053220 Metamodeling

Summer Term 2020

Project Concept

A Modeling Method for the Domain of Logistics

Group #10

Method Engineers:

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1. Domain Description

The domain of our modeling method is the logistic industry with a special touch of a specific factor; a pandemic.

*"**Logistics** is generally the detailed organization and implementation of a complex operation. In a general business sense, logistics is the management of the flow of things between the point of origin and the point of consumption to meet the requirements of customers or corporations. The resources managed in logistics may include tangible goods such as materials, equipment, and supplies, as well as food and other consumable items." [1]*

As the definition clearly describes, we are focusing on the flow of essential goods with the origin of the production sites and an end point of the resellers. Throughout this document we will describe the products we are observing, the pieces of information and data we will use and combine creating valuable data, and what outcome we want to realise with our modeling method.

Throughout our project we will take the pandemic factor on different levels into consideration; how a government can influence the transportation routes with border closures or the daily operation of producers and resellers with restrictions, how the consumer behaviour changes, how the shops and other economic parties react to these changes.

2. Scope and Purpose

Within this project we want to realise a new modeling method for the logistic industry during a pandemic crisis. A new modeling method, which is not only essential for the logistic industry, but taking into consideration how the circumstances have changed during the presence of the current COVID-19, it is more crucial than ever.

At the beginning of the project we defined two objectives that we aim to fulfill with the modeling method. The aim to support the relevant parties involved in the logistic industry with the ability of making adequate decisions during a pandemic crisis. By applying our modeling method, a user will gain insight on the current demand and supply situation of a specific area, meaning the user will be able to spot supply shortages, analyze the performance of production sites. With the appropriate usage of those pieces of information, an effective reaction plan can be created. The second goal is aiming to create a better understanding of the transportation system between the economic parties. To achieve this goal, we need to be able to identify transportation weak points including the worsen border situations. After having a better understanding of the possible routes, we want to help to find the optimal one.

As our focus with this modeling method is not on the whole Supply Chain Management, but a smaller part of it, the logistics, and also in a critical era, where we have to take a pandemic into consideration, we have to define in-scope and out-of-scope factors. First of all, we are focusing on products, where we can observe a significant rise in demand. These products consist of versatile products which we categorize in three different groups: food, medicine and care products. We are also having a limiting criteria regarding the parties within this method; we are focusing on producers (who are only selling the products to resellers, but have no contact to individual end customers) and resellers (who are responsible for the fulfilling of end customer needs). The transportational connection between these parties can be versatile, however, the vast majority of the activities are accomplished by using either truck or train. As such, we are concentrating on transports made by these vehicles and excluding all others. Even though we would like to focus on the logistic domain only on a national level, we have to take into consideration that national supplies are strongly dependent on the international situation; due to closed or strongly limited borders transportation routes can be cancelled or strongly hindered with delays.

Taking all above mentioned parameters into consideration we want to create a domain-specific modeling method, which grants several benefits for the relevant economic parties. We believe that the parties will 1) have a better understanding of the current pandemic situation 2) have a better overview of their own capabilities and 3) run simulations for gaining insights on what impact their decision could have.

In order to design, implement the DSMM and the enable all relevant users using this we approximate financial expenses as follows:

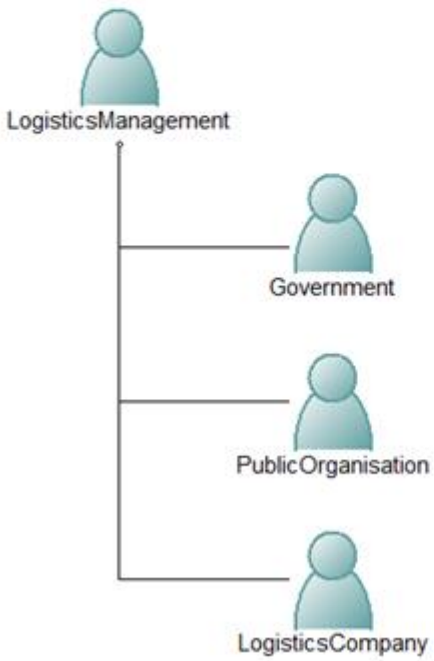
1) the fees of domain experts, who will be responsible for providing the expert knowledge in the field of logistics and crisis management
2) modeling engineers, who design the model instances and also help general users to use the tool
3) versatile costs which might occur during the collection of data (geographical) and the usage of other external resources.

There are several risks in our DSMM such as: wrong or insufficient geographical data, mistakes during the model generation, wrong estimations in regard to demand and supply, not taking all concepts and rules into consideration, misuse of objects, using the DSMM for a purpose, that is not in our scope and other errors which can occur due to the human factor.

Purpose diagram (created with CoChaCo)

3. Involved Roles

The target audience of our modeling method consist of diverse economic parties, who are affected by the logistic transformations in a pandemic era. We aim at governments, who need to have a better understanding of the pandemic situation to support decision-making. Logistic companies, who need to adapt to the pandemic situation and all extraordinary regulations made to eliminate the threat. Public organisations, who are now facing a unique situation. To be able to create a proper modeling method, we have to apply domain specific knowledge, which must be provided by domain experts. The first area where we need this kind of input is the supply chain. The supply chain is an aggregation of different subareas, like logistic, storage management, production, etc. Even though we are not focusing on all parts of it, a supply chain expert is capable of providing us the necessary logistic and transportation knowledge. To be able to make a judgement of the different routings, we need knowledge regarding the governmental decisions and pandemic experts, and in order to be able to find the optimal route, we need deeper knowledge of how the road system is situated (streets and rail map). After we have defined who are considered to be our target audience and what expert knowledge needs to be provided for us, we would like to introduce the tasks, which can be executed with our modeling method. We consider our project to be successful, if we are able to have at least two different outputs of the modeling method; a crisis management plan and an optimal route selection. For realising the first outcome, we need data from several sources. By having a list of the critical products, we can identify who are the producers of those products, what are their producing capabilities, who are the resellers and how they cope with the demand from the end customer side, and we can also measure the storage of both parties. With the help of these data we are capable of creating an as-is situation report, which reflects the current statuses and conditions. Out of this report, we will have a deeper insight on the producers and resellers, where we can identify a measurement, which indicates that an action is needed and the current situation is not sustainable. We can identify resellers, who are unable to handle the demand of their customers, or producers, who show an unexplained decline in production. After having a list of the critical parties and the reason behind their criticality, the users of the modeling method will have the possibility to create a strategy, which aims to resolve this situation. With the help of the included “time” parameter, the decision maker will have the capability to run simulations to check what the impact of the not yet introduced decision would be. For the second outcome, we will use nodes (which indicates a static element like the location of an economic party, the border, etc.), the paths between those nodes and the vehicles, which are supposed to move on those paths. By analyzing these pieces of information, we will be able to create a great amount of permutations of diverse transportation connections, a transportation map. Because of the pandemic situation, however, we are facing possible restrictions like closed roads, closed borders, shut-down economic parties, etc. In the next step we will filter down the transportation map to only the valid and possible routes. Finally, as there might be more than one route between economic parties, we will run simulations to enable the decision maker choosing the optimal route for himself, which can be selected by either the shortest distance, shortest duration, lowest fees, etc.



