows the load ratio (average if there are more than one trip there) given the total capacity and the absolute load of the trip at that time, between the specified stops. If load is 0, the segment will be grey. The last load will be kept until a new trip appears.
Actors involved	Tool Manager, Tool Operator
Triggering Event	
Pre-condition	Load data is available at the displayed routes.
Post-condition	Segments with gradient colours are visible showing the load.
Priority	High

L.P02	Trips will show the load with a green-red gradient colour
Cluster	Map Elements
Classification	Primary use-case
Description	The routes are divided in segments between stops. This segments have a colour between green and red that shows the load ratio given the total capacity and the absolute load of the trip at that time, between the specified stops. If load is 0, the segment will be grey. The last load will be kept until a new trip appears.
Actors involved	Tool Manager, Tool Operator
Triggering Event	
Pre-condition	Load data is available at the displayed routes.
Post-condition	Segments with gradient colours are visible showing the load.
Priority	High

TM.P01	*User Selects a Date*
Cluster	*Time Management*
Classification	*Primary use-case*
Description	*A user can select a date among the ones with data in a calendar.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The date has data*
Post-condition	*The map reloads with the date selected data.*
Priority	*High*

TM.P02	*User selects a time from input*
Cluster	*Time Management*
Classification	*Primary use-case*
Description	*A user can select a time "HH:mm:ss" from an input that shows the current time.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*A date is loaded, time is paused.*
Post-condition	*The slider changes the position, trips move.*
Priority	*High*

TM.P02	User selects a time from a slider
Cluster	Time Management
Classification	Primary use-case
Description	A user can select a time in a slider that represents an entire day
Actors involved	Tool Manager, Tool Operator
Triggering Event	
Pre-condition	A date is loaded, time is paused.
Post-condition	The input changes time depending on the slider position, trips move.
Priority	Medium

TM.P03	User can stop and start time
Cluster	Time Management
Classification	Primary use-case
Description	A user can stop the time or resume it, and trips react accordingly.
Actors involved	Tool Manager, Tool Operator
Triggering Event	
Pre-condition	Date is loaded.
Post-condition	Trips stop or resume accordingly, time flows or stops.
Priority	Medium

TM.P04	User can change time speed
Cluster	Time Management
Classification	Primary use-case
Description	A user can change how fast time moves, being x1 normal time.
Actors involved	Tool Manager, Tool Operator
Triggering Event	
Pre-condition	Date is loaded, time is running
Post-condition	Trips change speed of movement according to the flow of time.
Priority	Medium

TM.P05	*User can change time in hourly steps*
Cluster	*Time Management*
Classification	*Primary use-case*
Description	*A user can advance to next o'clock hour, or previous one.*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*Date is loaded*
Post-condition	*Trips change like if time input changed, time input and slider change accordingly.*
Priority	*Medium*

3 Graphical Analytics Tool design

3.1 Architecture

Graphical Analytics Tool is a web application with a client side and a server side that it is implemented and installed locally on the needed infrastructure. It feeds on CSV data supplied by the operator locally to represent data maps.
The operator will get a virtual machine installed with all the required appliances, and ready to use. This virtual machine (VM) can run in one-pc environment, or in an intranet or local network environment, depending on the needs of the operator.

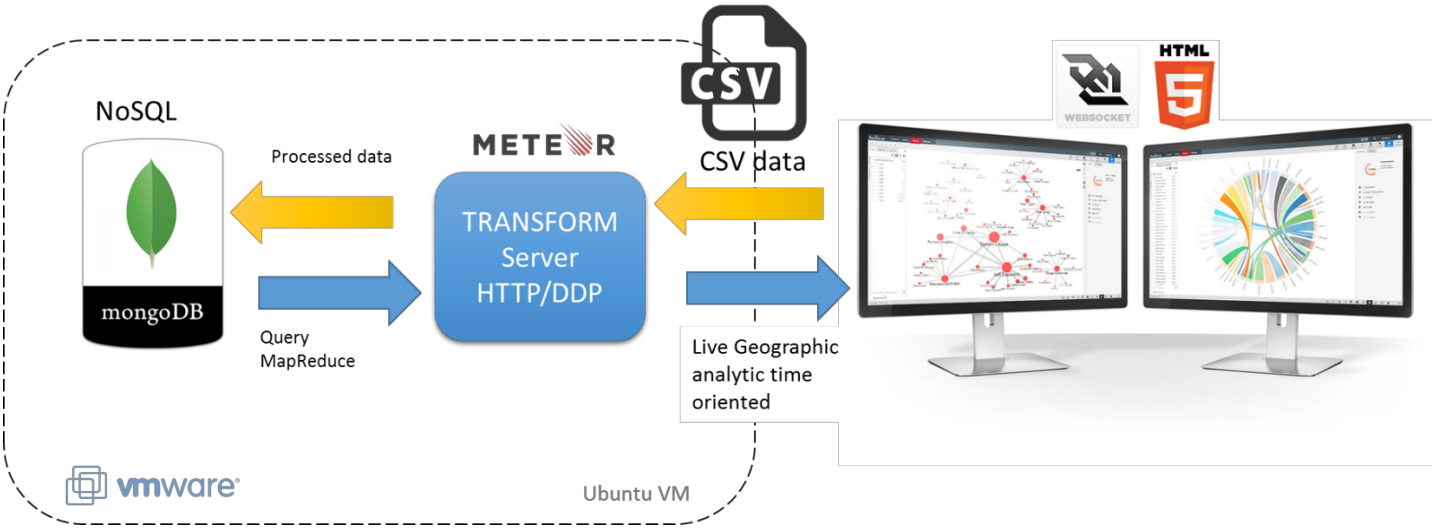


Figure 3 Graphical Analytics Tool architecture representation

The tool is based on 3 main services that communicate together:

- **Database:** MongoDB is used, which is a noSQL database system. MongoDB is based on collection/document system. Collections are a group of documents, they can be considered arrays. Documents are a set of keys and values. Values can be anything, from plain strings to complex objects. Documents can be considered objects, and they are the elements of the arrays. The Graphical Analytics Tool database system is a complex indexed set of information from two sources: ticketing information and GTFS information.
- **Server:** The server (as well as the client) is part of a Meteor application. The server side consists of a set of methods that queries the database, process the data and returns the requested information to the client. The data is GTFS information and live geographic analytic time oriented data.
- **Client:** The client is the other part of the Meteor application. This side displays a map with the queried GTFS information and allows all the user interaction and information. The client also has a settings section where CSV files with the information can be upload, transferred to the served and processed to the database.

3.2 Infrastructure

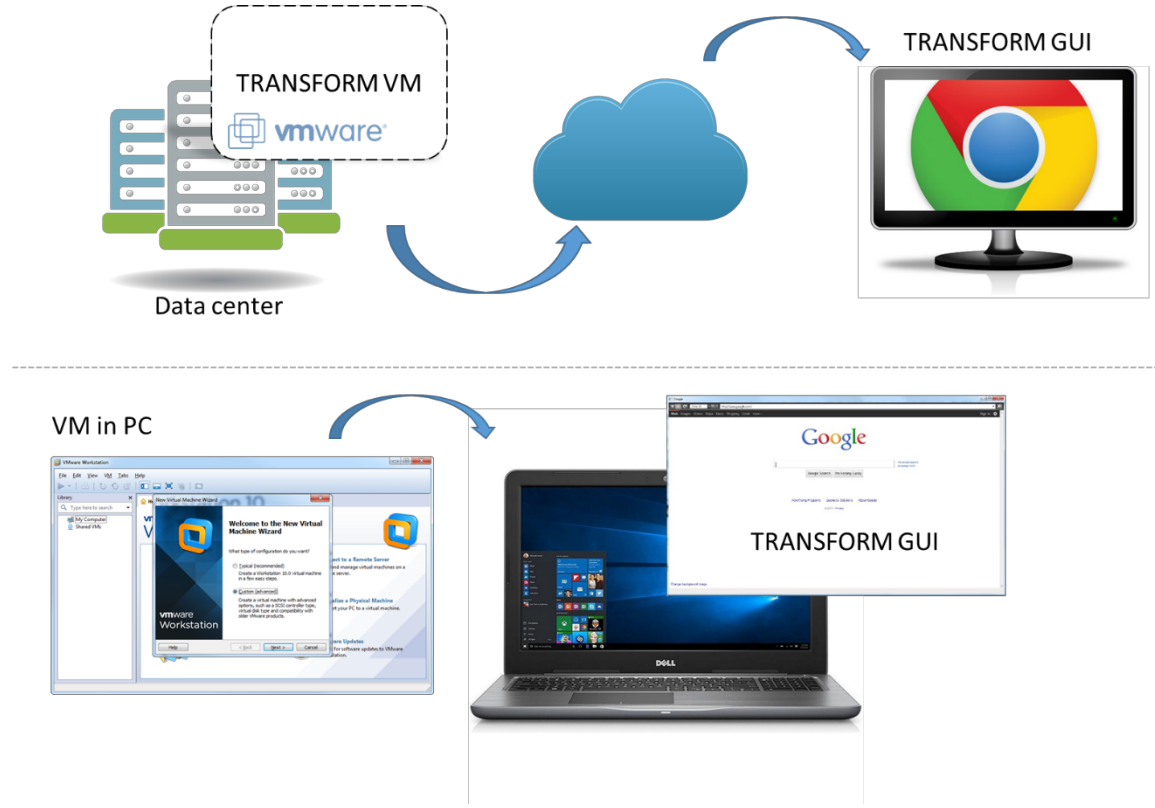


Figure 4 Architecture and installation

The application resides in a virtual machine (VM) that can be easily moved and integrated in any platform. The virtual machine is installed in a single PC, from which the web application will be accessed from a web browser, or it can be installed in an intranet/local network, so the application can be accessed from a web browser at any pc connected to the local network. In this case, data is shared among all the devices connected to the local network. No further configuration is needed, just the installation of a virtual machine. That virtual machine is pre-configured in advanced, and that is why no other configurations in target system are required.

4 Graphical Analytics Tool user manual

4.1 Regional/Urban Level

4.1.1 Types of data displayed

The regional level of the tool displays two types of data

- GTFS Data:
  - Feeds: The areas that have data, which are domains of an operator.
  - Routes: The vehicle paths.
  - Trips: The vehicle journey in a specific time. A vehicle does many trips. Trips display the vehicle position at the selected date and time.
  - Stops: The points in the map where passengers get on and off, and where vehicles may stop for a short time.
- AFC Data:
  - Load Segments: Routes are coloured in a green-red gradient depending on the passenger load ratio, given by the absolute load of the vehicle and its total capacity. This is the main representation of the load in the transport network.

