INNOVATIONS

New data exchanges and innovative simulation-optimization integrated framework

25th September 2019

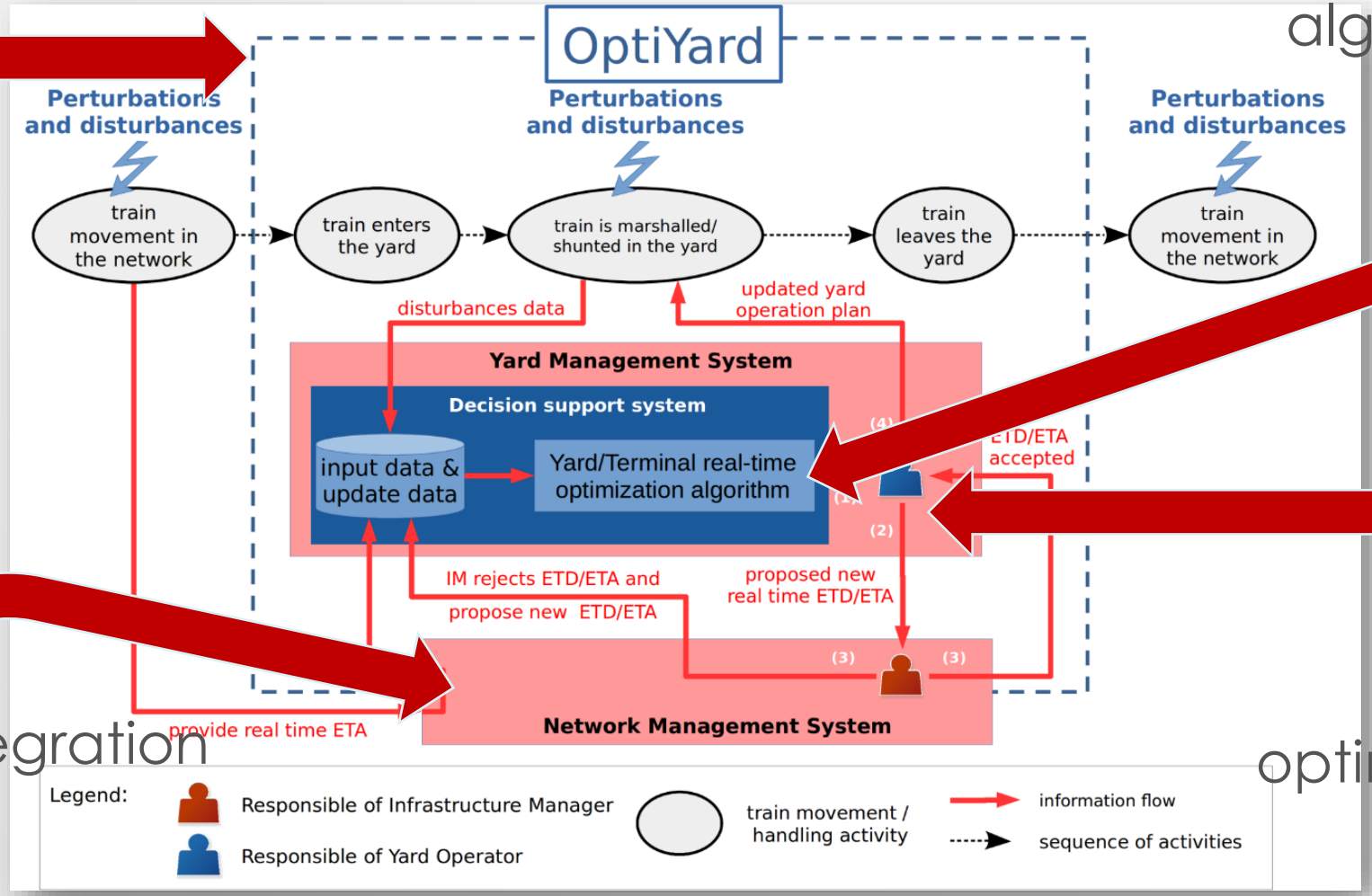
INNOVATIONS