Involved roles (created with CoChaCo)

4. Requirements

a. Generic Requirements

Formal Requirements

FR1	*The metamodel should be clearly structured and easy to understand. Main concepts as well as used symbols should be self-explanatory.*
FR2	*Instructions on how to use the modeling method should be included*
FR3	*Reusability not only for COVID-19 but for upcoming pandemics too*
FR4	*The syntax is clearly defined in the documentation and users get error messages whenever modeling conventions are broken*

User-Oriented Requirements

UOR1	*The users should be provided with easy-to-interpret graphics and notations, in order to give guidance for decision-making*
UOR2	*The DSML should provide only few general concepts for creating models*
UOR3	*The notations for the concepts have to be familiar for all users creating an interdisciplinary bridge between the different users, so that they can apply them intuitively*
UOR4	*Various levels of detail and abstraction should be allowed in the modeling language. The modeler is not forced to specify details that are not necessary.*

Application - Oriented Requirements

AOR1	*We have to avoid the modeling of overlapping semantics*
AOR2	*Limit the complexity and number of model elements, abstraction is used*
AOR3	*The basic concepts are generic enough to be used for potential future application scenarios and specific enough to achieve our DSMM goals*

b. Specific Requirements

i. Use Scenarios - Logistics Strategy Planner

The Austrian government requires guidance in the planning of an appropriate strategy to cope with supply shortages in the logistics system during the corona crisis. Consequently, the government decides to order the development of a modeling method for logistics strategy planning. The method supports government individuals with the modeling of the major logistics actors: producers and resellers. The producers and resellers are situated in an area aggregating their supply and demand. These actors are connected with a transportation net, which is used for the transportation of goods. Both, the actors and the distribution network, allow for models with different levels of abstraction. For instance, example diagram 1 shows a logistics map of Austria and its states. In order to reduce complexity, producers and resellers can be aggregated with their umbrella company and only major actors are modeled. Example diagram 2 shows a logistics map of selected districts of Vienna. The modeling elements are depicted with more detail (individual resellers and producers) and include borders to adjacent countries. Based on the created models, the modeler can simulate how well areas are supplied with essential goods over time and check how actions (e.g. restrictions) affect the provisioning. Areas are colored with respect to their supply situation ranging from red (critical supply shortage) to green (full stock). This should enable governmental decision makers to quickly identify shortages and act upon them.

Realisation:

Diagram 3 depicts the realisation of this use scenario in ADOxx. It shows all model elements of diagram 1 and diagram 2 and is reduced in model element amount. It demonstrates how the concept diagrams have been implemented and that the full functionality is present in the implementation.

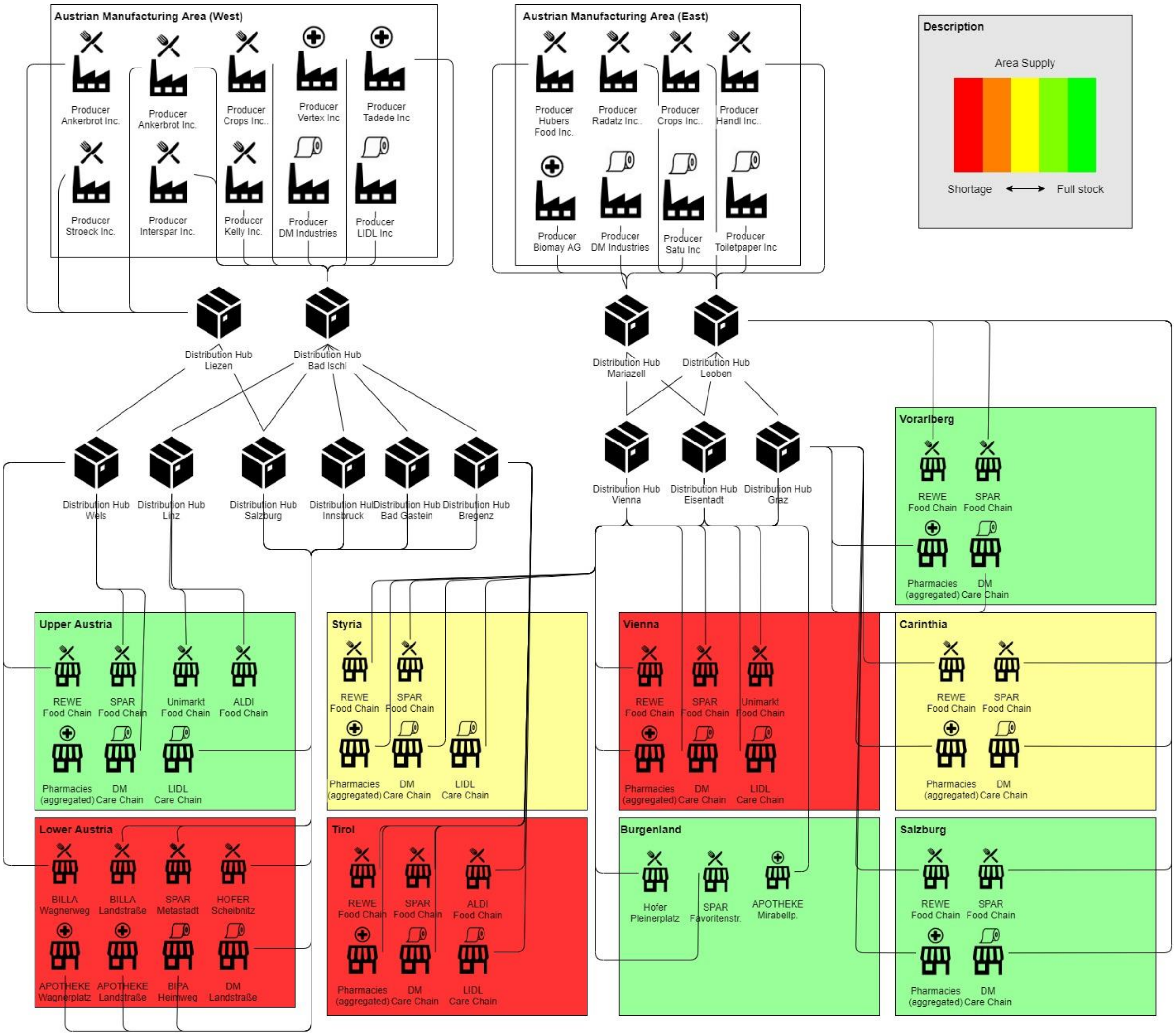
ii. Use Scenarios - Logistics Route Planner

Based on the use scenario logistics strategy planner, the government and logistics companies want to analyze the detailed routes between producers and resellers (e.g. between producer Radatz and reseller Billa). The user may select these actors and use the model creation capability to build a logistics route map between them. The map is created via a web service call returning paths and nodes between the actors. Path elements include railways and streets. Nodes include resellers, producers, train stations, borders and crossings. Example diagram 3 shows the connection between a producer and a reseller within the same country. It depicts a trivial view of all streets and crossings connecting the two parties. Example diagram 4 shows a more detailed model taking foreign producers into consideration, so that the border concept has to be applied. Furthermore, there are not only streets connecting the two parties, but also train stations with railways in between. The goal of the scenario is to then perform a path analysis, which shows the optimal route between the producer and the reseller in respect to transportation speed and distance.