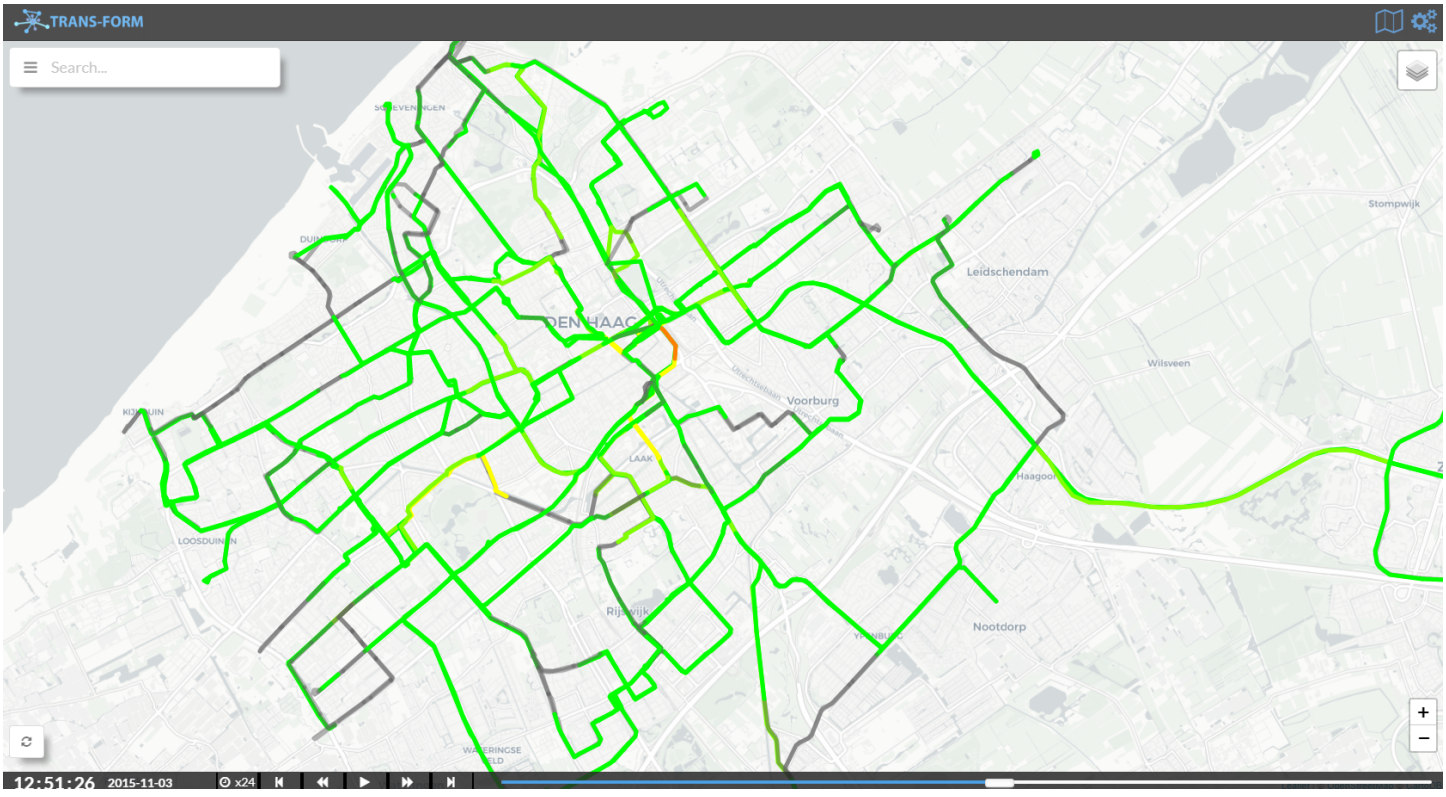


Figure 5 Network Load with segments in The Hague

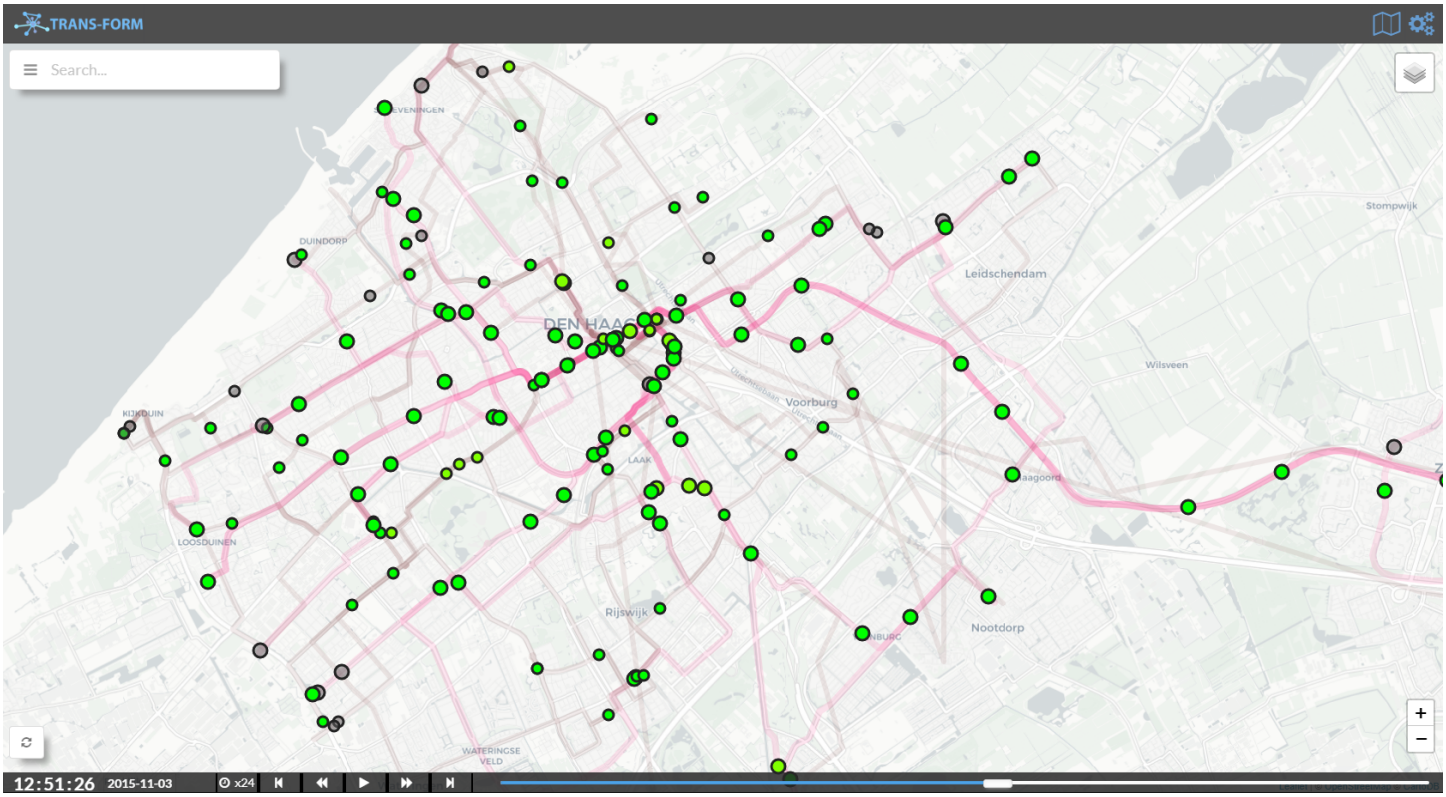


Figure 6 Trips and the load with colour in The Hague

The time selected will be stored in the local machine.

There are two types of time selection:

- Timestamp: a single time is selected. The network shows the load (or load averages) at that selected moment. There is one handle to select the time in that day, and also a time input.
- Time interval: the network shows the average of all the loads of the trips inside a time interval in a single day. There are two handles to select the initial and end times, and two inputs.

4.1.2 Charts features

Charts are also available to show the data in different ways to enable the analysis of stakeholders and the subsequent decision support. Charts allow showing intervals with initial and end times and dates. The Charts are a feature of time interval mode. They show OD data given a selection of stops on the map. Charts use the selection feature of the interval mode of the map.

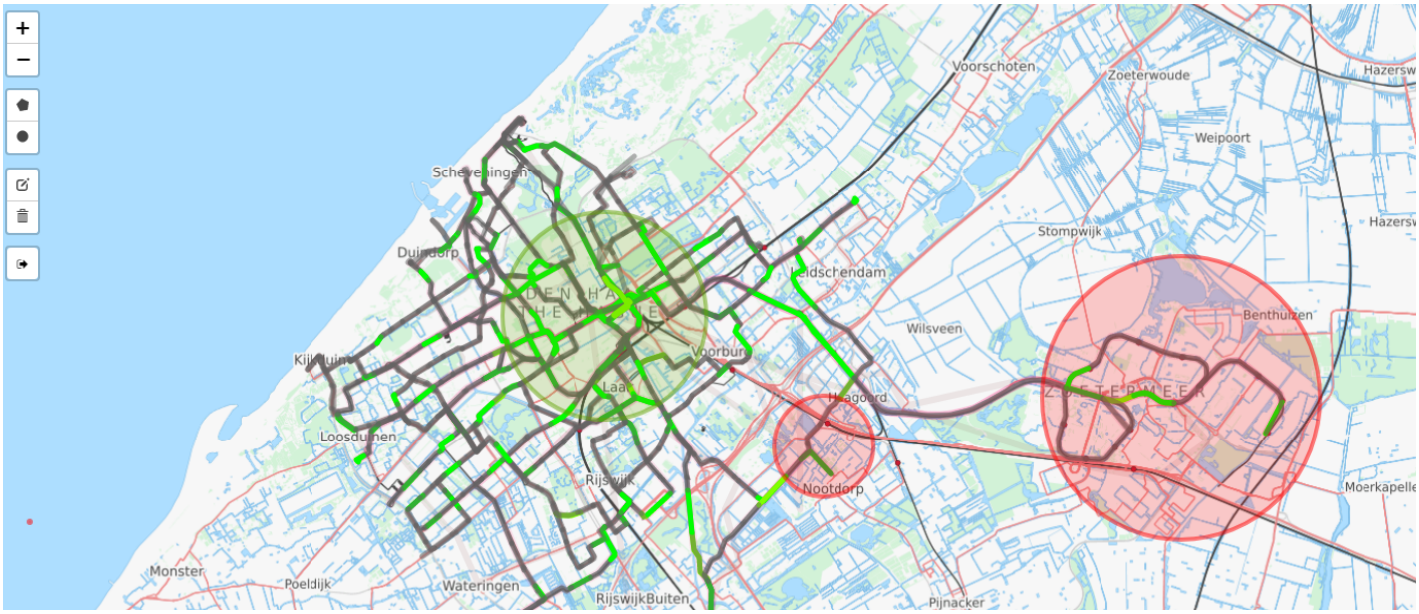


Figure 7 Area selection tool

The selection tool allows to select areas of the map (or a single stop) as origin, and other areas (or a single stop) as destination. The selection of the areas are used in charts as a filter for data. The OD Matrix will be scoped down to the green areas as origin stops (from), and the red areas as destination stops (to).

The selection tool allows the following actions:

⬟	Polygon: when clicked, draws polygons to select areas.
●	Circle: when clicked, draws circle to select areas.
✎	Edit: allows edition of already drawn areas.
🗑	Remove: allows removing some areas, or all of them.
➔	Mode: toggles between source (shapes are green) and target (shapes are red).

If no selection is done in origin, destination, or both, the OD Matrix will be calculated for all displayed stops in the map.

Once the selection is done, different types of chart can be selected to be displayed in an interval player:

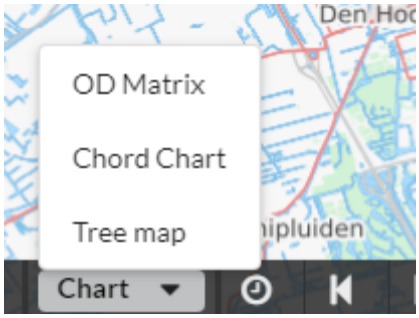


Figure 8 Chart type selection

The click of one of the options will show a modal with the chart inside.

There are 3 types of charts:

- *OD Matrix:* Displays a chart with origin stops on the X axis and destination stops of the Y axis, and a coloured rectangle with the amount of passengers in the graph.