Communication with the network

Yard optimization algorithm

Strategies for integration with the network

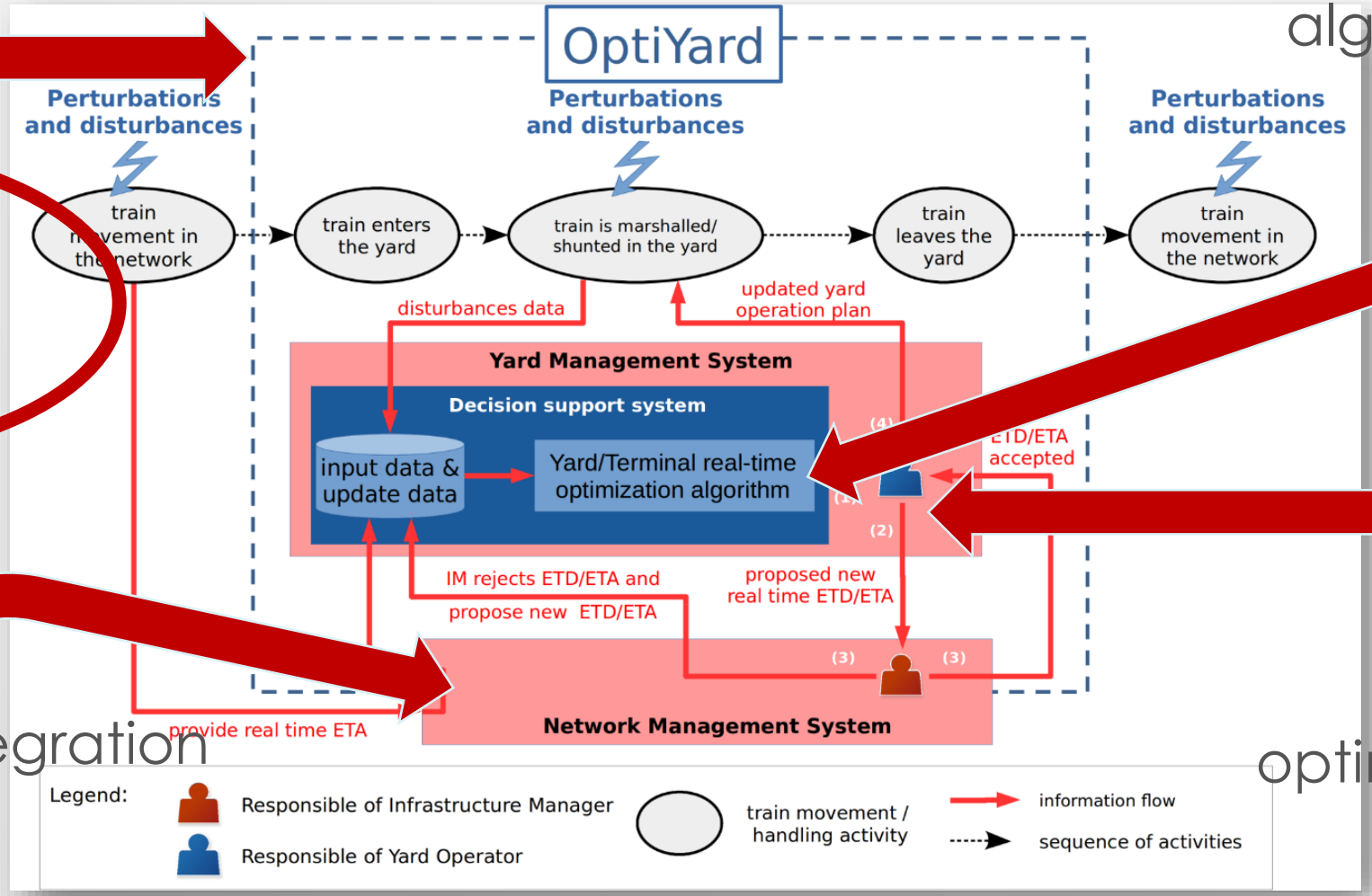
Integrated optimization and simulation framework



