Ring road logistics - efficient use of infrastructure

Appendices

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Content

Appendix 1 – Modelling and simulation

Microscopic models describe traffic flow dynamics in terms of single driver-vehicle units. The microscopic traffic simulation models are based on the reproduction of the traffic flows simulating the behaviour of the individual vehicles, this not only enables them to capture the full dynamics of time-dependent traffic phenomena but also to deal with behavioural models accounting for drivers' reactions. The underlying hypothesis is that the dynamics of a stream of traffic is the result of a series of drivers' attempts to regulate their speed and acceleration accordingly with information received. The driver's actions resulting from the interpretation of the information received will consist on the control of the acceleration (braking and accelerating), the control of heading (steering) and the decision of overtaking the precedent vehicle either to increase the speed or to position themselves in the right lane to perform a manoeuvre (i.e. a turning).

Being available as an open source microscopic simulation model under the GPL license, SUMO is used in our simulation work. The complete software suite includes tools for importing road networks, generating routes from different traffic sources, and two versions of the traffic simulation itself, one started from the command line and one including a graphical user interface. A car-following model defines how a driver adapts the speed of the following vehicle in relation to the vehicle ahead. SUMO implements a collision-free car-following model (Krauss et al., 1997). For lateral behaviour, the decision of vehicle drivers is represented by a hierarchy of motivations for lane-changing, namely strategic lane change, cooperative lane change, tactical lane change and regulatory lane change. The modelling details and implementation can be found in Erdmann (2015). SUMO also defines route choices to move vehicles from lane to lane, link to link, and across the network from an origin to a destination.

Simulation Model Development

Step 1: Network coding
For the purpose of traffic microsimulation, a properly scaled digital representation of the transportation network is required. The network coding of the model utilized the map data from OpenStreetMap, which is converted to be an overlay in SUMO. Next, the overlay is used as a guideline for manually coding the lane configuration of the simulated network in a great level of detail based on the map data obtained from GoogleEarth.

Step 2: Prioritized lane development:
The SUMO platform implements a detailed representation of the transportation network; for example, the number of lanes for each road is a required attribute. In a general implementation of the SUMO traffic simulator, vehicles are allowed to use all lanes in SUMO. By defining prioritized lane, the prioritized vehicles' behaviours on the approach to and traveling on prioritized lanes need to be handled. It also deals with non-prioritized-vehicle behaviour on the approach to a prioritized lane, allowing them to make an appropriate lane choice in advance.

The following two steps were carried out to make the prioritized lane operational. Firstly, a set of prioritized vehicle types are specified and coded in SUMO. Then, lane-based restrictions are coded in the transportation network. When coding the network, the effects on route choice, merging areas

for on-ramps/ off-ramps, and available lane range are considered. Specifically, prioritized vehicles are supposed to tend toward using the prioritized lane since the lane is only "open" to prioritized vehicle types.

Step 3: Model calibration

The calibration procedure refers to a previous study by Brockfeld et al. (2003). Since the optimization objective is evaluated through repeated traffic simulation runs, it is not convenient to resort to gradient-based optimization methods that require computing the Jacobian with respect to the parameters. On the other hand, direct-search methods work without the need for estimating derivatives or the need for an explicit analytical formulation of the system. Brockfeld et al. (2003) applied an unconstrained optimization algorithm, Unconstrained Optimization BY Quadratic Approximation (UOBQA), in the parameter search. Instead, this study employs the limited memory Broyden-Fletcher-Goldfarb-Shanno bounded optimization algorithm (L-BFGS-B). In practice, it leads to better calibration result while taking constraints into consideration as well as limited computational time. A detailed description of the method can refer to Byrd et al. (1995). The computational procedure is summarized as follows:

1   Define the mean absolute percentage error (MAPE) as
2   Initialize a set of parameters u_0 and set the epoch n to be 0.
3   Compute MAPE based on simulation results using u_n.
4   Use the L-BFGS-B method to change the set of parameters to u_n+1 and set $n = n + 1$.
5   Check if the iterations should be terminated according to the pre-defined termination rules, if so go to the next step, otherwise go back to step 3.
6   Obtain the optimal parameters u_n+1.

Data collection and simulation model implementation

To simulate the effect of letting trucks use the bus lane we use the road stretch on Kungälvsleden, between Hisings Kärra and Tingstadstunneln, shown in detail below. Note also that the most important bottleneck, increasing the travel time on the road stretch is in the Tingstadstunneln itself. This bottleneck is implemented in the simulation model. Upstream this bottleneck dynamic congestion will build in the morning peak, in terms of ques building up.
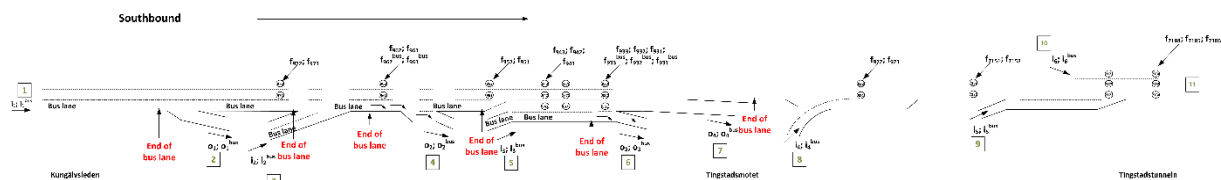
The selected segment is a three-lane highway (with some ramps), and several gantries are deployed which are equipped with a Motorway Control System (MCS). The MCS includes subsystems designed to collect traffic counts for different vehicle categories and the corresponding average speed. The scenarios used in this study are based on the data collected in a typical weekday (2016-02-01). For each simulation step, vehicle trajectory data is stored (e.g., vehicle ID, speed, position, vehicle type, etc.) to calculate travel time and traffic flow.