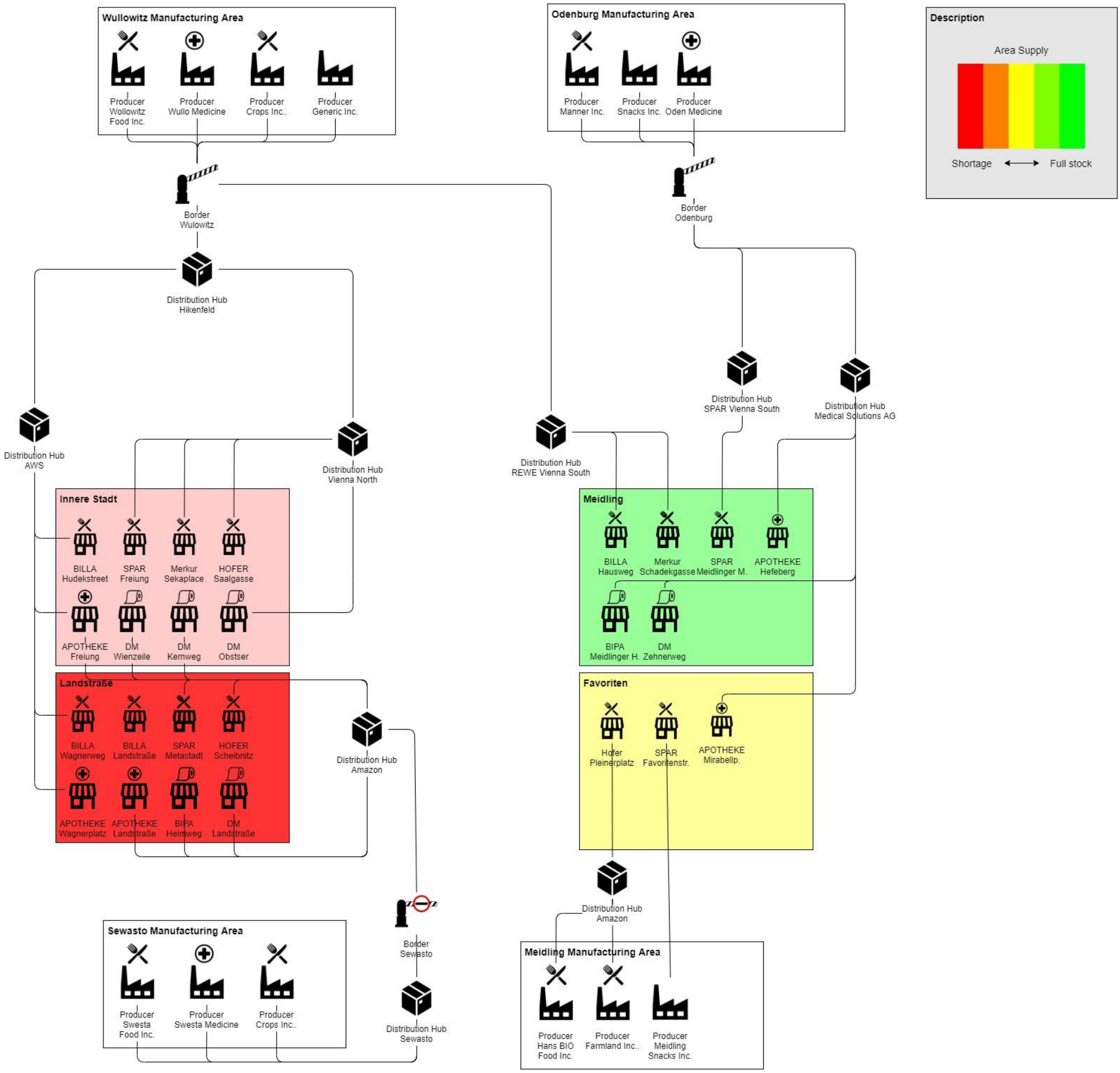
Realisation:

Diagram 6 shows the implementation of this use scenario in ADOxx. It shows all model elements of concept diagrams 4 and 5 except the border element. The authors decided that the border element is not of great importance in this model type so it is not part of the implementation. In addition to the concept diagrams, route costs have been implemented and visualized for the paths (streets and rails). In total, full functionality of the concept has been implemented for this use scenario.