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COMMUNICATION WITH THE NETWORK: METHODOLOGY

Four step methodology:

1. Analysis of the **current system** and identification of main **lacks**
2. Proposal of relevant **data attributes**
3. Proposal of **communication interface**
4. **Proof of concept** on representative scenarios

ANALYSIS OF THE CURRENT SYSTEM AND IDENTIFICATION OF MAIN LACKS

We identified three main lacks due to **insufficient communication** and **incomplete information sharing** before trains arrival:

1. Estimated time of arrival (**ETA**) is known only roughly
2. Precise **composition** is unknown → unknown time for service
3. Estimated time of departure (**ETD**) cannot be calculated

PROPOSAL

We propose **standards for communication** among key stakeholders

They respect existing legislation and are based on existing standards (European **TAF-TSI** Regulation)

Objectives:

- whatever the model of operations, the marshalling yard presents itself to RUs and IMs as **one entity**
- the services provided are **publicly known**

ONE STEP FORWARD TAF-TSI

TAF-TSI precisely defines the processes in the **planning and implementation** of transport

Our proposal defines the **extension for train marshalling**

It is very closely linked to TAF-TSI for:

- Path request,
- Train preparation and running forecast,
- Information in case of traffic disruption,
- ETI/ETA of wagons,
- …

DATA ATTRIBUTES

The data attributes we propose belong to three groups:

Technical data	Technological data	Information system data
Length of train unit	Wagon transfer (to which train)	Sender info (ID)
Braking power rate	Destination of wagon	Recipient info (ID)
Maximum speed	Wagon transfer (in which stations)	Train driver
Type of locomotive	Train ID number	Train driver's phone number
Length of wagon	Number of wagon	Equipped by a tablet
Number of axles	Order of wagons in train	Path ID
Weight of wagon	RID / dangerous goods	DISOM train number
…	…	…

INTERFACE

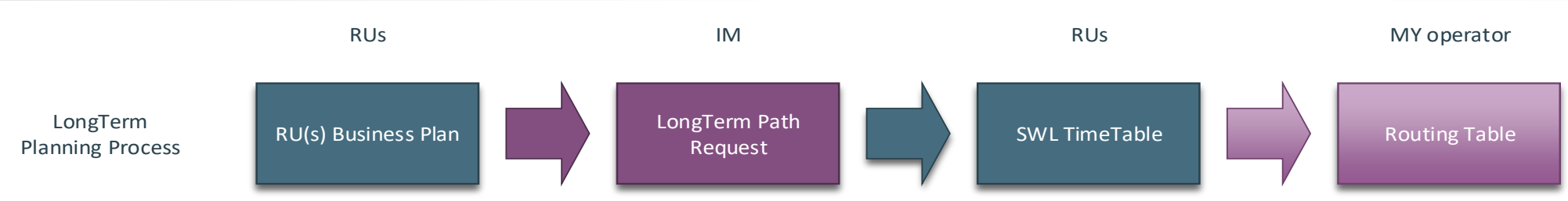
We propose to base the interface for exchanging data on a **routing table interface**

Attribute	Description	Data Type	Size	Mandatory (Y/N)	Validation	Note
PlanTrainMessage						
MessageHeader				Y		
CIMessageStatus		AN		Y	1, 2, 3	1 new, 2 update, 3 delete
MessageReference				Y		
MessageTypeCode		AN		Y		New type by EUAR
MessageTypeVersion				N		
MessageNumber		N		Y	1..999999	Created by sender
MessageDateTime	Date and time of message creation	DateTime		Y		
Sender		N		Y		e.g. 2154

....