References

Brockfeld, E., Kühne, R., Skabardonis, A., Wagner, P., 2003. Toward benchmarking of microscopic traffic flow models. Transportation Research Record: Journal of the Transportation Research Board (1852), 124–129.

Byrd, R. H., Lu, P., Nocedal, J., Zhu, C., 1995. A limited memory algorithm for bound constrained optimization. SIAM Journal on Scientific Computing 16 (5), 1190–1208.

Krauss, S., Wagner, P., Gawron, C., 1997. Metastable states in a microscopic model of traffic flow. Physical Review E 55 (5), 5597.

Erdmann, J., 2015. SUMO's lane-changing model. In: Modeling Mobility with Open Data. Springer, pp. 105–123.

Appendix 2 – Value of time per commodity

Value of Time per commodity type and vehicle class estimated using values recommended by ASEK based on a cost factor method (in SEK):

Commodity description	National share per commodity	National share accum.	2014 (incl. VAT)						
			Lorry HGV 74 ton	Lorry HGV 60 ton	Lorry HGV 40 ton	Lorry LGV 24 ton	Lorry LGV (LBS) 14 tons	Lorry without trailer (LBU) 3 tons	Car in commercial traffic (PBY)
Mould, stone, gravel and sand (151)	10,91%	10,91%	333,33	329,41	314,48	309,45	307,23	283,77	113,51
Roundwood paper industry (41)	13,95%	24,87%	337,23	332,53	316,58	310,71	308,07	283,95	113,58
Round timber sawmills (45)	3,39%	28,25%	341,13	335,65	318,68	311,97	308,91	284,13	113,65
Wood chips, wood and sawing waste (43)	2,81%	31,06%	342,43	336,69	319,38	312,39	309,19	284,19	113,68
Iron ore, scrap iron and steel scrap and blast furnace dust (110)	8,52%	39,58%	348,93	341,89	322,88	314,49	310,59	284,49	113,80
Coal, lignite and peat, coke and briquettes thereof (80)	1,85%	41,43%	354,13	346,05	325,68	316,17	311,71	284,73	113,89
Other raw and unprocessed minerals (152)	2,21%	43,64%	354,13	346,05	325,68	316,17	311,71	284,73	113,89
Potatoes, fresh or frozen vegetables, fresh fruit (20)	3,07%	46,71%	367,13	356,45	332,68	320,37	314,51	285,33	114,13
Cereals (10)	1,02%	47,73%	369,73	358,53	334,08	321,21	315,07	285,45	114,18
Cement, lime and building materials (140)	2,42%	50,15%	374,93	362,69	336,88	322,89	316,19	285,69	114,28
Fertilizers, natural and manufactured (160)	0,42%	50,57%	382,73	368,93	341,08	325,41	317,87	286,05	114,42
Sugar beet	0,08%	50,65%	397,03	380,37	348,78	330,03	320,95	286,71	114,68
Sawn / planed timber (42)	2,76%	53,41%	400,93	383,49	350,88	331,29	321,79	286,89	114,76
Oil seeds, oil nuts and grains (70)	0,65%	54,06%	416,53	395,97	359,28	336,33	325,15	287,61	115,04
Crude oil (90)	5,26%	59,32%	423,03	401,17	362,78	338,43	326,55	287,91	115,16
Pulp, recycled cardboard, paper waste (190)	1,43%	60,75%	424,33	402,21	363,48	338,85	326,83	287,97	115,19
Mineral oil products (100)	11,72%	72,47%	432,13	408,45	367,68	341,37	328,51	288,33	115,33
Carbon-based chemicals and tar (170)	0,21%	72,68%	434,73	410,53	369,08	342,21	329,07	288,45	115,38
Paper, paperboard and articles thereof (231)	2,29%	74,97%	437,33	412,61	370,48	343,05	329,63	288,57	115,43
Living animals (31)	0,18%	75,15%	484,13	450,05	395,68	358,17	339,71	290,73	116,29
Paper products (233)	1,95%	77,11%	486,73	452,13	397,08	359,01	340,27	290,85	116,34
Non-ferrous metal ores and scrap (120)	0,65%	77,76%	510,13	470,85	409,68	366,57	345,31	291,93	116,77
Chemicals other than carbon based and tar (180)	5,18%	82,94%	534,83	490,61	422,98	374,55	350,63	293,07	117,23
Raw materials, semi-finished iron/metal (130)	3,65%	86,58%	543,93	497,89	427,88	377,49	352,59	293,49	117,40
Food and animal feed (60)	5,99%	92,57%	631,03	567,57	474,78	405,63	371,35	297,51	119,00
Glass, glassware, ceramic products (220)	0,16%	92,73%	696,03	619,57	509,78	426,63	385,35	300,51	120,20
Works of metal (210)	1,04%	93,77%	796,13	699,65	563,68	458,97	406,91	305,13	122,05
Raw materials or semi-finished materials regarding textiles (50)	0,08%	93,85%	832,53	728,77	583,28	470,73	414,75	306,81	122,72
Various other finished goods (232)	3,39%	97,24%	854,63	746,45	595,18	477,87	419,51	307,83	123,13
Machinery, appliances, transport equipment (200)	0,78%	98,02%	2045,43	1699,09	1236,38	862,59	675,99	362,79	145,12
Machines (201)	1,98%	100,00%	2826,73	2324,13	1657,08	1115,01	844,27	398,85	159,54