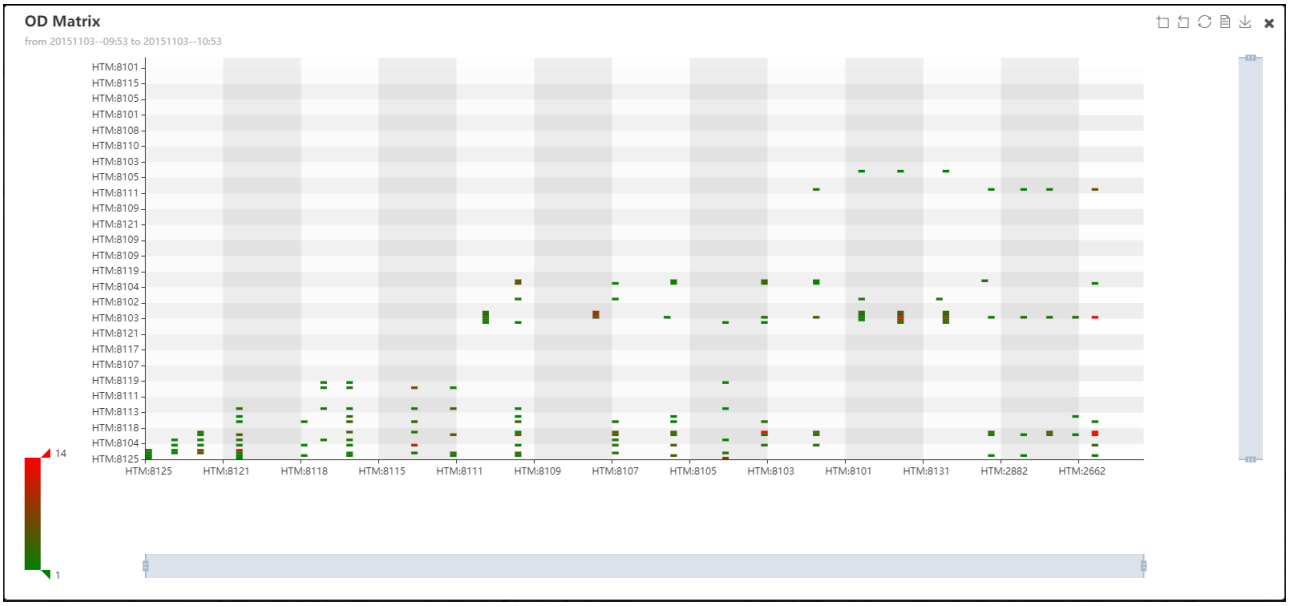


Figure 9 OD Matrix

- *Chord Chart:* Displays a circular graph with nodes as stops, which size and colours depends on the amount of passengers that go from that stop, and links to the stops with different thickness and colour depending on the amount of passengers that move from one stop to the other.

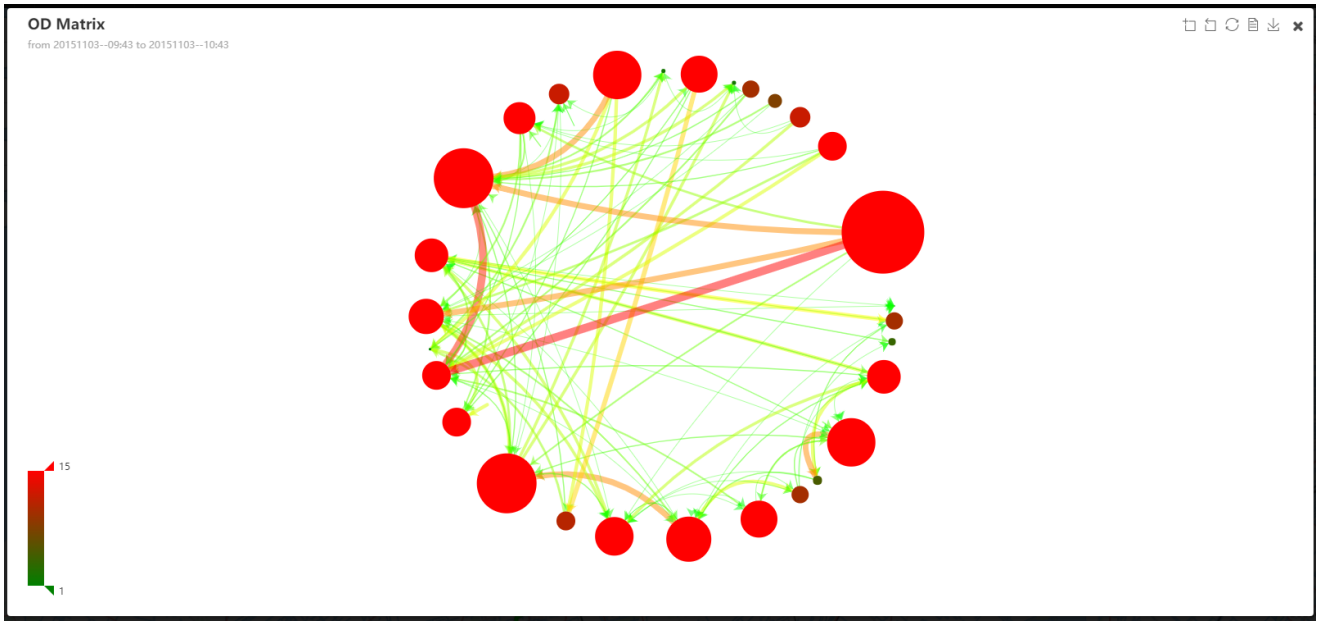
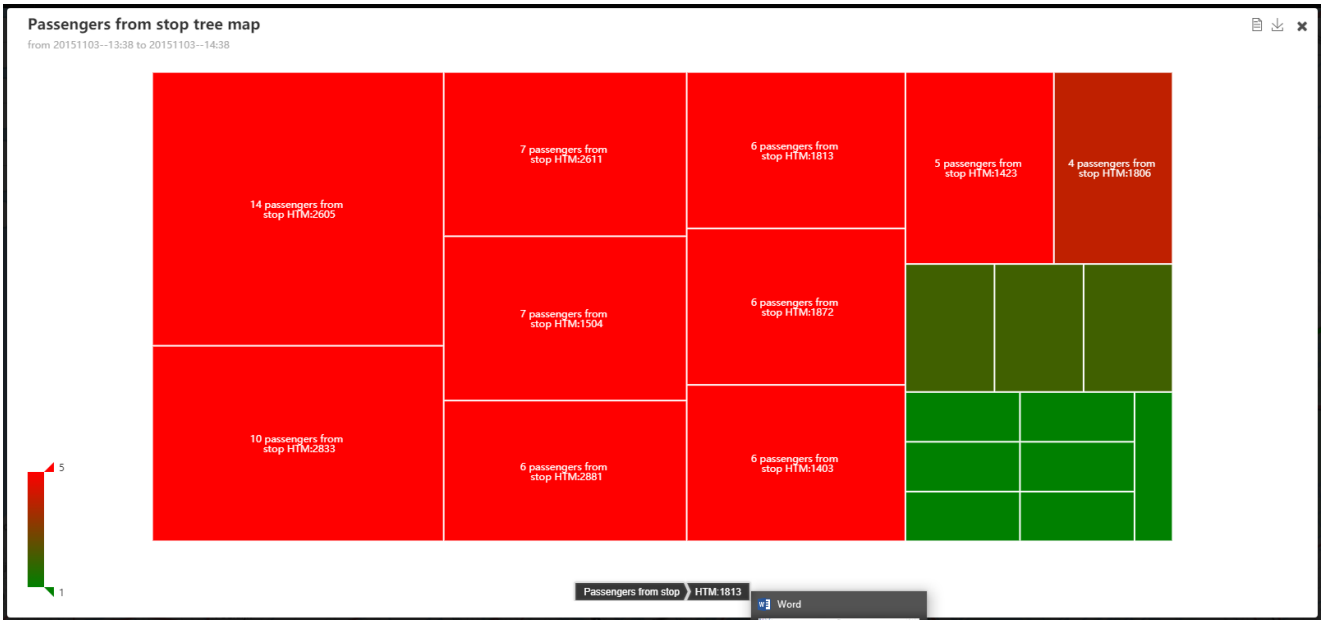


Figure 10 Chord Chart

- *Tree map:* Displays a tree map showing all the stops with a size and colour depending on the passengers that go from or to the stops.



4.1.3 Interface

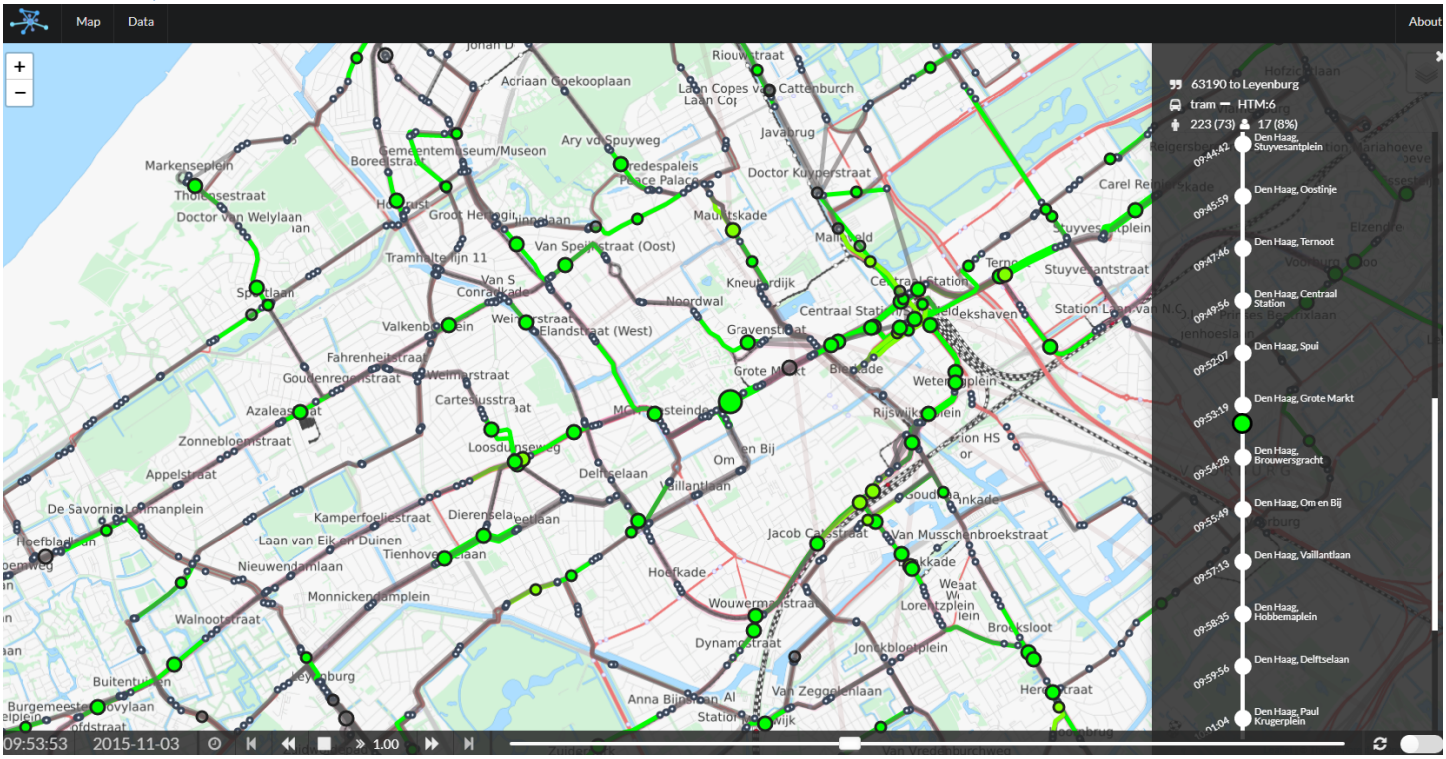


Figure 11 Main tool window

The tool contains only one window with the map showing all the features:

- The map shows different kinds of elements:

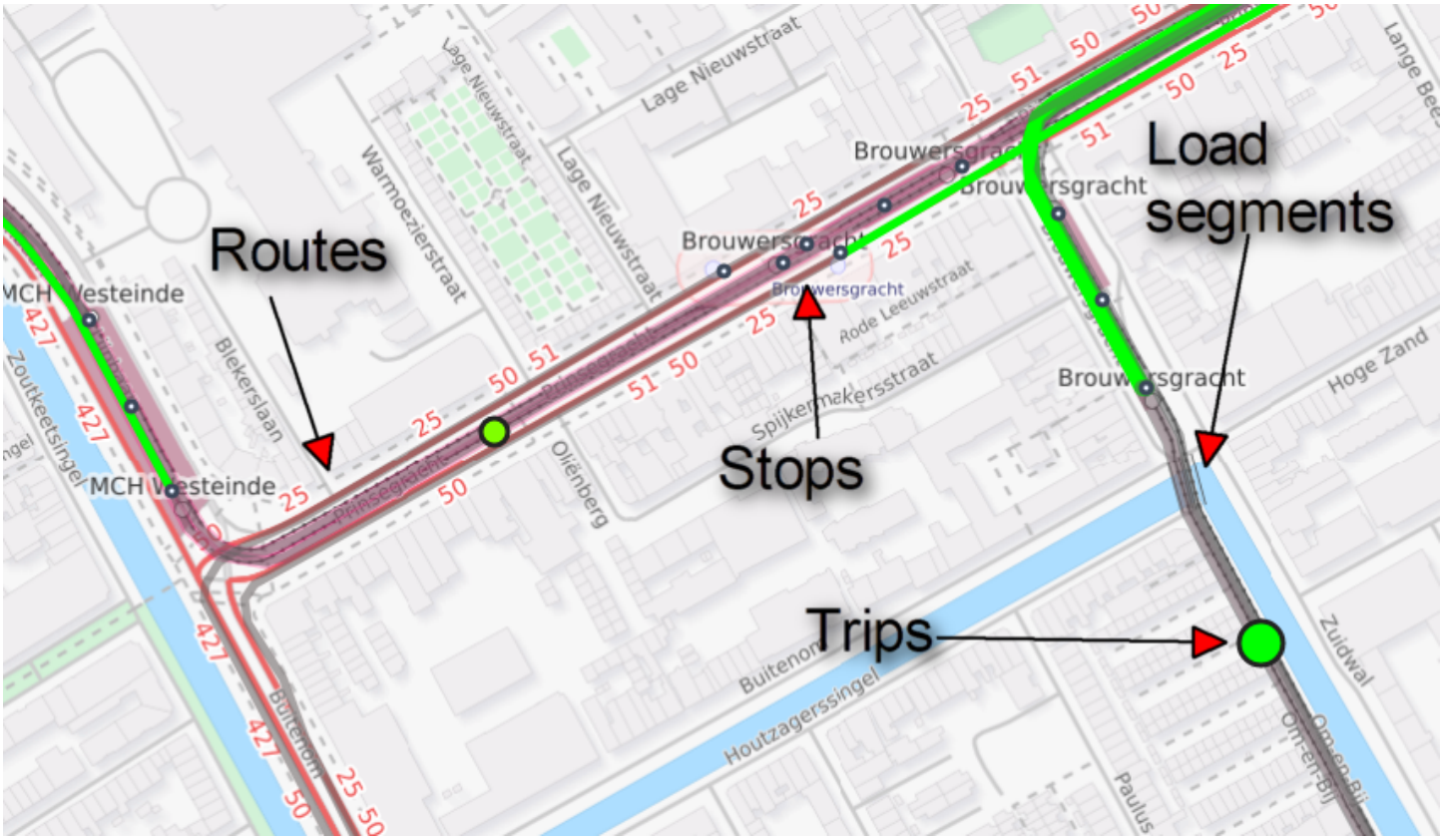


Figure 12 Elements shown in map

- *Routes: segments that describe a physical path, different colours depending on the route type (bus, train…)*
- *Trips: Circle that define a vehicle and its position at the selected time. It moves while time is running.*
- *Stops: Small grey circles displaying the position of the stops in the routes.*
- *Feeds: Circles that shows different domains. They are visible when zoom is low.*
- *Load Segments: red-to-green coloured segments that show the average load at that moment in that segment depending on the trips passing by at the selected time.*

- The top header bar contains the TRANSFORM Logo and buttons to access the different tool features:
  - *Map, the main window.*
  - *File Manager, to upload and manage data (AFC, GTFS files and others).*
- The right side shows a sidebar if an element is selected:

Figure 13 Stop selection, trip selection, and route selection

- *The top part contains a cross to close the sidebar (and deselect the element) and general information about the selected element, the same information as the tooltip.*
- *The rest of the space is to show specific information:*
  - *If a trip is selected, a linear map of the trip and the current position is shown.*
  - *If a route is selected, the linear map of that route with all the trips in it is shown.*
  - *If a stop is selected, all routes will be displayed in the shape of linear maps.*
- *All the information will show real time load information.*

- On the bottom part a player is found with the following features:
  - *Time: The time can be changed clicking on it, and it shows the current selected time. If the player is running, the time flows continuously in single player. Interval player has 2 time pickers.*
  - *Date: Same as the time. It shows the selected date and can be changed clicking on the day, month and year. When the date is clicked, the entire map reloads to show the new day status. Interval has 2 date pickers.*

- *Speed multiplier: How fast the time flows it can be set as a number bigger than one for faster times, and between 0 and 1 to make it slower than normal time. If clicked, it behaves as an input to select how fast the time goes.*
- *Player controls:*
  - *Play / Stop: Allows to pause or resume action in the map. To change time, the player needs to be stopped.*
  - *Backward / Forward: It moves to next o'clock hour for fast time switch.*
  - *Speed up / Speed down: Changes the time speed multiplier.*
  - *To Current Time: Goes to actual time.*
- *Time slider: it has one handler that can be dragged if the player is paused to change the time and see the flow at the desired speed while dragging it.*
- *If the mode is set to interval, 2 handles and 2 time inputs will appear to select a time range.*

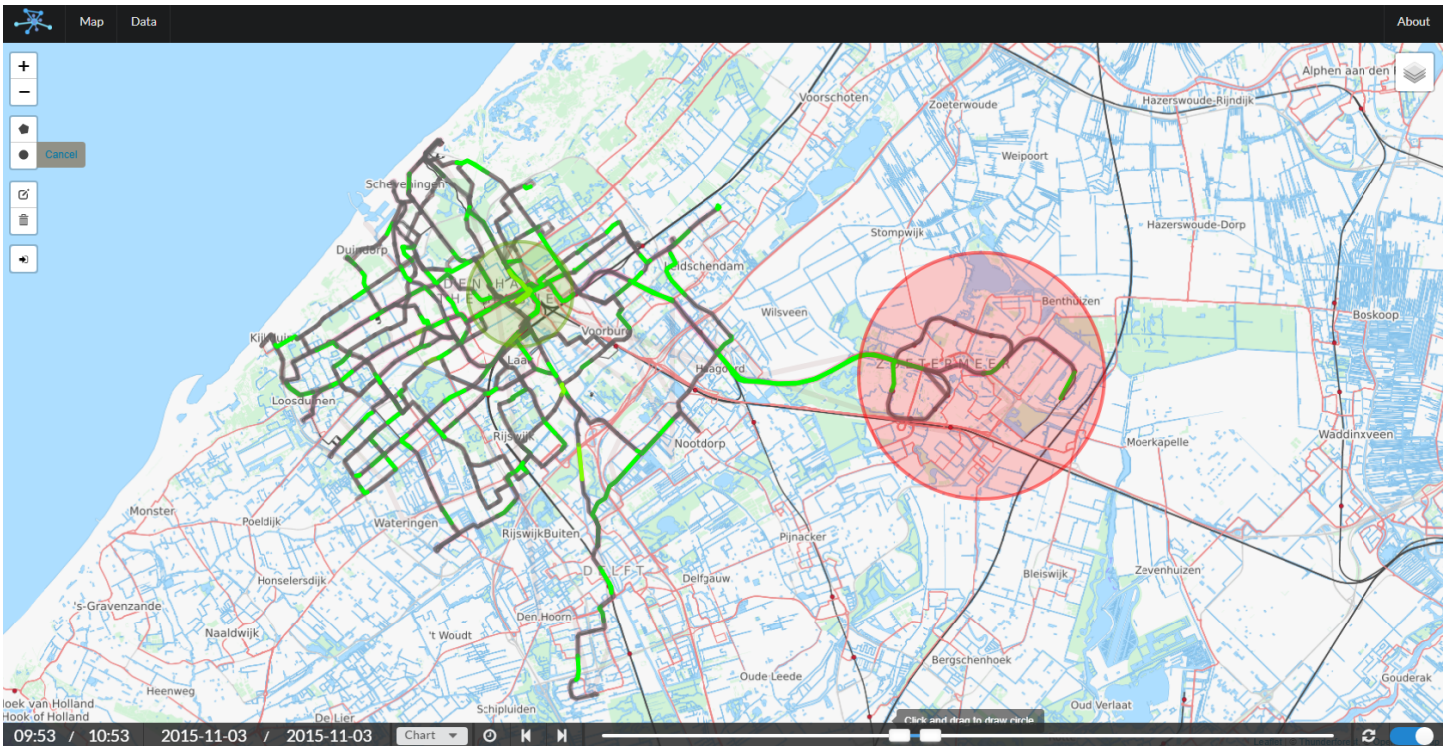


Figure 14 Interval mode

- *The interval mode has also a selection area feature, to select origin stops and destination stops for chart representation. The tool is explained in Charts section.*

4.2 Hub Level

4.2.1 Types of data displayed

*The Hub Level is a special case of visualization for stations. The data displayed comes from two sources_*

- *Blueprint data: Data to show the blueprint of the station. The source for Lausanne is a CAD by Ecole polytechnique fédérale de Lausanne. It shows in red the station blueprint, and in blue squares with black outline the different nodes where people comes from and goes to.*