LONG AND SHORT TERM PLANNING

In **long term planning**, long term path requests are treated



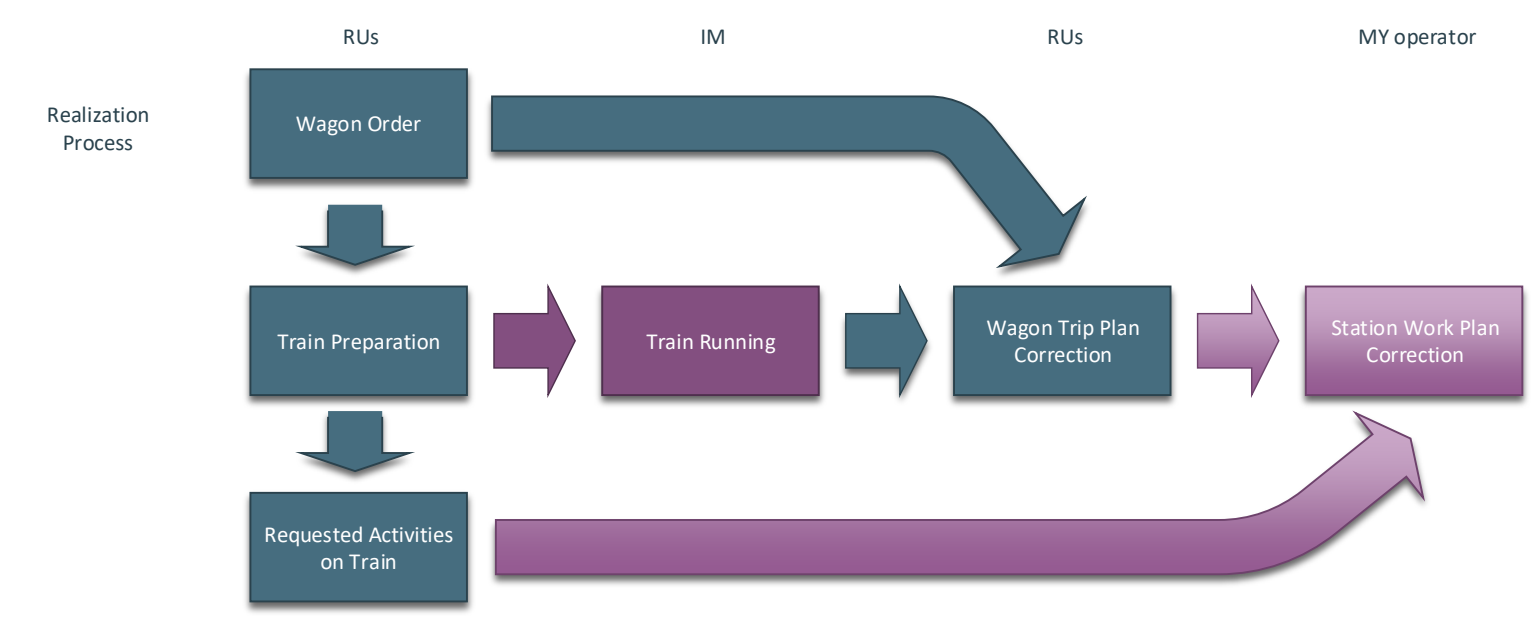
In **short term planning**, the same process is performed for specific requests

The routing table interface includes the definition of **train check-in requirements** upon arrival and before departure

DURING OPERATIONS

During operations we consider four communication interfaces:

- **Wagon transfer** in the station
- Required **activities on the train**
- **Train composition**
- Train ready for **departure**