Reference

Trafikverket (2016b) *Analysmetod och samhällsekonomiska kalkylvärden för transportsektorn: ASEK 6.0.* Trafikverket, 2016

Appendix 3 – Interviews and workshops

Interviews

2017-10-25	WP3	46 surveys	Multiple transport companies	
2017-11	WP3	One interview	Martin Pettersson	Oriola
2017-11	WP3	One interview	Kjell Håkansson	Coop
2017-11	WP3	One interview	Patrik Nilsson	DB Schenker
2016-11-24	WP5	One interview	Fredrik Cederstav	Volvo
2016-12-02	WP5	One interview	Staffan Persson	Scania
2016-12-22	WP5	One Interview	Jonas Wilhelmsson	Ericsson
2018-01-30	WP5	One interview	Peyman Tavakoli	Technolution
2016/2018	WP5	Several occasions	Arne Lindeberg	Trafikverket
2017/2018	WP5	Several occasions	Anders Fagerholt	Ericsson
2017/2018	WP5	Several occasions	Andreas Höglund	Scania
2017/2018	WP6	Several occasions	Various people	Transportstyrelsen

Workshops

Several internal workshops have been held during the project, but here we list the workshops where external stakeholders have been invited:

2017-05	WP5	20 participants	Volvo, Ericsson, CLOSER/Lindholmen, DB Schenker Consulting, Trafikverket, Stockholm Stad, Trafik Göteborg, Combitech
2017-12-06	WP3	11 participants	Chalmers, Schenker, Stockholm city, Trafikverket, CLOSER, Volvo, SSPA
2018-02-02	WP5	5 participants	Scania, Trafikverket, Ericsson, Trafik Göteborg
2018-02-15	WP7	7 participants	SLL, Stockholm city, Trafikverket, Schenker, CLOSER
2018-03-20	WP7	6 participants	Västtrafik, Trafik Göteborg, CLOSER, Schenker, Trafikverket
2018-04-05	WP7	25 participants	Arranged together with K2 with participants from both academy, industry and authorities representing both public transport and freight transport

Appendix 4 – Use cases for Technology and Service development

A. Manage Priority Service

Who

Relevant traffic management center/s are suggested as the owner of the system.

What

Configuring priority rules on transports to access the priority functionality, updates, adjustments and maintenance on system architecture need to be planned and executed. Ability to shut down/pause the system when needed, e.g. maintenance, accidents, planned roadwork.

How

The TMC dispatcher uses the interface dedicated to the relevant traffic management center in order to carry through the configuration of priority rules.

(from Actors)

Dispatcher TMC

Management of priority functions

(from System objects)

Configure priority rules()
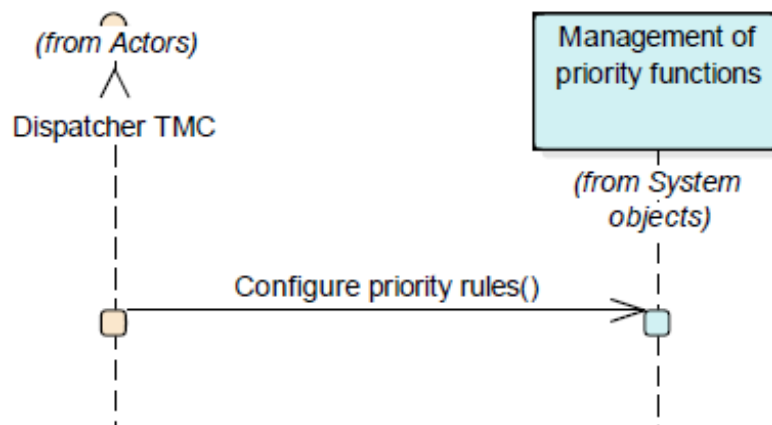
B. Application for trusted partner

Who

The Authorized signatory is responsible for registering the transport company.

The Policy officer is responsible for approving or declining the application as trusted partner. The policy officer could be a manual process for a dedicated department at the authority or it could be an automated set up with predefined criteria, possibly a mix where a rule based evaluation is made and exceptions are handled by an administrator.

What

In order to request a slot for a transport in the priority lane an approval of application for trusted partner is needed. To be a trusted partner will make the request for priority of a specific transport easier as a lot of the needed information already is accessible through the approval of the trusted partner-application. The application is a one-time application, which is updated by the transport company when needed or renewal on a regular basis. Content in the application is general information about the transport company.