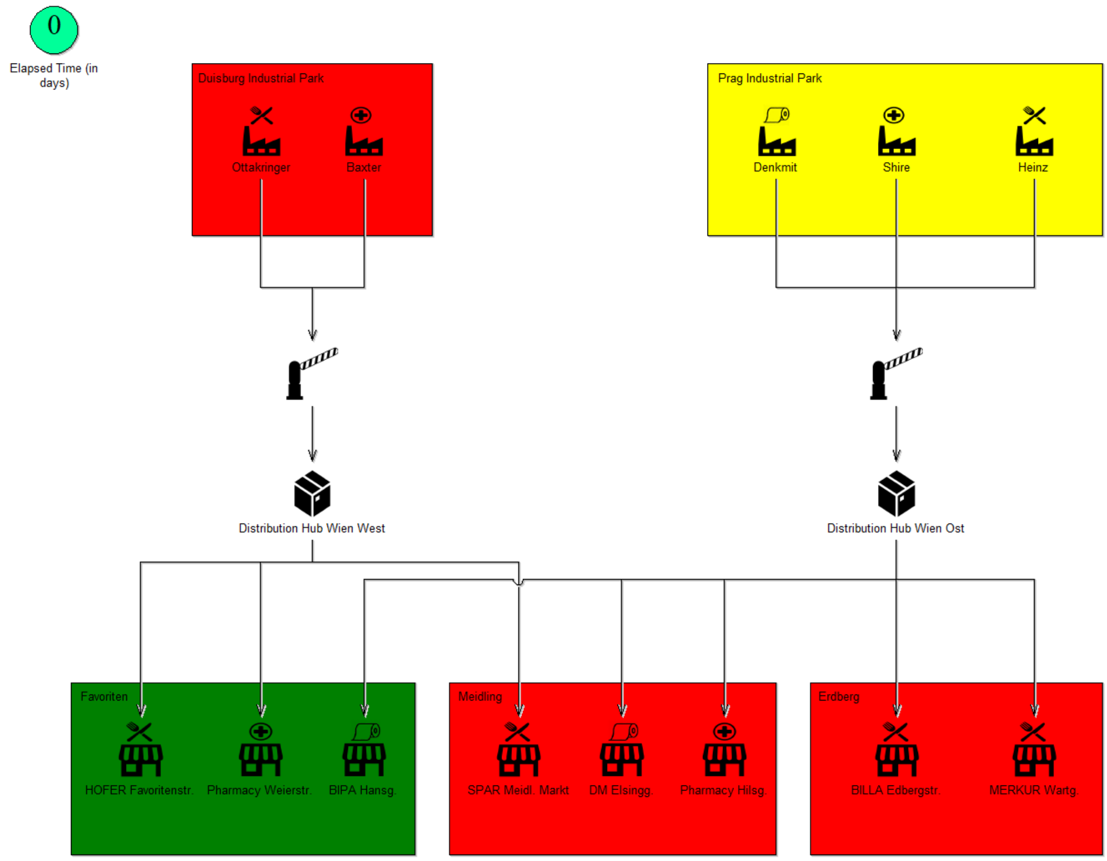
ii. Example Diagrams



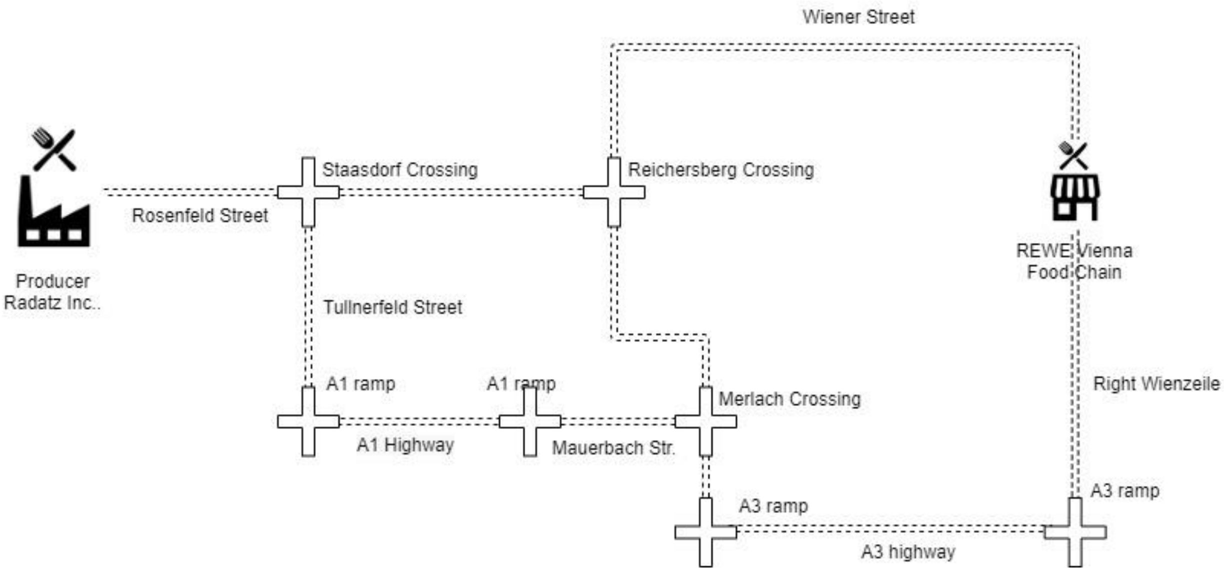
Example diagram 1: Governmental state view of Austria (created with draw.io)



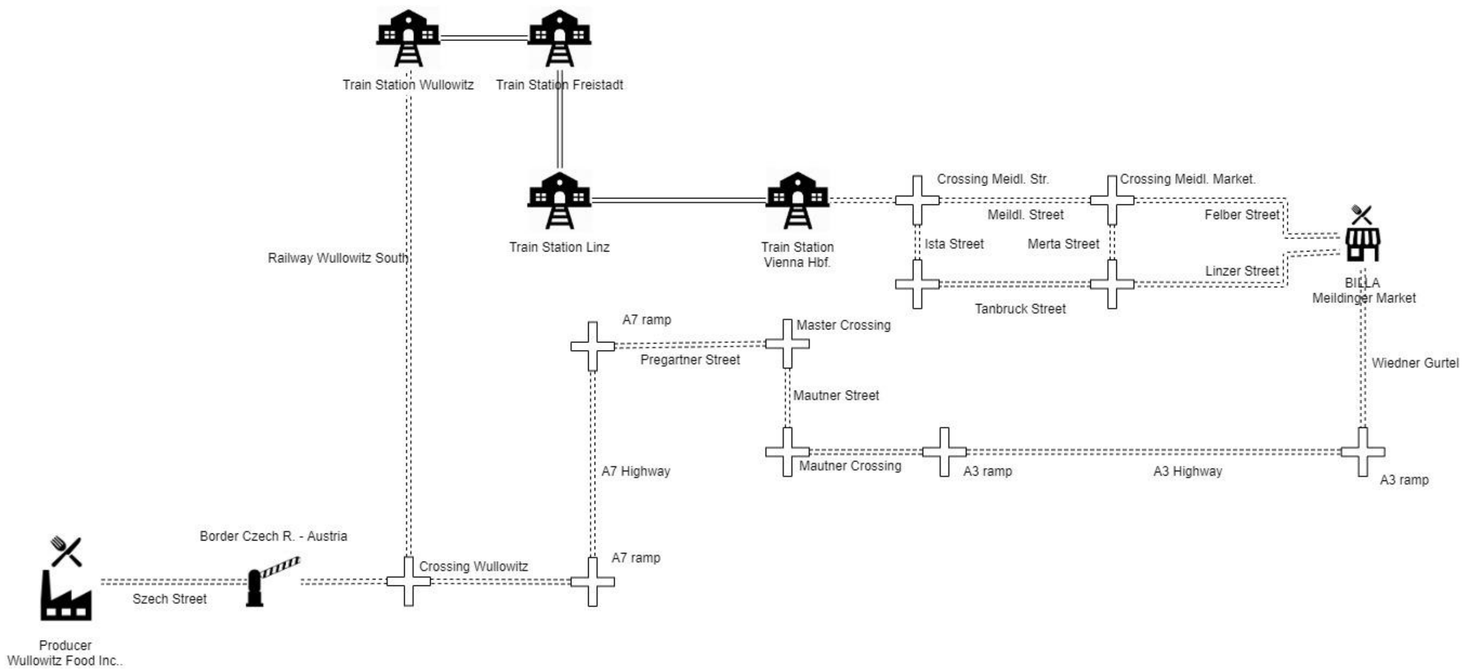
Example diagram 2: Governmental district view of Vienna (created with draw.io)



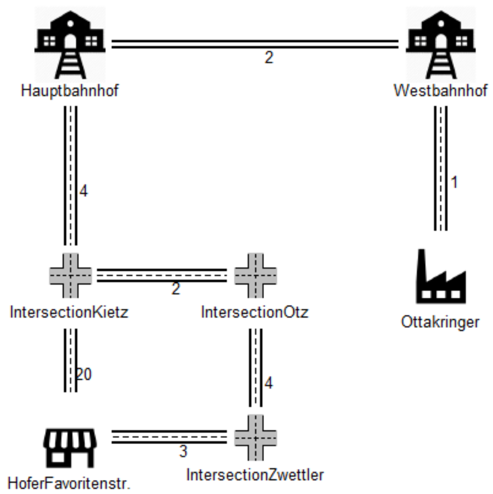
Example diagram 3: District view of Vienna (excerpt of modelling method in ADOxx)