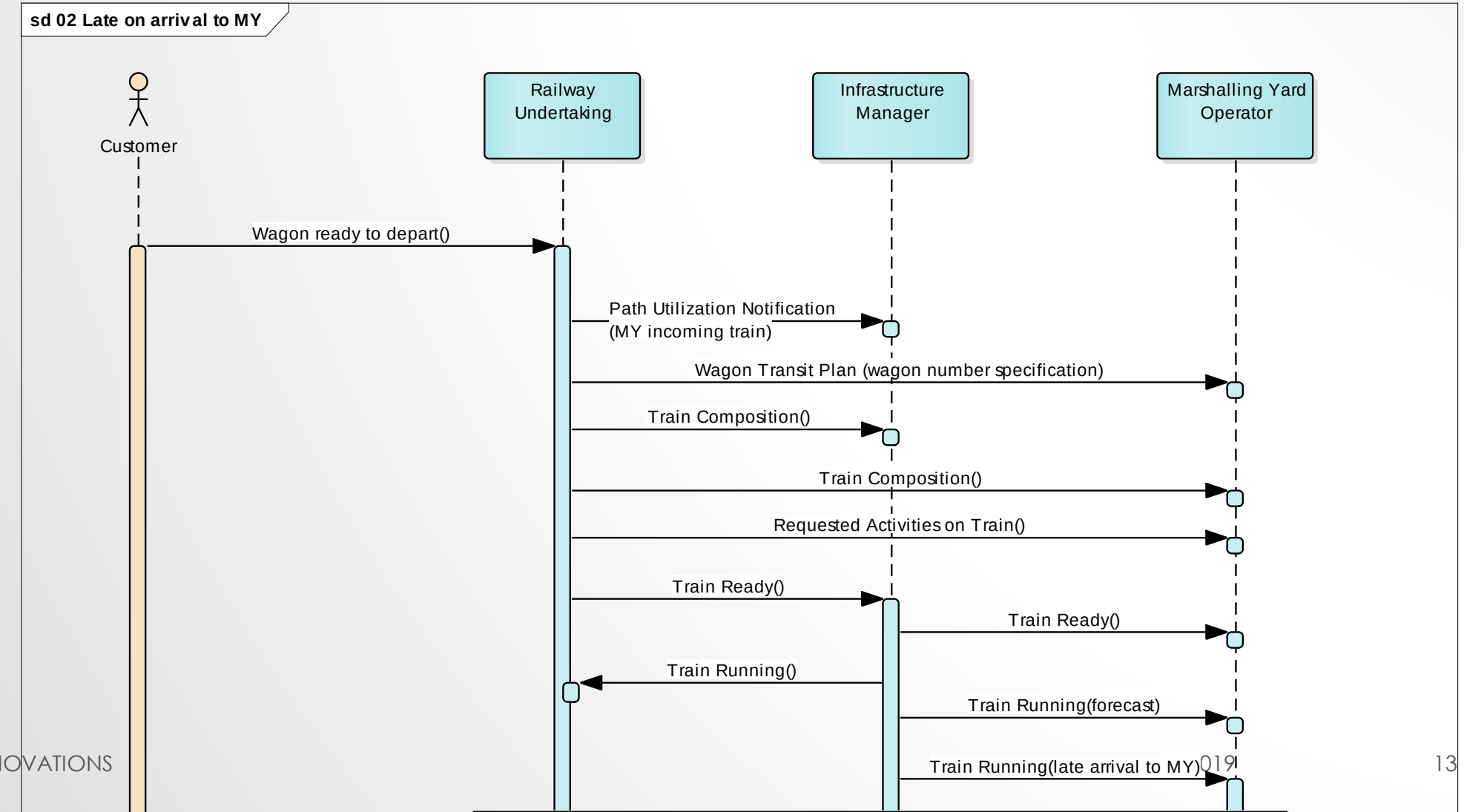


PROOF OF CONCEPT

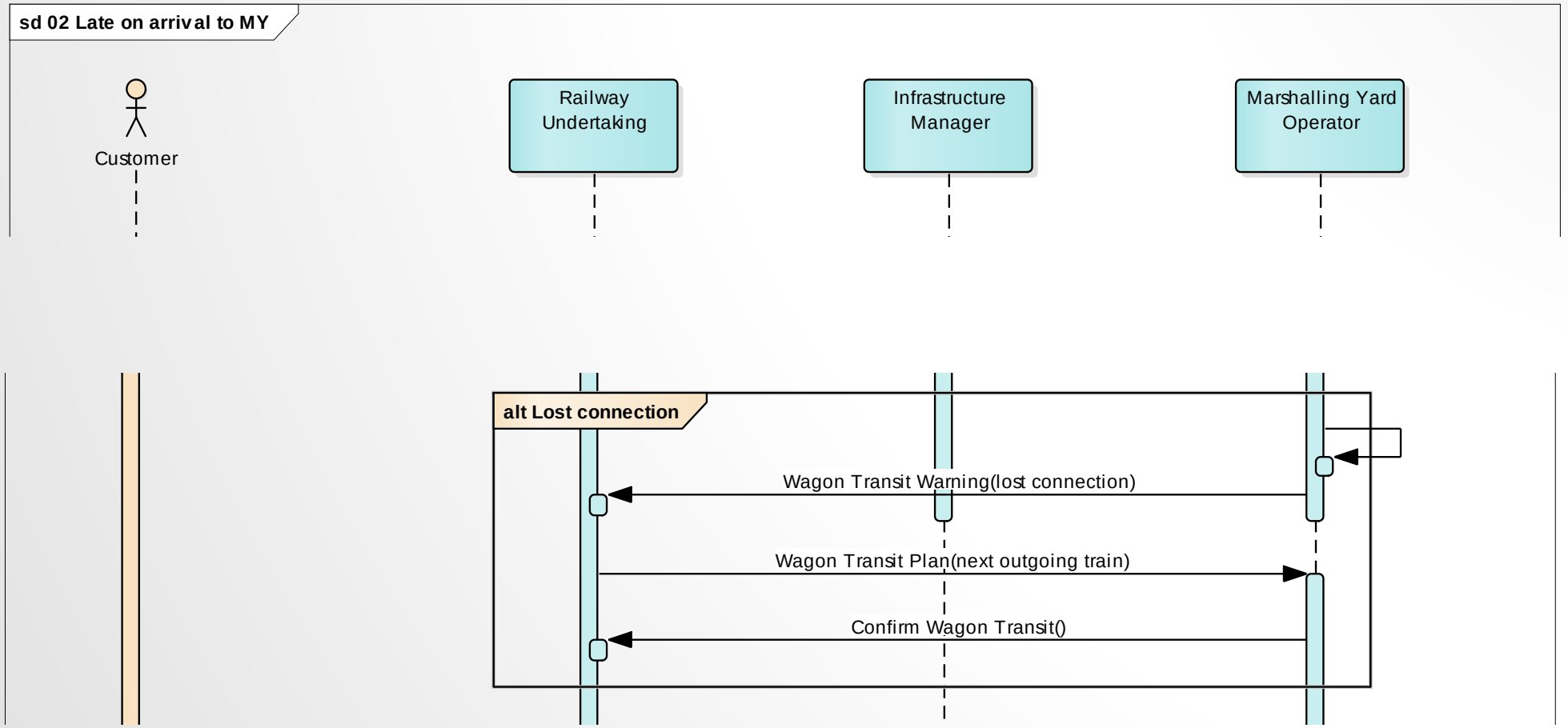
We apply our communication proposals to six scenarios:

- train running **without perturbation**
- **inability to reach the yard** on time: unloading along the route
- train delayed on arrival, **wagon transfer ensured**
- train delayed on arrival, **wagon transfer not ensured**
- **non-compliance** with the wagon transfer schedule
- **change in routing or operations** on wagons