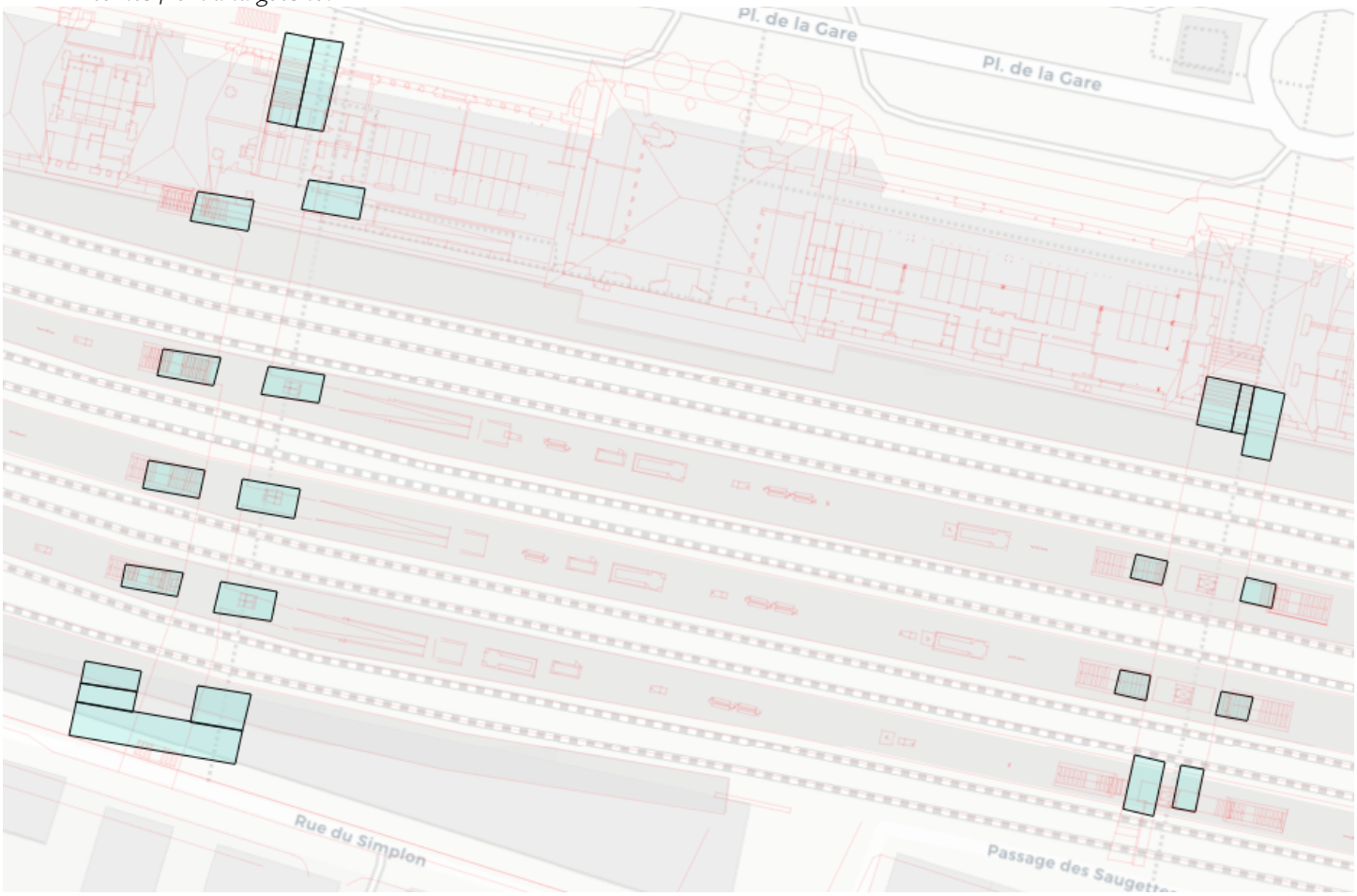


Figure 15Lausanne Blueprint station

- *Pedestrian trajectories data: Data to display the paths of each pedestrian crossing the station from one node to another. This data is provided for Lausanne by Ecole polytechnique fédérale de Lausanne. The data shows a trajectory of each individual pedestrian for single mode in real time, with red circles representing each person and blue lines for the trajectories. For interval mode, it shows the accumulation of pedestrians that follow similar trajectories. The thickness and colour of the trajectory represents the accumulation of pedestrians for it.*

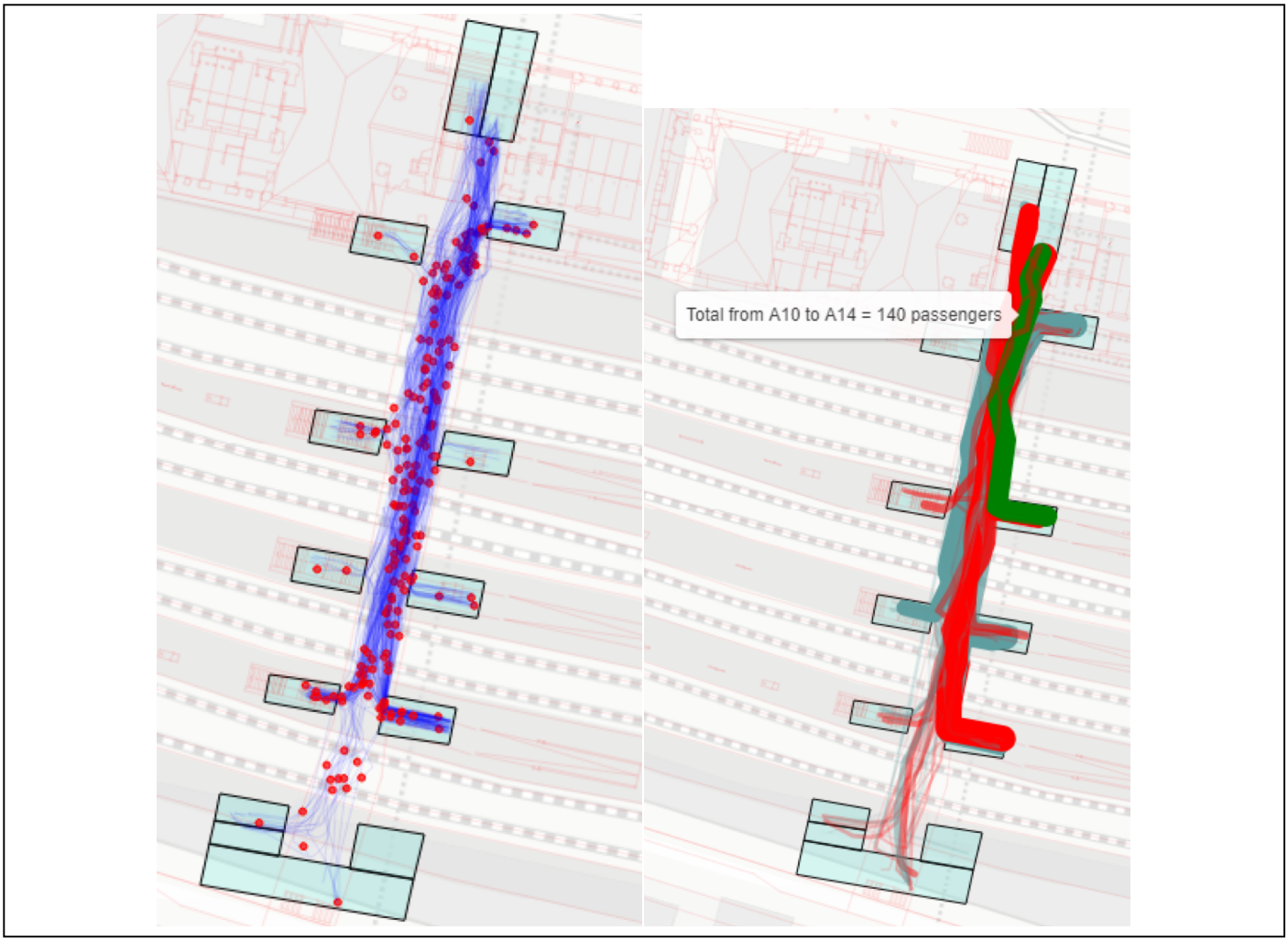


Figure 16 Single and interval trajectories

4.2.2 Charts features

The Hub level can display three types of charts, one for single mode and two more for intervalmode. Charts are available pressing a button display in the middle of the hub.

Figure 17 Chart button for hub mode

- *In single mode, the chart displayed is a timeline that shows the total amount of passengers per minute. It flows in real time.*

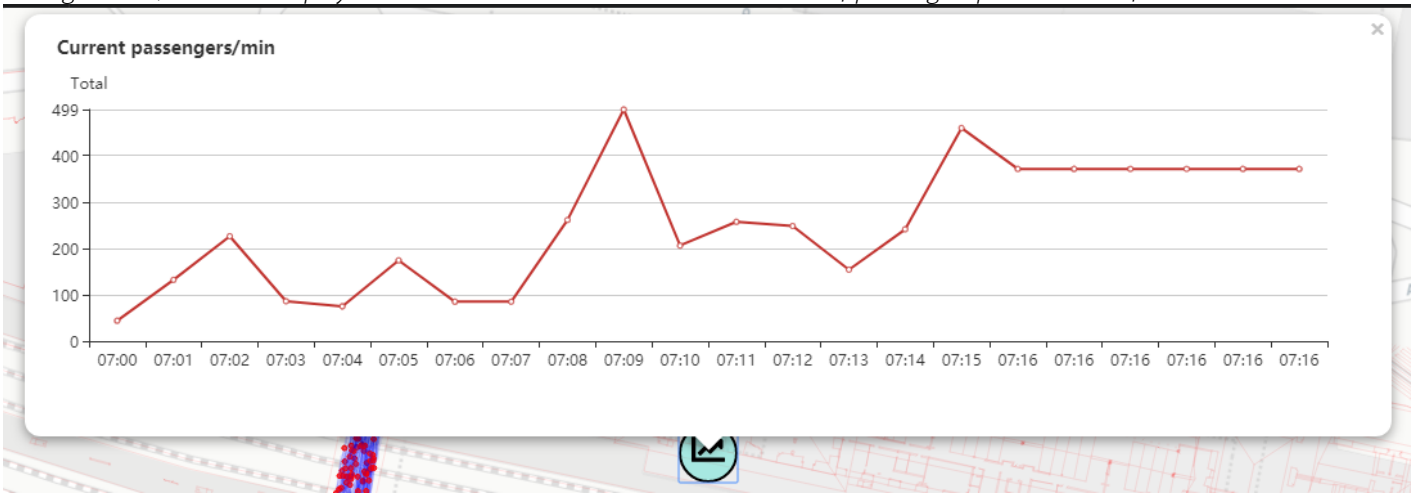


Figure 18 Single mode timeline chart for hubs

- *In interval mode, the chart represents the OD Matrix of passengers, displaying the amount of passengers that go from one node to another in the selected interval. This chart can be a Matrix or a Chord Graph.*

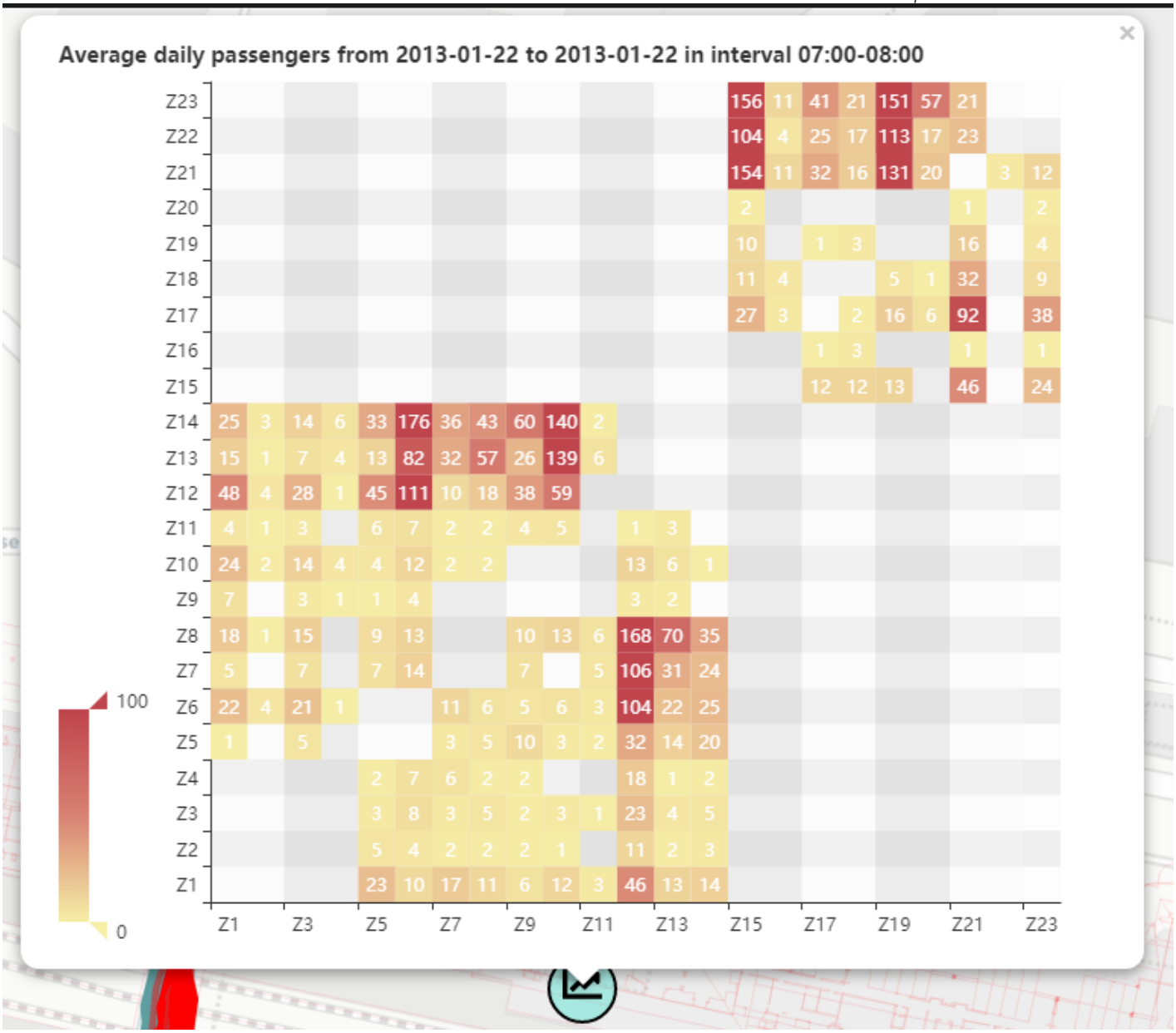


Figure 19 OD Matrix for hubs, interval mode

4.2.3 *Interface*

The tool interface is the same described in Regional/Urban Level for Hub Level.