Example diagram 4: Logistics planner - national view (created with draw.io)



Example diagram 5: Logistics planner - international view (created with draw.io)



Example diagram 6: Logistics planner – national view (excerpt from modelling method in ADOxx)

iii. Catalog of Requirements

RQ1	The modeling method must include general concepts of logistics (e.g. transportation infrastructure, producers and resellers)
RQ2	The modeling method must include domain-specific concepts for a pandemic crisis (e.g. restrictions and shut downs)
RQ3	The concepts must be connected via relationships to form a logistics system enabling algorithms and simulations
RQ4	Models have to fulfill their defined purposes (e.g. transportation route optimization and detecting shortages)
RG5	Modeling method should enable user to model on different levels of abstraction (e.g. modeling generic logistics concepts such as producer versus defining specific of concepts such as food producer)
RQ6	Modeling method must integrate the dynamic concept time to the model, so that simulations can be performed in time lapse mode
RQ7	Concepts with external resources and decision-making have to access the corresponding changes via web services, so that they will get automatically integrated into the models

iv. Additional Functionality

1. Simulation

The first model type (logistics strategy planner) shows logistics actors (producers and resellers) delivering goods via a transportation net. Within a model instance, there is a time component and the possibility to perform strategic decisions (e.g. apply restrictions). The modeling method can then perform a simulation to check how these model changes affect the supply of essential goods in areas. The simulation results are visually presented to the user in the form of coloring the supplied areas (e.g. red for supply shortage and green for full stock).

2. Model Transformation

The Logistics Strategy Planner model type offers an overview and analysis of the logistics situation in times of corona. Within this model type, producers and resellers are connected over a rather abstract and simplified transportation net. By selecting one producer instance and one reseller instance, the user can trigger a model transformation. The modeling method then accesses an external web service which returns the concrete paths and nodes between the actors and creates a map for the logistics route planner.

3. Path analysis

The second model type (logistics route planner) offers a detailed model of the transportation net between 2 actors (e.g. 1 producer and reseller) including all paths and nodes between them. Paths can be railways or streets; nodes can be crossings, train stations and generic nodes. Based on this transportation map, the modeling method can perform a path analysis creating an optimal route between the actors as output. This route can be used for logistics companies such as carriers.

4. Linkage to external web services

The logistics strategy planner model type offers the model transformation stated before. This model transformation requires external resources of the transportation net layout such as streets, railways, crossings, train stations and borders. These resources are accessed via a web service, which returns a list of all elements connecting producers to resellers.

v. Concept Dictionary

Concept: Economic party (abstract superclass)	
Economic parties are in our modeling language producers, which create goods and products, as well as resellers, which are in direct contact with consumers and sell the goods obtained by producers. Additionally, distribution hubs are introduced as links between producers and resellers. Economic parties have capacities, which indicate how many goods they can store.	
Attributes	
Title	Name of the economic party

Current_Capacity	Describes how many goods are stored at a certain moment in time by an economic party. During simulation the current capacity is updated after each iteration. Therefore it describes a dynamic variable.
Maximum_Capacity	Describes the peak capacity of an economic party. It is a predefined static variable.
Location	Defines the geographical place of the entity
Associations	
Path	The path relationship describes the generic connection between economic parties. (used in the pandemic strategy planner)
Route	An economic party is connected to roads and/or to train stations.
Constraints	
Restrictions	In case of a (pandemic) crisis, parties can be open as well as close. If they are closed the capacity of the ones affected goes to zero.
NotNull	Capacity attribute cannot be null, it has to contain a numeric value
Children of the superclass	

child_1	Producer
child_2	Reseller
child_3	Distribution hub

Concept: Producer	
Producers are divided into our three critical product-groups, i.e. food, medicine and care products. They are an important supply chain member because they manufacture goods that are concludently transported to resellers.	
Attributes	
Production output	Defines how many products of a specific type can be produced within a given time period.
Type	Specifies which type of products the produces manufacturers (i.e. food, medicine, care product).
Utilization	Describes the relative utilization of a producer
Associations	
Constraints	

Limitation	Restrictions to the producers (e.g. limited number of employees allowed in the production site) result in a relative reduction in production output (i.e. supply).

Concept: Reseller	
Resellers, equal to producers, are divided into food-, medicine and care product resellers. They represent the most fragile element of the supply chain as they are a direct contact point to consumers.	
Attributes	
Demand	Defines the required amount of products
Type	Specifies which type of products the resellers offer to their customers (i.e. food, medicine, care product).
Associations	
Constraints	

Concept: Distribution Hub

Distribution hubs behave like warehouses where goods can be stored. Their purpose is to bridge distances between producers and resellers, especially in regard to foreign producers.

Concept: Border	
Foreign producers are connected to borders before they are linked to a national distribution hub or reseller. In the course of a pandemic crisis borders can be closed, which impacts the supply chain system.	
Attributes	
Status	Borders can either be open or closed.
Crossing-time	Time necessary to cross the border.
Associations	
Route	A border is connected to roads.
Path	The path relationship describes the generic connection between economic parties. (used in the pandemic strategy planner)
Constraints	

Limitations	If a border is closed, there is no possibility to transport goods from producers of the affected country.

Concept: Area (aggregation)	
An area groups all economic parties that are situated within this aggregation. It is important for decision making to be provided with a high level of information (ideally well visualised) in order to have an overview of the situation to be able to take sophisticated measures. An area combines all relevant numeric information and visualises the current situation of a given zone.	
Attributes	
Title	Provides a name to the aggregated area.
Sum_of_area	Cumulates all demands and supplies within an area
Status	Defines the status of the area (e.g. red for shortages)
Quarantine	Sets the corresponding area und quarantine, so that no outgoing or incoming flow of goods are allowed
Associations	
Is_Inside	Has an “is inside”-relation with economic parties that are inside the area

Constraints	
Allowed_objects	The area can only summarize a set of producers or resellers

Concept: Train station	
A train station is the connection between the rail and the road system. Trains are only allowed to drive on rails, so train stations can be thought of the starting and end point of a train bound transportation.	
Attributes	
Title	Gives the train station a name.
Associations	
station_to_station	Relational associated with another train station.
station_to_road	Relational associated with a road
Constraints	
constraint_1	Must be connected to a rail. Can be connected to a road.

Concept: Crossing	
A crossing (intersection) is a decision point (node) in the road system.	
Attributes	
Title	Defines the name of the crossing.
Associations	
Route	Relational associated with a road.
Constraints	
NumberOfConnections	There is a minimum of 3 connections for a crossing.