How

The authorized signatory uses the interface in order to send in application and if fulfilling requirements gain approval as a trusted partner.
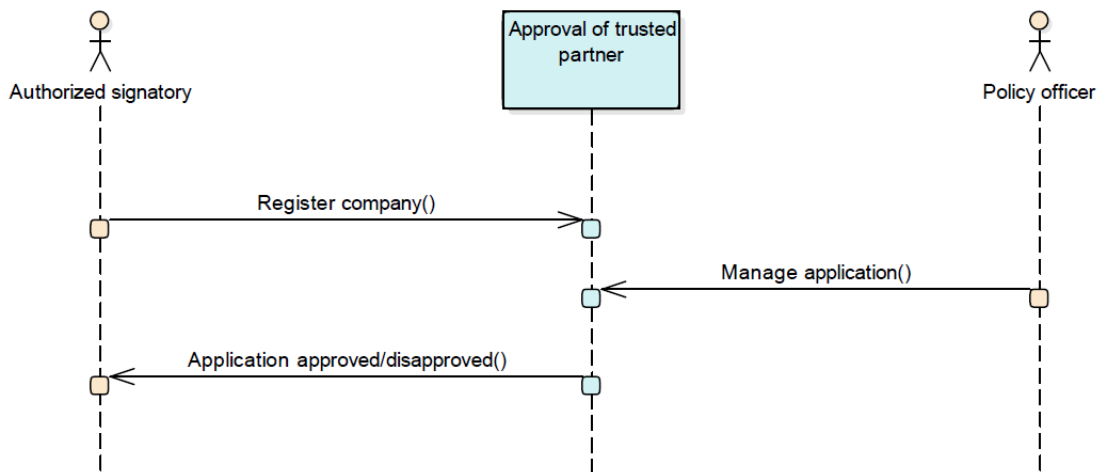
C. Monitor traffic and capacity

Who

This is preferably an automated process where the system architecture gathers enough information to make the decision on its own. It could also be either a manual/partly manual process done by the TMC.

What

- The system should identify when and how much available capacity there is in the priority lane, and thereby identify how many transports can have their request approved
- The system should be able to prioritize between different transports who all have approved requests
- Should be able to re-plan if changes in capacity

How

This will be possible through communication in the system architecture with number of requests, either at a specific time slot or ad hoc, and the data from public authorities in order to predict how many requests that can be approved in the priority lane.
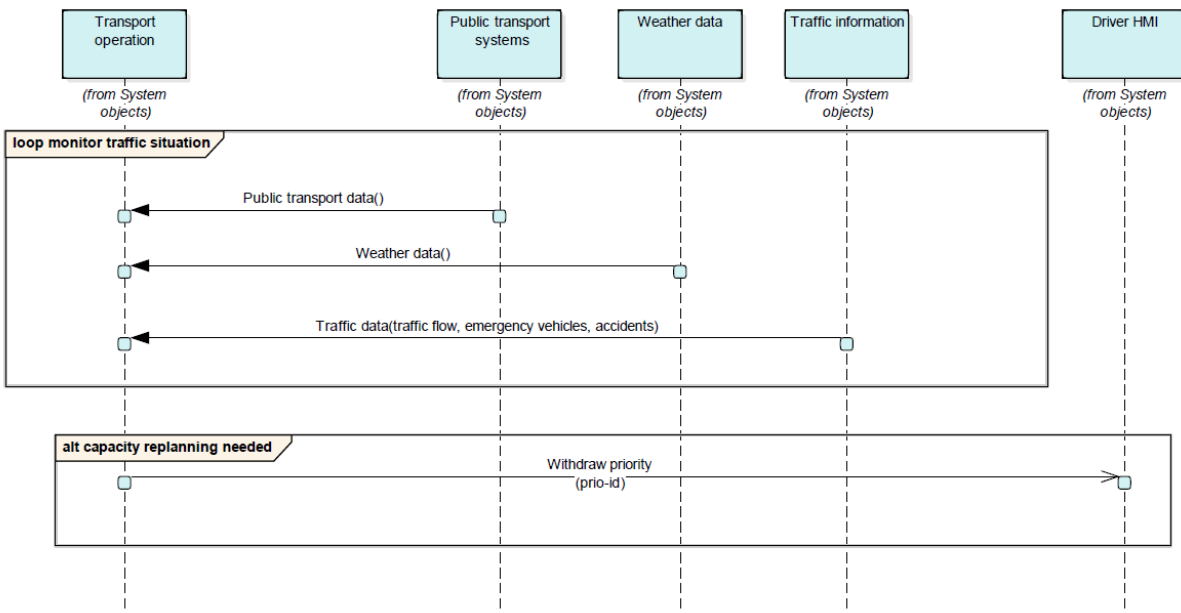
D. Plan transport

Who

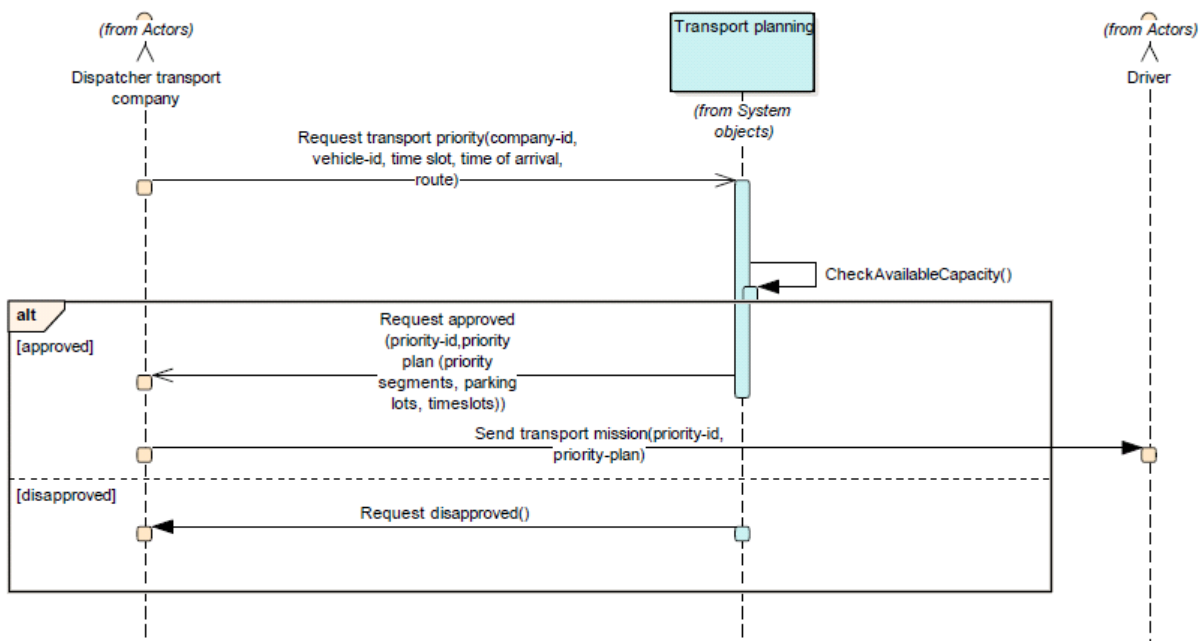The dispatcher at the transport company is likely the one planning the transport.