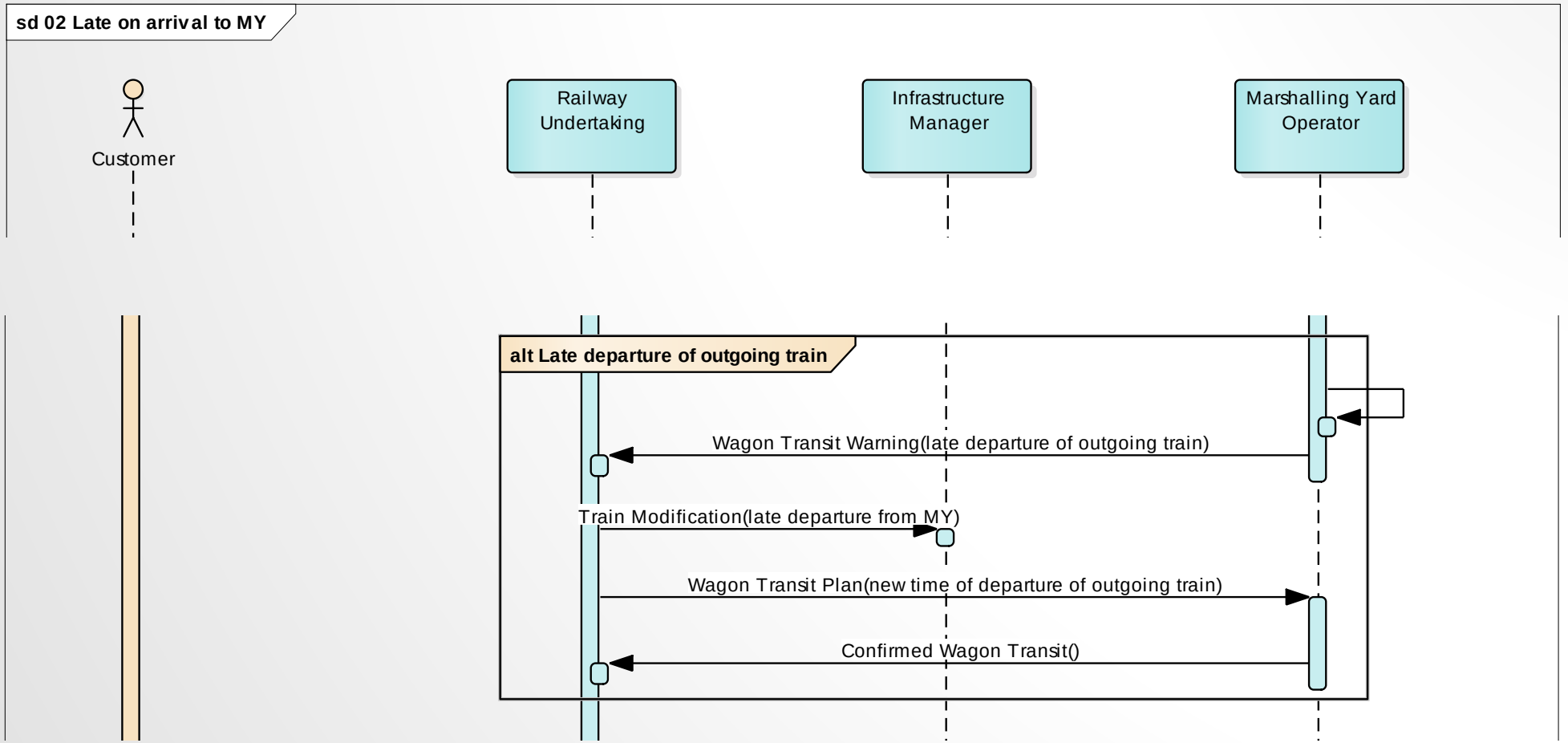
TRAIN DELAYED ON ARRIVAL, WAGON TRANSFER ENSURED



TRAIN DELAYED ON ARRIVAL, WAGON TRANSFER ENSURED