Concept: Social distancing	
Because of the infection distance of a virus, people within an area must keep the distance. This results in limiting the number of customers,- workers in a closed unit. This affects the production of a producer (having less workers) and the income of resellers (having less customers).	
Attributes	

DistanceFactor	Defines the reduction of workers on production sites or the reduction of customers at resellers necessary (percentual production output)
Associations	
Constraints	
HasEconomicParty	The model needs to have EconomicParty concept

Concept: Shortened shift (kurzarbeit)	
As there is less demand for specific products, producers might need to optimize their production without reducing workforce. This can be achieved by a reduction of working hours.	
Attributes	
Reduction	Defines the relative reduction of labor on production sites
Associations	

Constraints	
HasProducers	The model needs to include producers

Concept: No More Schengen	
Due to governmental decisions open borders might face with a greater number of pendlers, who needs to have extra permission apart from passport or ID, needing more time to get their prerequisite documents checked to cross the border	
Attributes	
Delay	Defines the time necessary per border crossing
Associations	
Constraints	
HasBorders	Concept can only be applied if borders are present in the model.

Concept: Panic buying	
During a pandemic the customers buying habits are strongly affected by fear of running out essential goods. In order to alleviate this hysteric behaviour, they cumulate those products.	
Attributes	
level_of_panic	Defines the factor by which the demand of all resellers rises due to panic buying
Associations	
Constraints	
HasReseller	The concept requires resellers to be defined in the model

Concept: Path (relationship)	
The path relationship describes the generic connection between economic parties. (used in the pandemic strategy planner)	
Attributes	

Associations	
Constraints	
Connection	The concept connects economic parties with each other and with borders.

Concept: Street (relationship)	
For the logistic view a street shows the logistic connections, which can only be utilized by trucks.	
Attributes	
speed_limit	Shows the maximal speed legally allowed.
length	Defines the distance of the connection.
Associations	

Constraints	
connect_economic_party	A street is used to connect economic parties with each other and with train stations as well as with borders.

Concept: Rail (relationship)	
For the logistic view a rail shows the logistic connections, which can only be utilized by trains.	
Attributes	
speed_limit	Shows the maximal speed legally allowed
length	Defines the distance of the connection
Associations	
Constraints	
connect_station	Rails can only connect train stations to each other. Any other relationship is not allowed.

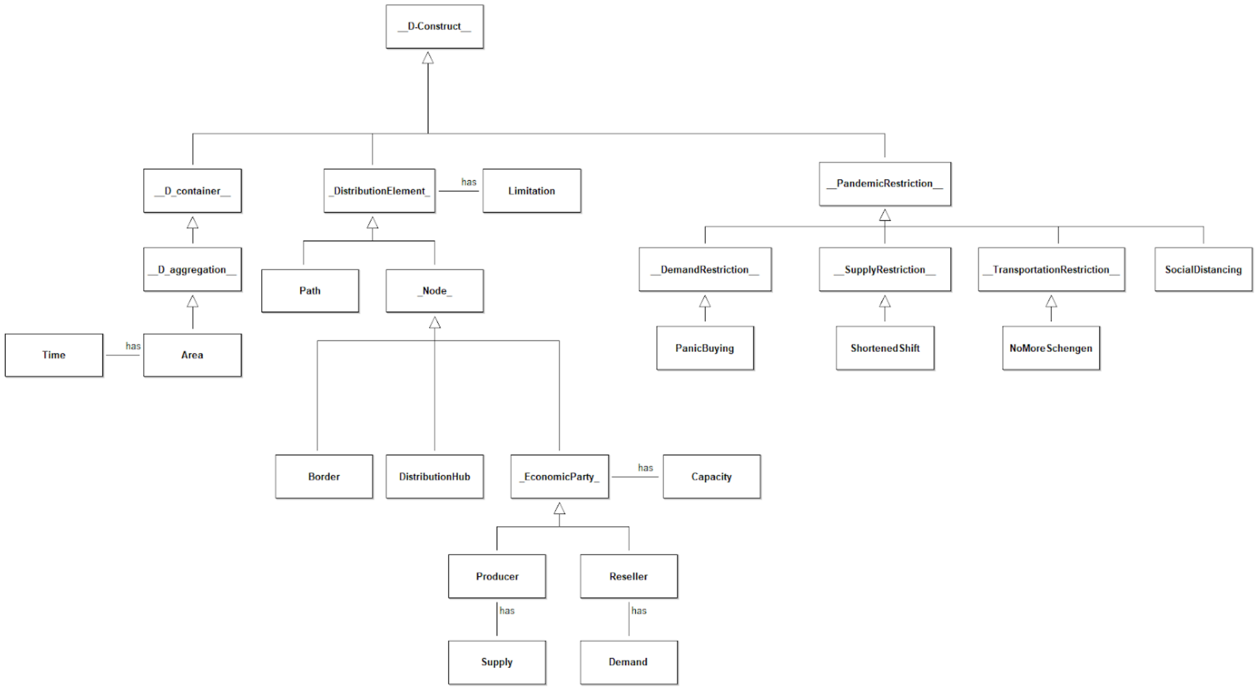
5. Metamodel

a. Specification of Metamodel

ConceptName	**Specification**
Area	<Area>:<__D_aggregation__>
Time	<Time>:<__D_variable__>
DistributionElement	<DistributionElement>:<__D_Construct__>
Length	<Length>:<Restriction>
Node	<Node>:<DistributionElement>
TrainStation	<TrainStation>:<Node>
Crossing	<Crossing>:<Node>
Border	<Border>:<Node>
EconomicParty	<EconomicParty>:<Node>
Producer	<Producer>:<EconomicParty>
Reseller	<Reseller>:<EconomicParty>
Restriction	<Restriction>:<__D_construct__>
Time	<Time>:<Restriction>
VehicleNumber	<VehicleNumber>:<Restriction>
Capacity	<Capacity>:<LocationStatus>
Supply	<Supply>:<__D_Construct__>
Demand	<Demand>:<__D_Construct__>
PanicBuying	< PanicBuying >:<__D_construct__>
NoMoreSchengen	< NoMoreSchengen >:<__D_construct__>
ShortenedShift	< ShortenedShift >:<__D_construct__>
SocialDistancing	< SocialDistancing >:<__D_construct__>