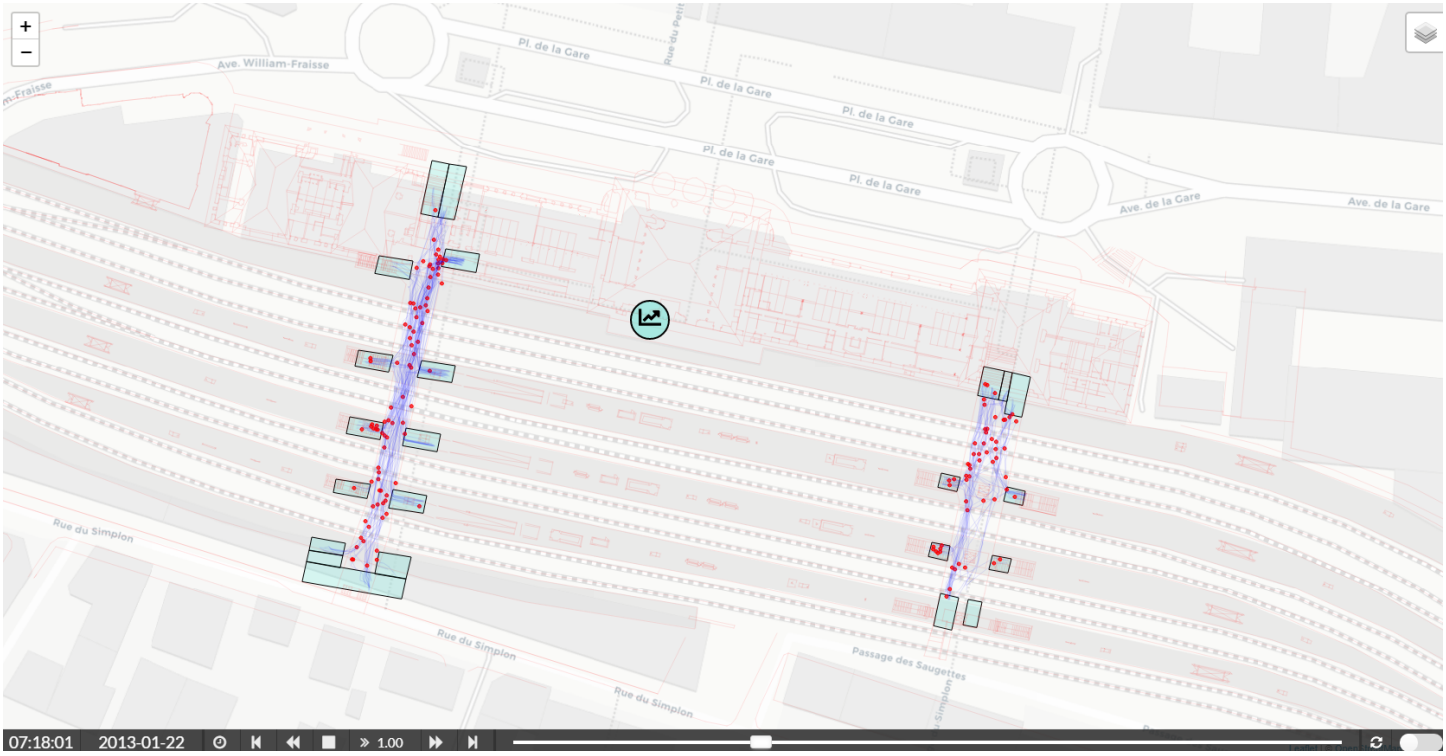


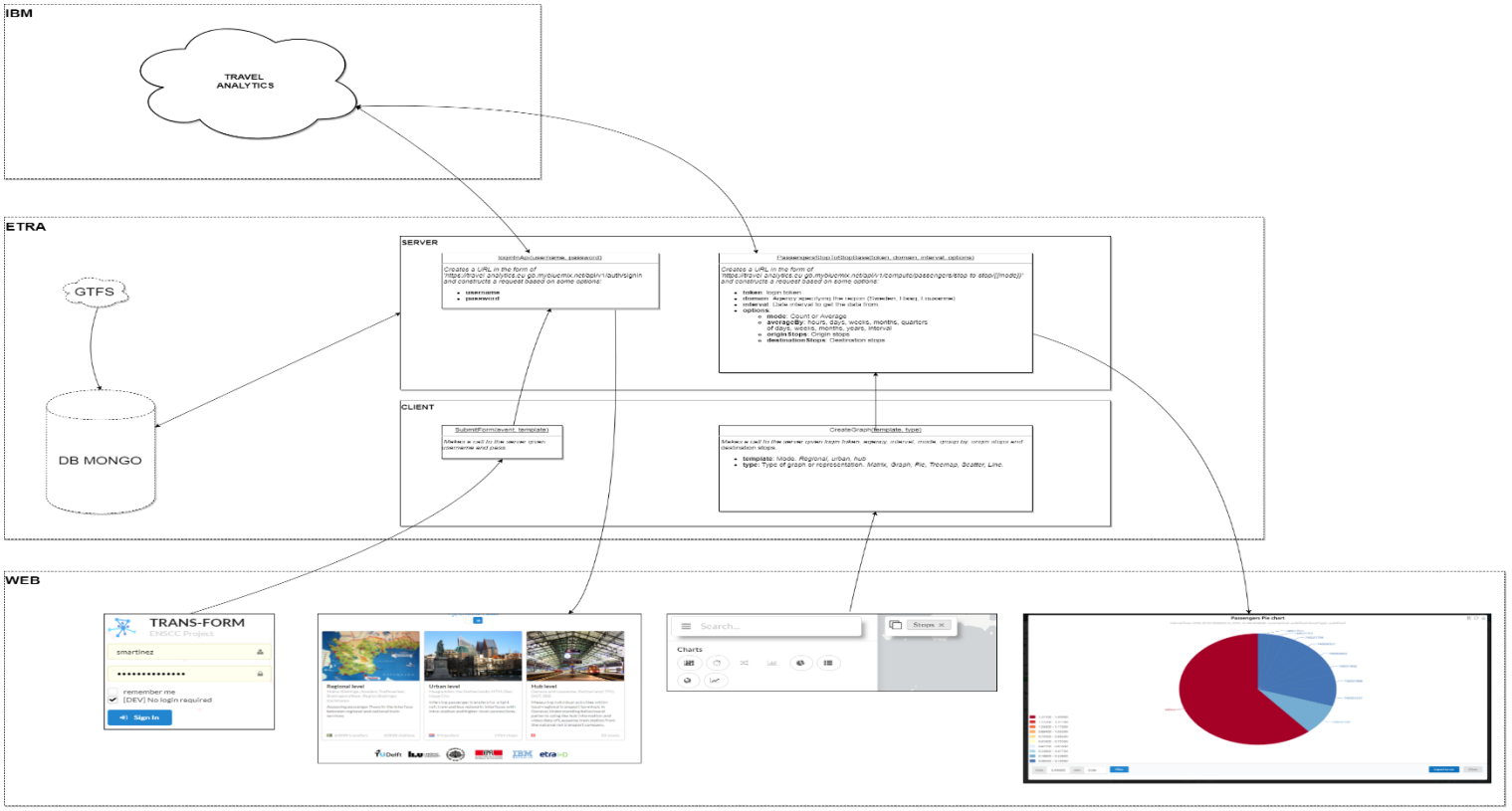
Figure 20 Hub Leve Interfacel

However, there are some small differences. The data represented is different, and it is explained in Section 4.2.1 and 4.2.2. There is no selection sidebar in this level, since there is no data to select in order to get more information. Available data can be shown by placing the mouse over the element. There is no selection for charts in this level, since charts in this level are global and available from a different source, explained in section 4.2.2.

5 Appendix: past developments

In this section additional information would be showed, basically those information related to the first approach of the graphic tool, that is to say, before IBM partner withdrawal of the consortium on the 29th August 2017. Thus, ETRA assumed the responsibility of the takeover of the analytics and visualization tool as a whole, as agreed in the consortium meeting at The Hague, the 24th October 2017 (as explained in the Introduction of this deliverable).

5.1 Visualization tool architecture diagram (before IBM withdrawal)



5.2 Conceptual Model (before IBM withdrawal)

The ODM tool imports passenger data from external applications. This Data is transformed in a common Data Model and stored in a Data Base.

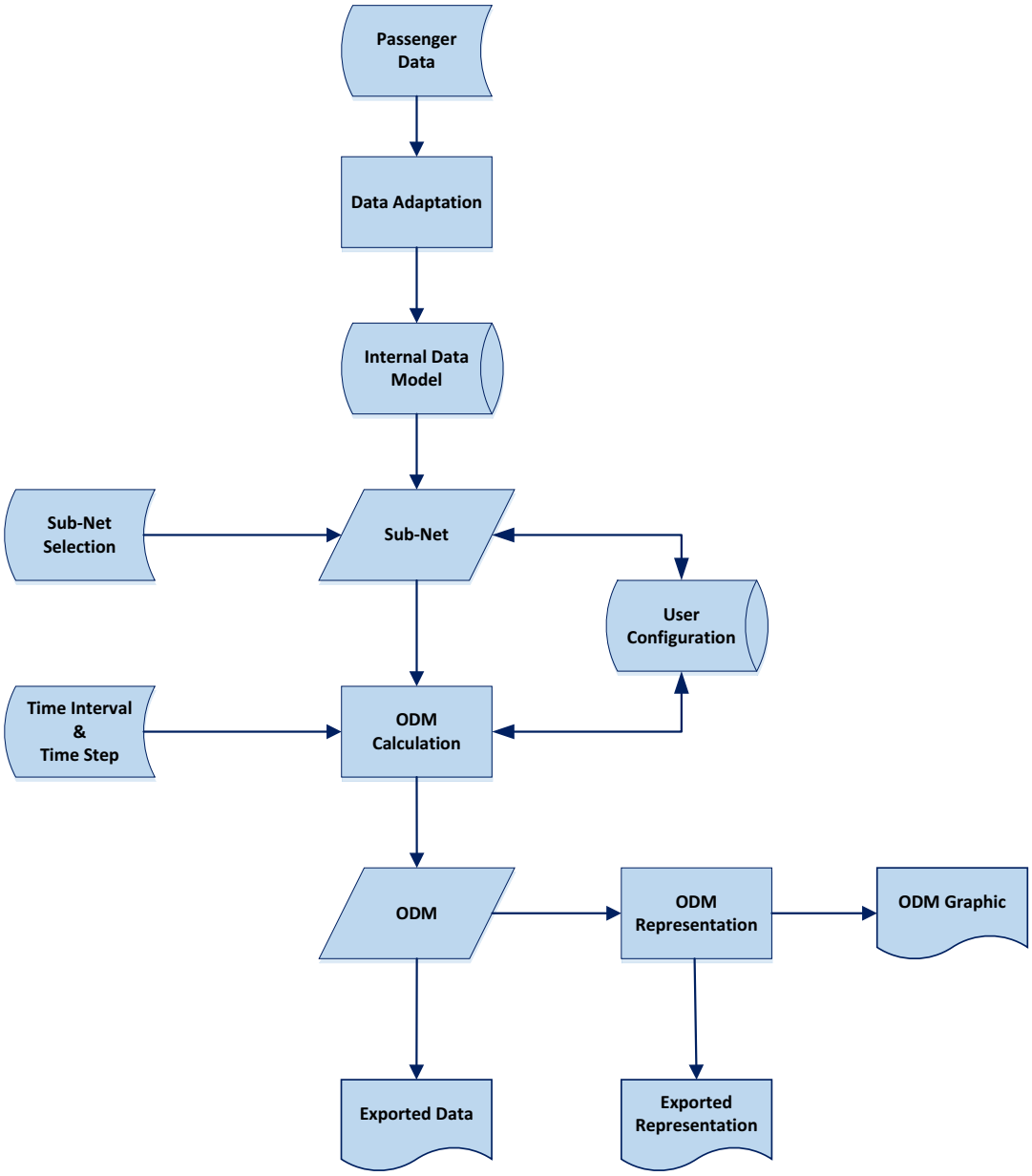


Figure 21. Work Flow Diagram

An ODM Tool user can select the road network of interest. The selection is made identifying road network nodes or edges. This sub-net can be stored as part of the user's configuration.