What

To gain access to the priority lane a request is sent to the transport planning module where the request is approved or disapproved.

How

The dispatcher plans the transport and requests for priority in the interface of the own FMS, adding requested information. The system checks if there is available capacity at the requested time slot. If approved a unique priority-ID is created and used to identify that specific transport. An approval on the request is sent to the dispatcher at the transport company. When it is time for the planned transport a transport mission is sent to the driver to confirm.

If a transport is disapproved information is sent to the dispatcher at the transport company.

E. Cancel transport

Who

The dispatcher at the transport company or the driver are the ones cancelling the approved request for a time slot. TMCs should also be able to cancel transports due to e.g. accidents.

What

If changes occur and the approved time slot no longer is needed or possible to carry through, perhaps because of delays, re-planning, need for break, the dispatcher or driver can cancel their allocated priority.

How

The driver or dispatcher uses their interface to cancel their allocated priority.
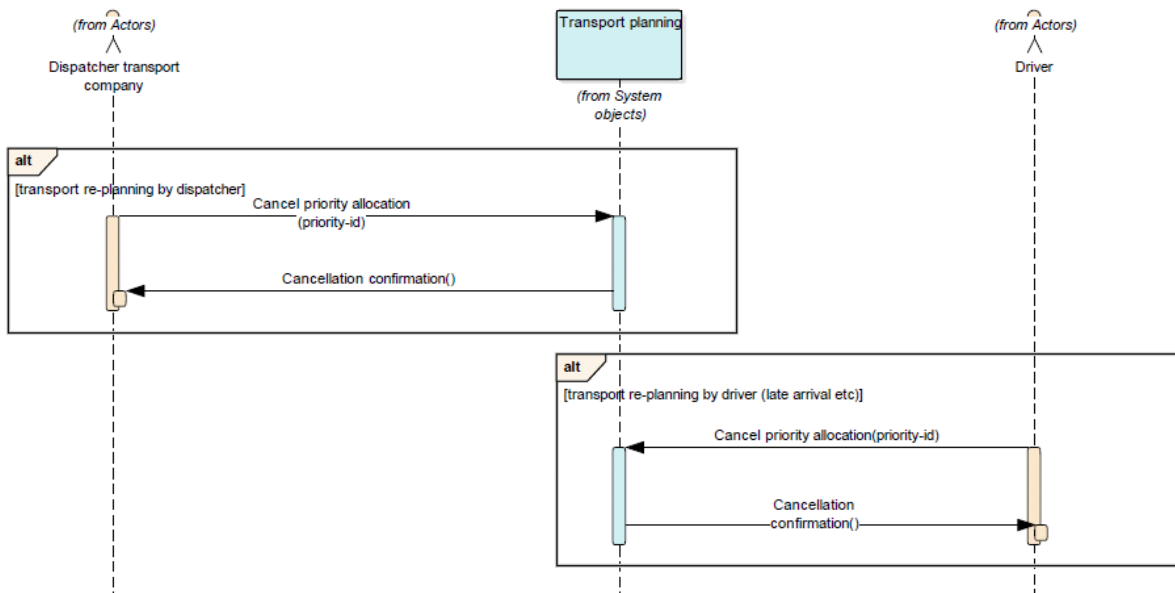
F. Execute transport
Who