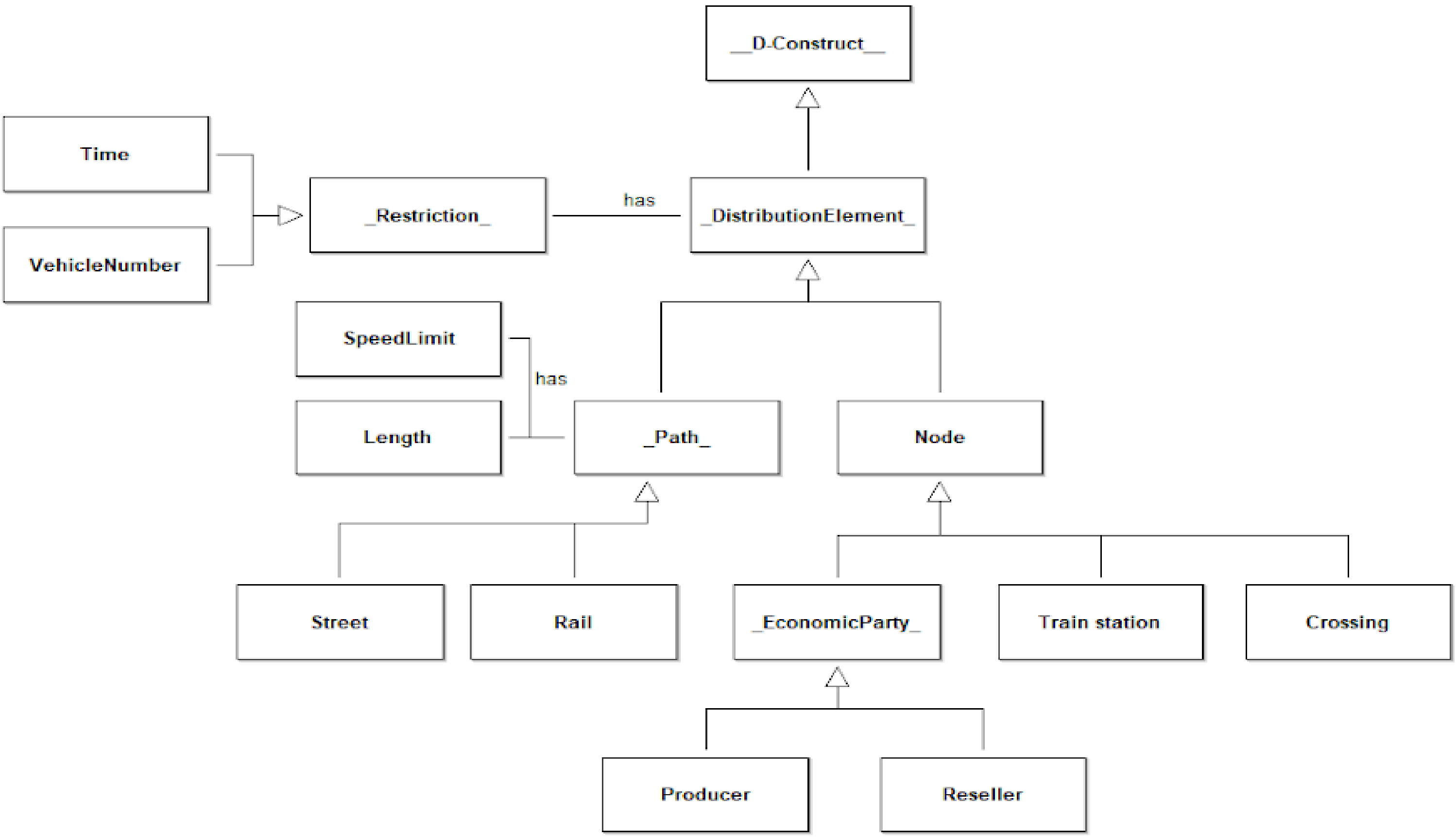
b. Modeltypes

Modeltype 1:Logistics Strategy Planner

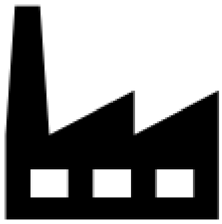


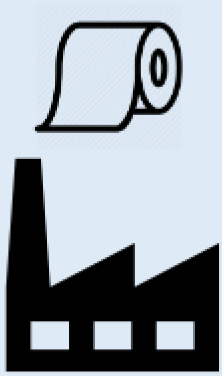
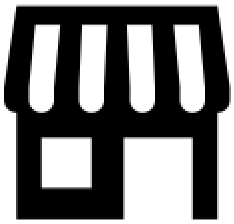
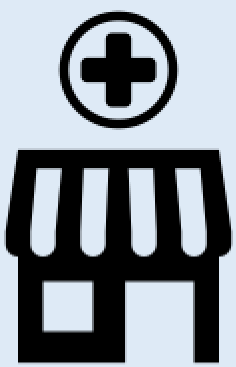
__D-Construct__
__D_container__
DistributionElement
has
Limitation
__PandemicRestriction__
__D_aggregation__
Path
Node
__DemandRestriction__
__SupplyRestriction__
__TransportationRestriction__
SocialDistancing
Time
has
Area
PanicBuying
ShortenedShift
NoMoreSchengen
Border
DistributionHub
EconomicParty
has
Capacity
Producer
Reseller
has
has
Supply
Demand

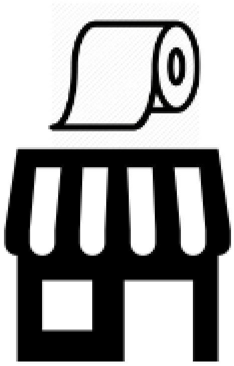
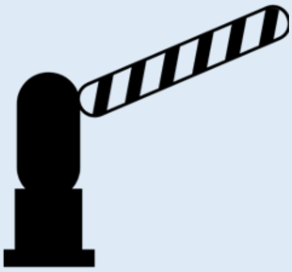
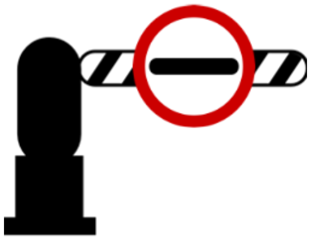
Modeltype 2: Logistics Route Planner

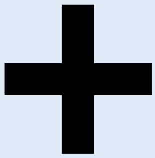


6. Notation

Concept	Notation
Producer (generic)	
Food producer	
Medicine producer	

Care product producer	
Reseller (generic)	
Food reseller	
Medicine reseller	

Care product reseller	
Border open	
Border closed	
Distribution hub	

Train station	
Crossing	
Road (relationship)	
Rail (relationship)	
FlowOfGood (relationship)	

7. Modeling Procedure

1. I want to create an economic map of a national area and simulate several scenarios upon the model

MODELING (model type 1)

Create a new model of type “Logistic strategy planner”.

Within the modelling environment create 1-n producers, 0-n borders, 0-n distribution hubs and 1-n reseller.

Connect those entities using the relation “FlowOfGood” in the following fashion: producer => (border) => distribution hub => (border) => reseller

(Hint: any other order of connections is restricted, the product flow always originates at a producer and ends at a reseller, if not necessary you won’t have to model distribution hubs).

You can specify (or leave your model generic) if a producer or reseller is of type “food”, “medicine” or “care product” to approximate the model to reality, by double-clicking on an entity and flagging the corresponding radio box.

After the basic economic overview of an area (e.g. a state, a district) is created, you can now detail the supply and demand parameters of the object’s producer, distribution hub and reseller.

In order to make the simulation work every entity should be enriched by those parameters.

Short explanation to the parameters:

<u>Non special parameters for any economic entity</u>
Current capacity: represents the current stock of goods at t=0 at a specified economic party e.g., producer of type food has a current capacity of 5, this means the producers stock is filled with 5 units of the product “food”.

Maximum capacity: this parameter represents the maximum amount of goods an economic party can store at any time; it is not possible to store more than the maximum capacity. You can imagine this parameter as the size of the warehouse/stock of an entity.

<u>Special parameter only for producer</u>

Supply: this parameter describes the number of goods that are manufactured by the producer within one time unit (time units will be described later on, as they are important for the simulation phase).

Special parameter only for reseller

Demand: this parameter describes the number of goods that are bought by the customers of the reseller within one time unit.