For creating the ODM, the user must select a time interval and a time step. The time interval defines the total amount of data that contributes to the ODM definition. The time step indicates the time granularity.

$$TimeStep \leq TimeInterval$$

$TimeStep$ should be an exact divisor of $TimeInterval$. E.g.: $TimeInterval$ = 24 hour. $TimeStep$ = 15 minutes.

If $TimeStep = TimeInterval$ only one OD static Matrix is generated for the full time interval, else a Dynamic ODM is generated for the full time interval composed of a static ODM for each time step.

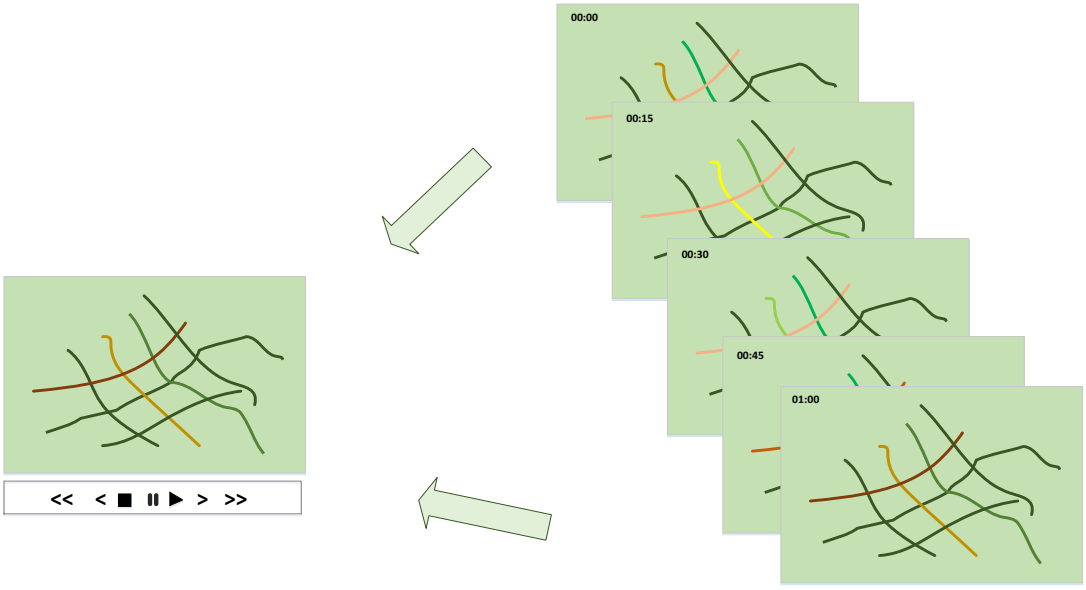


Figure 22. Dynamic and Static ODM

The ODM can be stored in the user's configuration.

User can display the ODM. There are several representation options: Flows Map, Densities Map, Chord Diagram, Direct OD Representation, Distribution Plot (examples available).

ODM Tool User can export ODM data and ODM representations.

5.3 Use Cases (before IBM withdrawal)

UM.P01	*User Login*
Cluster	*User Management*
Classification	*Primary use-case*
Description	*A user login the ODM Tool*
Actors involved	*Tool Operator, Tool Manager*
Triggering Event	*A user needs to work with the ODM Tool*
Pre-condition	
Post-condition	*The user is logged in the ODM Tool*
Priority	*High*
Acceptance	*Already implemented in the tool.*

UM.P02	*User Logoff*
Cluster	*User Management*
Classification	*Primary use-case*
Description	*A user logoff the ODM Tool*
Actors involved	*Tool Operator, Tool Manager*
Triggering Event	*A user end working with the ODM Tool*
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*The user is logged off the ODM Tool*
Priority	*High*
Acceptance	*Already implemented in the tool*

UM.P03	*User Definition*
Cluster	*User Management*
Classification	*Primary use-case*
Description	*A Tool Manager defines a user*
Actors involved	*Tool Manager*
Triggering Event	
Pre-condition	*The user is not defined for the ODM Tool*
Post-condition	*The user ID is defined for the ODM Tool*
Priority	*High*
Acceptance	*Already implemented in the tool*

UM.P04	*User Profile Configuration*
Cluster	*User Management*
Classification	*Primary use-case*
Description	*A Tool Manager configures a user profile*
Actors involved	*Tool Manager*
Triggering Event	
Pre-condition	*The user must be defined for the ODM Tool*
Post-condition	*The user's profile is defined in the ODM Tool*
Priority	*High*
Acceptance	*Already implemented in the tool*

OD.P01	*User generates an ODM*
Cluster	*ODM Management*
Classification	*Primary use-case*
Description	*A user generates an ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*An ODM is generated*
Priority	*High*
Acceptance	✅

EX.P01	*User Exports ODM results to .csv file*
Cluster	*Export capabilities*
Classification	*Primary use-case*
Description	*A user exports ODM results to a .csv file*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An ODM is generated*
Post-condition	*ODM results are saved in a .csv file*
Priority	*High*
Acceptance	✅ *Already implemented in the tool. Any chart data can be saved into CSV in the regional area. Not implemented in urban or hub yet since there is no data available.*

GR.P01	*Geographical representation of an ODM*
Cluster	*Graphical Representation*
Classification	*Primary use-case*
Description	*A user generates geographical representation (flows/ densities) of an ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	

Pre-condition	*An ODM is generated*
Post-condition	*User Interface displays a geographical representation of an ODM.*
Priority	*High*
Acceptance	✅ *Already implemented. Geomap with stops and lines from one stop to others. Not done with the entire OD because the data representation would be too chaotic. Done from one station to the rest, selecting a group of stations as origin is not available yet.*

GR.P02	*Chord diagram of an ODM*
Cluster	*Graphical Representation*
Classification	*Primary use-case*
Description	*A user generates a chord diagram of an ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An ODM is generated*
Post-condition	*User Interface displays a chord diagram of an ODM.*
Priority	*High*
Acceptance	✅ *Already implemented for regional. Data for urban or hub is not available yet, but it's ready to be implemented*

GR.P03	*Direct representation of an ODM*
Cluster	*Graphical Representation*
Classification	*Primary use-case*
Description	*A user generates a direct representation of an ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An ODM is generated*
Post-condition	*User Interface displays a direct representation of an ODM.*
Priority	*High*
Acceptance	✅ *Already implemented in the tool.*

GR.P04	*Colour representation of an ODM*
Cluster	*Graphical Representation*
Classification	*Primary use-case*
Description	*A user generates a colour representation of an ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An ODM is generated*
Post-condition	*User Interface displays a colour representation of an ODM.*
Priority	*High*
Acceptance	✅ *Already implemented for regional. Treemap representation and pie charts are available, with legends to select different stations. Done from one station to the rest, selecting a group of stations as origin is not available yet.*

GR.P05	***Exporting graphics to png file***
Cluster	*Graphical Representation*
Classification	*Primary use-case*
Description	*A user export an ODM Graphical representation to a png file*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*An ODM graphical representation is generated*
Post-condition	*A png file is generated with the graphical representation of the ODM.*
Priority	*High*
Acceptance	 *Already implemented for any chart.*

ES.P01	*Node Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects a subset of nodes for the generation of the ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A subset of nodes is selected*
Priority	*High*
Comments	*No selection of nodes implies that all nodes are selected*
Acceptance	*Not done, but it's in the plan to select various stops as origin.*

ES.P02	*Edge Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects a subset of edges for the generation of the ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A subset of edges is selected*
Priority	*High*
Comments	*No selection of edges implies that all edges are selected*
Acceptance	*Out of the scope for this project.*

ES.P03	*Variable Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects a variable for the generation of the ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A variable is selected*
Priority	*High*
Comments	*Examples of Variables: Travel time, speed, vehicles/passenger count*
Acceptance	*ODM includes only the count (number of passengers) and the total transfer count. It is in the backlog of IBM to include average travel time and vehicle occupancy. Vehicle speed will not be available. So, at the moment, it is not possible to implement this use case.*

ES.P04	*Time Interval Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects a time interval for the generation of the ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A time interval is selected*
Priority	*High*
Comments	*Examples of time intervals: working days, Monday, morning peak*
Acceptance	? *Day of the week and time stamps are available in IBM tool, but not working days or specific moments in the day. Time intervals (which kind of intervals) have to be specified, then IBM will implement them.*

ES.P05	*Time Step Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects a time step for the generation of the ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A time step is selected*
Priority	*High*
Comments	*If the time step is not selected then time step = time interval. It implies a static ODM. Examples of time steps: days, hours, 15-minute intervals*
Acceptance	✓ *API allows to group data in different intervals. We can use that as time steps*

ES.P06	*Continuous/Stepwise Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects if the representation is Continuous or Stepwise*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool* *Time Step != Time Interval*
Post-condition	*Continuous or Stepwise representation is selected*
Priority	*High*
Comments	*Continuous representation implies displaying the time evolution of the matrix in the same graphic.* *Stepwise representation implies generating one graphic for each time step of the time interval.* *If time step = time interval implies only one graphic.*
Acceptance	*Depending on the way the API allows us to group data, we can represent based on that.*

ES.P07	Time Interval Criterion
Cluster	Elements Selection
Classification	Secondary use-case
Description	A user selects a criterion to demarcate time intervals
Actors involved	Tool Manager, Tool Operator
Triggering Event	
Pre-condition	A time interval is selected
Post-condition	A criterion to demarcate time intervals is selected
Priority	Medium
Comments	Examples of time interval criteria: journey check-in time, journey check-out time, average between journey check-in and check-out time If no time interval criterion is selected, the journey check-in time is used as default to demarcate different time intervals For example: a journey with tap-in time 06:50 and tap-out time 07:15 would be classified within the morning peak (07:00-09:00) when the journey tap-out time or average between journey tap-in and tap-out time is used as time interval criterion. When the journey tap-in time is used: the journey would be classified in pre-morning peak
Acceptance	There is only information of one day at the ODM Tool, so we cannot implement time intervals at the moment. IBM has journey_start_time implemented but not available in the API. Journey end time is not implemented. Implementing average or midpoints between journeys would involve too much effort.