The driver is executing the transport and will have the interface to the system architecture.
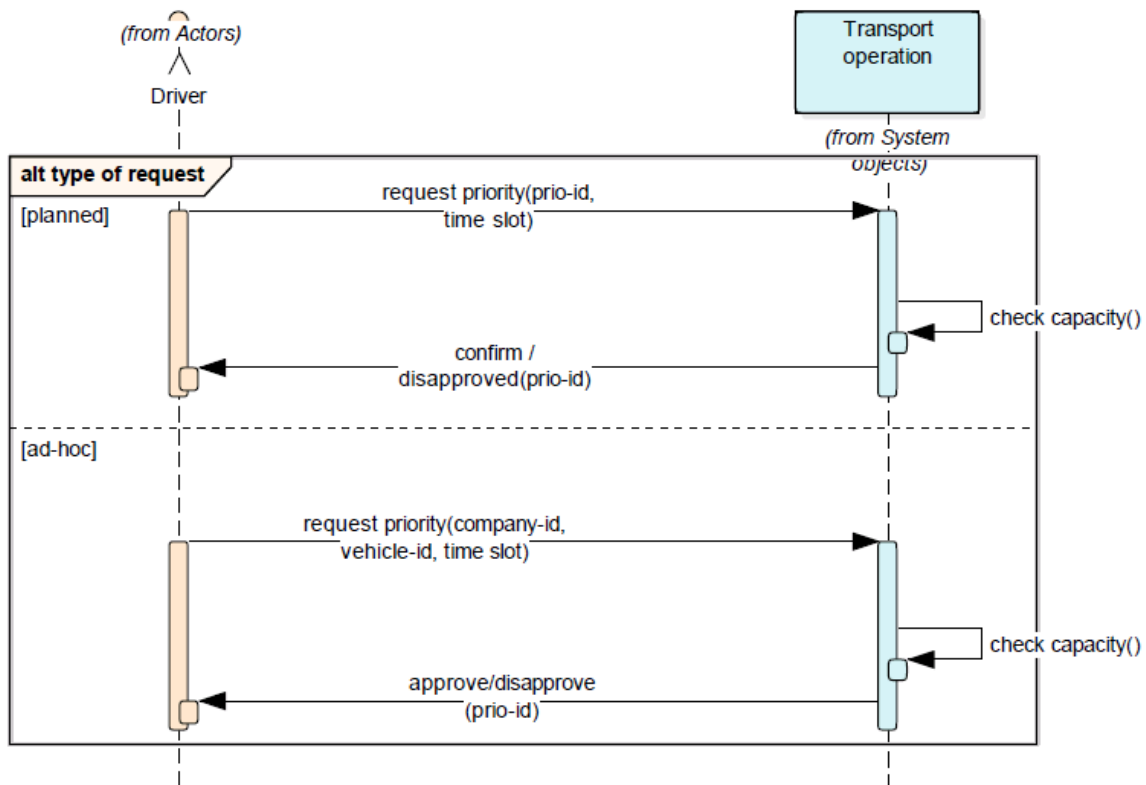
What

To access the priority lane a confirmation of an already planned transport or an application of approval for an ad-hoc transport is needed.

How

For planned transports the request to access at a specific time slot is already approved and the driver will be notified according to use case D. When transport is getting close to the priority area another request, with less information because of the actions already being performed in use case D, is sent by the driver and the driver awaits confirmation or disapproval depending on e.g. unpredicted traffic situation.

For ad-hoc transports more information is needed and driver awaits an approval or disapproval to access the priority lane.

In both described cases traffic safety is of greatest importance. The interface need to be user friendly and appropriate for the conditions.

G. Check transport

Who

The authorities should pursue control and supervision of the processes described, as well as assign penalties for violations of the regulations.

What

A control authority could have two ways to control enforcement. One way would be road side controls to view permission to access the priority lane, and one way would be audits where information is requested.

How

Enforcement should be performed by authority, by checking permission either on the road or by audits. As development moves forward a more automated system for enforcement could be possible.
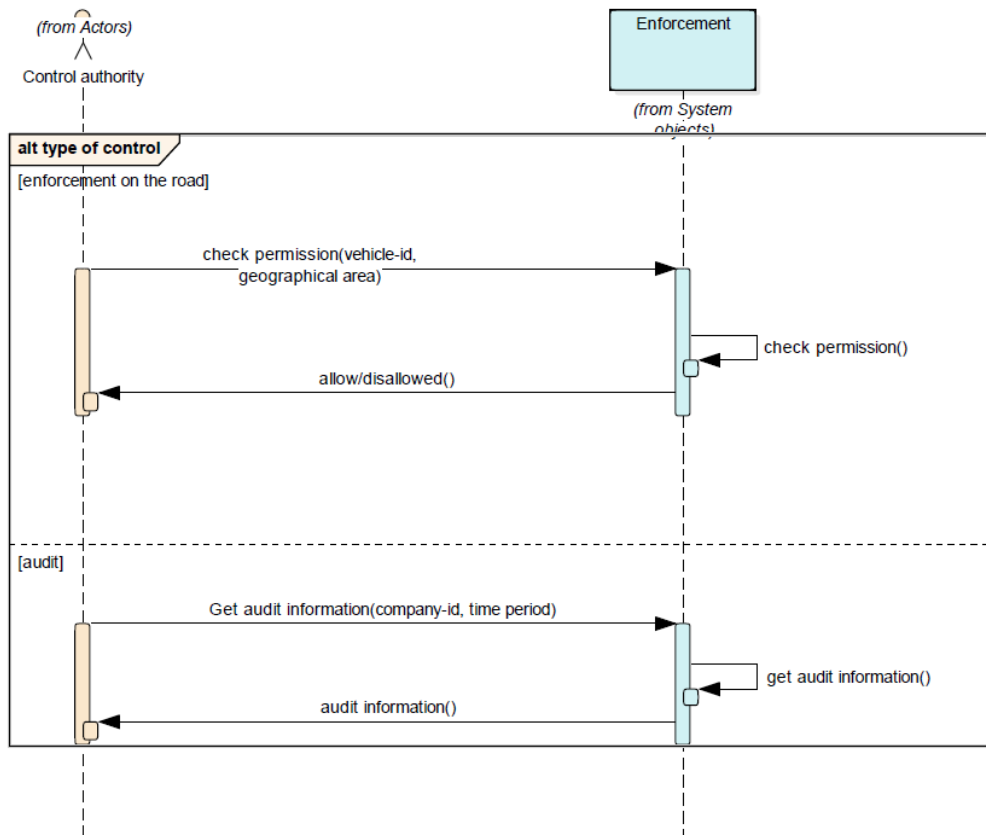
H. Analyze transport
Who
Analyzing transports is likely interesting for several parties; traffic analysts at the TMC, the transport company and the road authorities.
## What
Store and visualize data in defined form, extent and time period

- To study the utility (possible time gain, average speed, number of vehicles that was granted access, number of transports that used the priority lane when given access, environmental benefits etc.)
- In order to ensure that the regulations in the Priority Service are used as agreed
- Provide a basis for planning of the maintenance of the infrastructure.
- Assess the degree of compliance

How
Defined data is stored based on need for information of the different interested parties. The data should be stored in safe manner during adequate time to minimize privacy intrusion and tampering, according to relevant law. As the General Data Protection Regulation (GDPR) will be implemented in Europe as of May 2018 it is expected that the architecture/system is built in Privacy By Design[1] from all involved parties.