Now that every economic party is fairly well parameterised, we can cluster producers and resellers by creating aggregations, so called “areas” which arrange groups of producers/resellers more granular.

If an area overlays the producer or reseller sent it to the background by right-clicking and choosing “Layer” and then “To background”.

Borders along the route between producers, distribution hubs and resellers can either be open or closed.

Last but not least create a “duration tracker” by using the model object “TIME” and place it anywhere you like (we suggest the left upper corner as convention).

Do not forget to give producers, distribution hubs, resellers and areas names so that the viewer of the model instantly will understand what the model is about.

SIMULATION

It is time to do some simulations on top of the created economic model.

Open the simulation module of ADOxx and click on “Economy Simulation” and “Update supply and demand”.

The upcoming dialog box will ask you how many days you’d like to simulate
After filling in the desired amount of time units (=days) you can click on “OK” and the simulation will start.

By looking at the time object we can see while the simulation runs through at which point in time, we currently are.

Every second the time objects jump to the next day until the specified duration is completed.

What we see is that the colour of the areas (aggregations) will change according to the current capacity situation.

What do the colours mean?

Colours indicate how critical the capacity situation at a given area is, green indicates that everything is alright, yellow shows that the capacity situation is fairly well, but not ideal. Starting for orange the capacity situation is indicating that there might be problems within the supply chain. If an area is coloured red there is a severe problem with stock replenishment, immediate actions are needed.

Mathematics behind the colour code:

Green: 100% - 80% as the result of the calculation: Current capacity / Maximum capacity at a particular time
Yellow: 80% -50% as the result of the calculation: Current capacity / Maximum capacity at a particular time
Orange: 50% - 20” as the result of the calculation: Current capacity / Maximum capacity at a particular time
Red: 20% - 0% as the result of the calculation: Current capacity / Maximum capacity at a particular time

If all areas stay green this might indicate the normal stage of affairs.

But how does the modelled adapt if e.g. a pandemic crisis occurs?

RESTRICTIONS

We enriched our modelling method by pandemic related concepts that can be applied to the model to see how the market dynamics change, if certain events occur.

We cluster the restrictions into the following effect-groups:

<u>Demand restrictions</u>
Panic buying: By inserting this model object into the model the modeller can simulate how demand sided effects could worsen the situation. This object comes with one parameter, namely “Magnitude of Panic” which requires a percentage value of how severe the effects of the panic buying increase the demand. The demand value of all resellers will be increased by the defined percentage.

<u>Supply restrictions</u>
Shortened shift: This concept is interesting after the big panic has settled down. Demand for non-essential goods decrease massively and there is no need for producers to bring out that many goods. Shorten shifts are introduced to understand how much work hour reduction is bearable before supply scarcity kicks in. Similar to panic buying the modeller is equipped with the parameter “WorkHoursReduction” in which s/he can define on a perceptual basis how much the shift duration will be reduced.

<u>Transportation restrictions</u>
No more Schengen: As the crisis escalates nations do anything for damage control. They close down borders so that the virus can’t be brought into the nation for the outland. The

modelling object “NoMoreSchengen” closes down all borders, disabling all foreign product flows into the nation. By deleting the object all borders will be opened again.

General pandemic restrictions

Social distancing: Due to the way the virus is transferred from person to person the nation obligates its citizens to keep a minimum distance to each other, while shopping, while working at a production site. This effects the demand, as well as the supply, because there is a limited number of people allowed in a building. By activating the modelling object “SocialDistancing” every resellers demand and every producers supply is decreased by 20%.

2. I want to visualise the route between two economic parties (one producer, one reseller)

MODEL TRANSFORMATION

Within the modelling environment of the “Logistic strategy planner” there is the “Model transformation” function.

You have to choose two objects by holding the strg-button on your keyboard and clicking on them to make them eligible for model transformation.

(Hint: The only implemented allowed pair of objects within the “Logistic strategy planner - perfect setup” is the producer “Ottakringer” and the reseller “HOFER Favoritenstr.” - This is a mock-up because there is no standard functionality for our use case)

After having both objects selected you can click on “Model transformation” and furthermore “Create logistic route planner”. After doing this a new model of type “Logistic route planner” is created. This model is using a web service call to get possible routes between these objects.

As you can see the objects of the created model are somehow glued together, easily distribute the objects so that they look nicely placed.

3. I want to calculate the shortest path and visualise it on the model

ANALYSIS

For this task we decided to implement the Dijkstra shortest path algorithm to our modelling method. You can use the newly transformed model to perform this analysis or any self-made model. (we will discuss how to create a “Logistic route planner”-model later on).

In order to analyse the shortest path, you have to change to the analysis environment within ADOxx and click on "Route Optimizer" and then decide if you want to visualize the optimal route "Visualize Optimal Route" or if you'd like to calculate the shortest path "Calculate Shortest Path".

By choosing the "Visualize Optimal Route" option the relation objects of the model, the corresponding nodes, as well as the producer and reseller, will be manipulated in the following fashion:

- All relations (might it be road or rail) that are part of the shortest path change their colour and are painted green
- All node objects along the optimal route (=shortest path), such as crossings and train stations, are enriched with a green quadrangle surrounding those objects

By using the "Calculate Shortest Path" function the user of the model will be presented with an INFOBOX, displaying the following information:

- An enumerated list beginning at the producer, ending at the reseller, of nodes which are chronically sorted, that have to be passed in order to reach the destination (the reseller) by taking the optimal route into account
- The result of the Dijkstra algorithm returning the total length of the optimal route

MODELING (model type 2)

Create a new model of type "Logistic route planner"

Within the modelling environment create 1 producer and 1 reseller. Create 0-n intersections and 0-2*n train stations (you always have to create train stations pairwise).

There are two different relation types, namely road and rail, embedded, the following constellation of connection is allowed (any other constellation will be denied):

- **Road**
    - Producer to intersection
    - Reseller to intersection
    - Intersection to intersection
    - Intersection to train station
    - Intersection to producer
    - Intersection to reseller
    - Train station to intersection
    - Train station to producer
    - Train station to reseller
- **Rail**
    - Train station to train station
    - Producer to train station

Now connect your node objects, these are producer, reseller, intersection and train station according to the map you'd like to model.

After these connections are established you have to specify the cost of a connection (we call it "Cost" because it can be interpreted in regards to several attributes, cost might be distance, speed-limit, etc.). The default cost-value for a road is 2 and 1 for a rail.

If you are satisfied with your model you can go back to the ANALYSIS chapter of this instruction and perform the shortest path analysis.

8. Work Responsibility

Part/Task	Done by
Notation, **Concept Dictionary items:** economic party, reseller, producer, distribution hub, border, area, train station, crossing, panic buying	Lukas
Requirements, Scenarios, Additional Functionality, Metamodel: Specification & Modeltypes	Daniel
Domain Description, Scope and Purpose, Modeling Procedure, Concept Dictionary items: all remaining	Mate
Review and adaptations	Lukas, Daniel, Mate

9. Resources

[1] https://en.wikipedia.org/wiki/Logistics