ES.P08	*Numerical (top X OD flows) selection (ranking)*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects only the top X (user-specified value: e.g. top 20) largest OD flows of a considered (part of the) network*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A top X of largest OD flows is selected*
Priority	*High*
Comments	*Example of user-specified value for top X largest flows: select only the top 20 largest OD flows*
Acceptance	*Inside the Matrix chart, the legend can be moved to show only specific data.*

ES.P09	*Numerical (top % OD flows) selection (ranking + summation)*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects only Y % of all OD flows ranking from high to low (user-specified value: e.g. only visualize all OD flows from high to low adding up to 20% of all OD flows)*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A top percentage Y of all OD flows is selected*
Priority	*High*
Comments	*Example of user-specified value for Y percentage of flows: select only the OD flows adding up to 20% of the total OD flow in the dataset*
Acceptance	*This is complex and would require too much time.*

ES.P10	*Hierarchical Selection*
Cluster	*Elements Selection*
Classification	*Secondary use-case*
Description	*A user selects a hierarchical level for the generation of the ODM*
Actors involved	*Tool Manager, Tool Operator*
Triggering Event	
Pre-condition	*The user is logged in the ODM Tool*
Post-condition	*A hierarchical level is selected*
Priority	*Medium*
Comments	*Examples of hierarchical levels are the stop level (default), hub level and area level (see figure below as illustration).* *The stop level shows OD patterns to/from/between individual stops and is the default level for generation of the ODM* *The hub level consists of several stops located near to each other, where transfers between several lines occur. This level shows OD flows from/to/between different hubs (inter-hub), but also OD flows between stops belonging to one and the same hub (intra-hub: indicating transfer flows within the hub). The key to identify which stops belong to a hub will be provided by TUD in a table with format as shown below.* *The area level shows OD patterns within a specific area (intra-area) and between different areas (inter-area). The considered total network is divided into several spatial areas (in example figure below: area 1-4). For the urban case study network of The Hague, one can think of about 15-20 areas.* *The key to link the stop level to the area level is provided by TUD for WP1.2: each specific smart card transaction (from stop X to stop Y) also contains a column indicating the area of the origin (e.g. city centre The Hague) and the area of the destination (e.g. Zoetermeer) and can thus be inferred directly.*

Acceptance	? *Can be done if values are represented in a JSON file that is on the cloud and we gather the information every day. It has to be provided by the case study leader.*
	Example of json file:
	`{idArea: xxx,`
	`Hubs [{ idHub: xxx; stops:[xxx, xxx, xxx]`
	`}; … ]`

5.4 Visualization requirements: Hub Level Case (before IBM withdrawal)

Always the time dimension (dynamics)

- *Georeferenced hub infrastructure (multiple-levels underpass (-1), platforms (0), waking areas, waiting areas, shops (coffee, etc.), ticket machine, escalators, moving walkways, control barriers, traffic light)*
  - *Acceptance:* ❌ *This requires the availability of a lot of data that is not available now.*
- *Trajectory for each individual (with a degrading tail: the length and intensity of the tail should be a parameter ranging from 0% = no tail, to 100% = full static trajectory)*
  - *Acceptance:* ❓ *The amount of individuals is very high to handle data correctly. This cannot be done with each individual, but if the data is managed by the source to be grouped in waypoints it can be done. Waypoints can be declared in each station to reduce the data, so each group of individuals that made more or less the same trajectory can be grouped.*
- *Control action visualization: Traffic light colours, Gates opening/closing, Directions (floor marking, escalator direction, moving walkway direction)*
  - *Acceptance:* ❓ *It can be done, but data is not available at the moment.*
- *Public transport arrival/departure (train, bus, metro). A simple representation of the vehicles is sufficient.*
  - *Acceptance:* ❓ *Can be done when data is available.*
- *Heat map (calculated by IBM starting from the raw data). The size of the cells should be a parameters ranging from IBM unit size to any possible aggregation of the individual cells.*
  - *Acceptance:* ❓ *Using waypoints and already refactored data, it can be done.*
- *Heat map without underlining density. Considering individuals as light bulb, the heat map can be created increasing the intensity of the light emitted by the individuals*
  - *Acceptance:* ❓ *Using waypoints and already refactored data, it can be done.*
- *Pedestrian specific information, colour of the pedestrian changing following: surrounding density, lateness, class, desired free flow speed, difference between the desired free flow speed and the actual speed, performed activity, Simulated data (receiving information, following information, change destination, change activity)*
  - *Acceptance:* ❓ *Can be done when data is available and if the individual data is grouped and managed from the source, as mentioned above.*
- *OD matrix as circle-plot (dynamic)*
  - *Acceptance:* ❓ *Can be done when data is available.*
- *Arrival/departure dynamics for each origin/destination (bubble growing proportionally to the arrival rates)*

- *Acceptance:* ? *Can be done when data is available.*

- *As we would like to use this tool for both the empirical data and data resulting from simulations, we would like to have a means for switching data sets. The data sets would be stored at IBMs side, then in the visualization tool we can choose which one to represent. Regarding the visualization of the full trajectories, it might be interesting that ETRA has a copy of the full data to avoid transferring lots (megabytes/gigabytes) of data online via JSON files.*

  - *Acceptance:* ? *The main issue on the hub level is the huge amount of raw data from the video feed. This data is pre-processed during import in the Graph DB so that the Graph DB only stores the information needed to serve the APIs (1) and (2) but does not contain anymore the detailed information about every single trajectory. Therefore the visualization of individual trajectories is not possible using the data stored on the Graph DB. In order to do a dynamic visualization of detailed trajectories, the data would have to be stored in-memory in the visualization application.*

5.5 Visualization requirements: Urban Level Case (before IBM withdrawal)

Visualization of moving individual transit vehicles over map

- *Individual transit vehicles moving over a geographical map are shown, using the real public transport routes based on transit line shape files (GTFS).*

  - *Acceptance:* ✗ *IBM API doesn't consider vehicle positions. We only have data in real time (from an external source), but this is out of the scope of the app.*

Visualization of delay and occupancies per moving vehicle on a map

- *Delay visualization: for each vehicle preferably the deviation from the scheduled time is mentioned above the vehicle: e.g. '+ 20 sec' indicating the vehicle runs 20 seconds behind schedule*
- *Occupancy visualization: for each vehicle preferably the occupancy is indicated by the colour of the vehicle: a higher occupancy (or even better: a higher occupancy rate: number of passengers / total vehicle capacity: vehicle capacities to be provided by TUD) leads to a more 'red coloured' vehicle*
- *An option could be that the user is able to click on each vehicle moving over the network, to get some more information (e.g. line number, destination etc.) over this specific vehicle*

  - *Acceptance:* ✗ *The project is oriented to study the behaviour of passengers, and not vehicle. Not all required data is available. This is out of scope.*

Visualization of static line and link loads on network map

- *The static line load can be visualized (per user-defined time period, or user-selected line): by summing the individual vehicle loads the total line occupancy (e.g. for a morning peak) is shown for each line segment.*

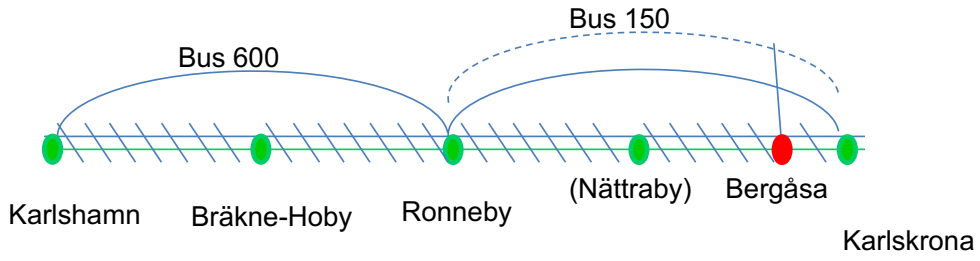
  - *Acceptance:* ? *Not done yet but in the plan to be done. IBM has to provide the computation, so it can be visualized afterwards.*

5.6 Visualization requirements: Regional Level Case (before IBM withdrawal)

Visualizing the passenger transfer data *(created by LiU and IBM)*

i) Select a pair of nodes/hubs from a list of options (e.g. Karlshamn-Karlskrona as below) or from a "clickable" graphical view of a service public transport service network.

⇨ *A graphical view showing the available physical, directed services and intermediate nodes/hubs between the selected two origins/destinations is provided.*



ii) A directed service link, or a node/hub, is selected using the graphical view.
iii) A time period is selected from a list of available pre-computed options.

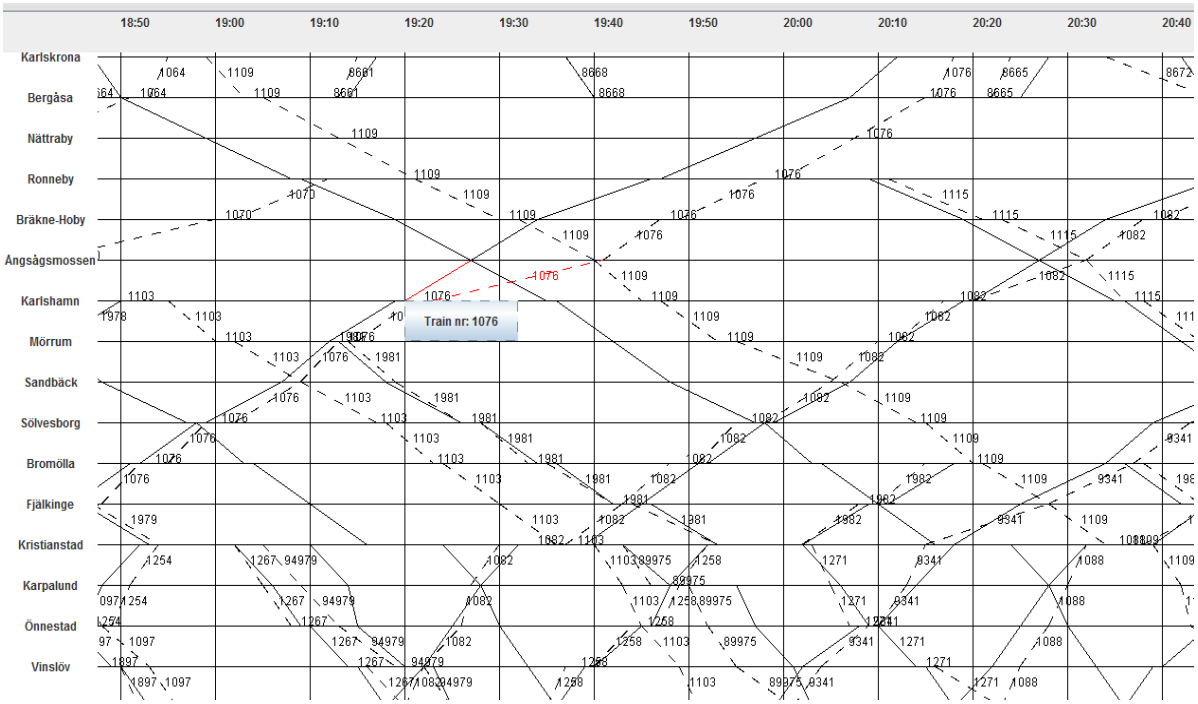
⇨ *For the selected service link, a time-based OD-matrix is presented showing the number of pax getting off and on for a particular service per scheduled stop.*
⇨ *For the selected node/hub, a transfer matrix is presented showing the exchange of passengers between various pairs of services (including options like "walking -> bus 600 westbound". Perhaps also the scheduled transfer times for selected pairs of services can be indicated by a "mouse over" option.*

Acceptance: ⛔ *Out of project scope. Data analysis related to the connections between two given stops was not part of the original requirements. The current implementations are focused on the "intra-stop ODM" described in D1.1 under the "trip-to-trip" and "route-to-route" APIs.*

Visualizing the re-scheduled services between pairs of nodes during a disturbance *(i.e. the results from BTH's optimization-based re-scheduling method)*

i) Select a pair of nodes/hubs from a list of options (e.g. Karlskrona-Vinslöv as below) or from a "clickable" graphical view of a service public transport service network.
ii) Choose a time period.

⇨ *For the selected pair of nodes and the selected time period, show in a time-distance graph the scheduled and re-scheduled services. Provide options to click on the services or nodes for additional information related to travel demand and transfer data.*



Acceptance: *This is too complex and out of scope for this project. Currently there is no real-time data, but technically the necessary data for creating a time-distance graph of the scheduled trips would be possible to generate (from the GTFS data stored in the Graph DB).*

6 Acronyms

AFC	*Automated Fare Collection*
GTFS	*General Transit Feed Specification*