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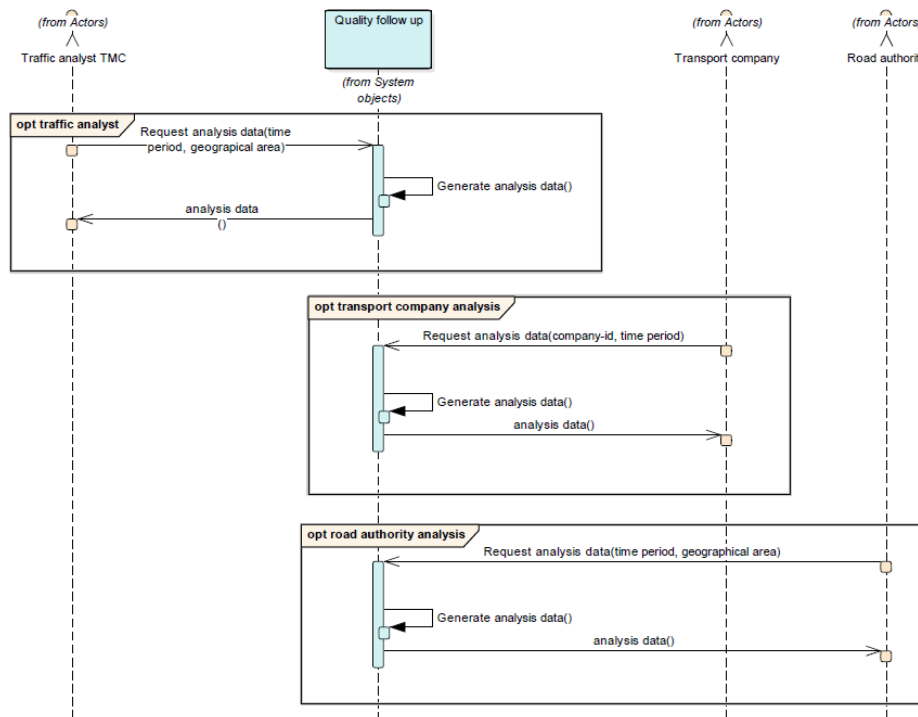
[1] Built in data protection to consider the integrity regulation

Appendix 5 – Preparation for demonstration

Proposed stretch for demonstration in Gothenburg

This stretch seemed possible in consultation with Trafikverket region väst, Trafik Göteborg, Västtrafik, Schenker and CLOSER. It is an interesting stretch as it would be good from a safety perspective and there are freight transports using this road. In addition, there are fewer buses on this stretch that could be disturbed by the demonstration. On this stretch there are only two bus operators which makes it easier for Västtrafik to monitor the bus movements on the stretch.
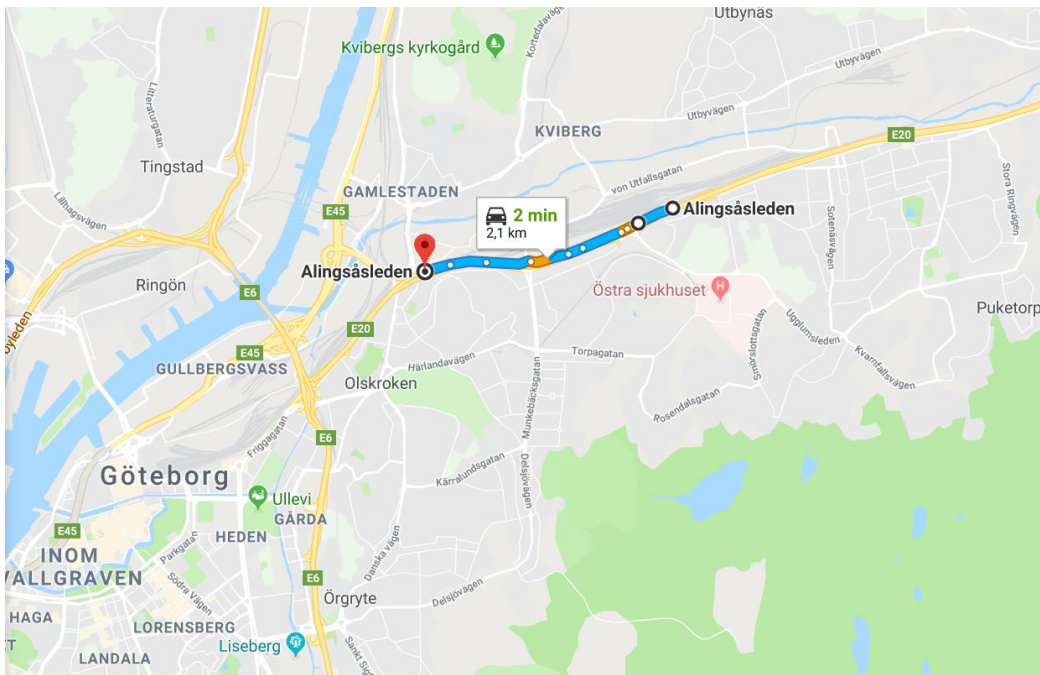
Stakeholders that in some way should be included in the preparation or the execution of the demonstration are:
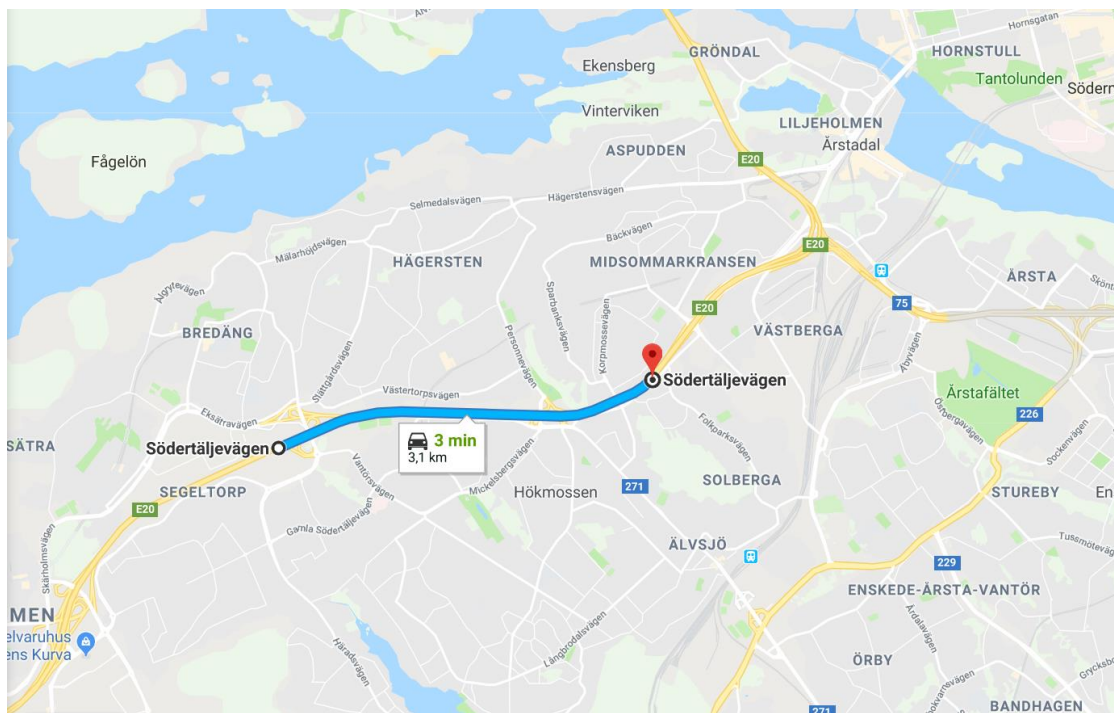
- Road authority – Legislation, traffic management center/s, responsibility of road usage
- The county administration board for applying for dispensation to use the priority lane
- Public transport actors
    - Västtrafik
    - Operators such as Keolis & Nobina, Nettbus, Swebus, Transdev, Flixbus
- Traffic management (Trafik Göteborg) for consultation on long-term perspective and possibilities on active traffic management
- Transport operators and OEMs to develop a service that is functional and possible to implement
- Authorities (police/Swedish transport Agency) for consultation on compliance
- Software developer/s – in order to develop the functionality in the priority system
- System integrator/s – connecting the different actors and systems in the system architecture

- Cooperative Intelligent Transport System (C-ITS) expertise @ OEM – provide the team with expert knowledge regarding vehicles, FMSs etc.
- Specialist/s of communication in cloud services – provide information on designing and managing cloud solutions
- Specialist/s of communication via infrastructure – provide information on designing and managing communication solutions based on infrastructure

Proposed stretch for demonstration in Stockholm

This stretch seemed possible in consultation with Trafikverket region Stockholm, SLL, Stockholm city, Schenker and CLOSER. It is a interesting stretch as it would be good from a safety perspective and there are freight transports using this road, for instance freight transports to Årstaterminalen. This enable a more realistic case for demonstration when it is a stretch with a normal freight flow. In addition, there are fewer buses on this stretch as there are additional subway on this stretch which reduce pressure on the bus system.

Stakeholders that in some way should be included in the preparation or the execution of the demonstration are:
- Road authority – Legislation, traffic management center/s, responsibility of road usage
- The county administration board for applying for dispensation to use the priority lane
- Public transport actors
    - SL
    - Operators such as Keolis & Nobina

- Traffic management (Trafik Stockholm) for consultation on long-term perspective and possibilities on active traffic management
- Transport operators and OEMs - clarify requirements, test functionality and provide feed back
- Authorities (police/Swedish transport Agency) for consultation on compliance
- Software developer/s – in order to develop the functionality in the priority system
- System integrator/s – connecting the different actors and systems in the system architecture
- Cooperative Intelligent Transport System (C-ITS) expertise @ OEM – provide the team with expert knowledge regarding vehicles, FMSs etc.
- Specialist/s of communication in cloud services – provide information on designing and managing cloud solutions
- Specialist/s of communication via infrastructure – provide information on designing and managing communication solutions based on infrastructure