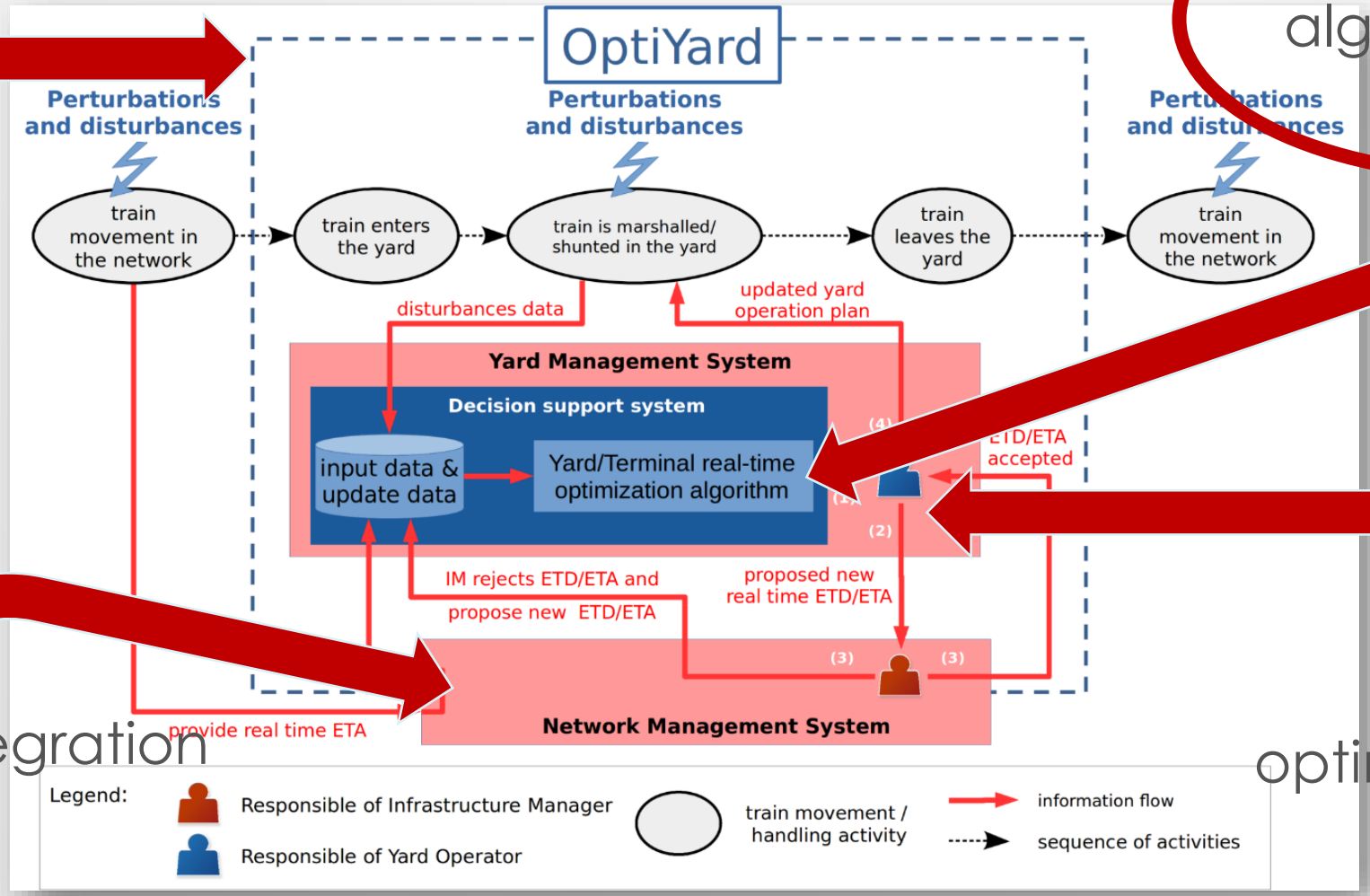
TRAIN DELAYED ON ARRIVAL, WAGON TRANSFER ENSURED



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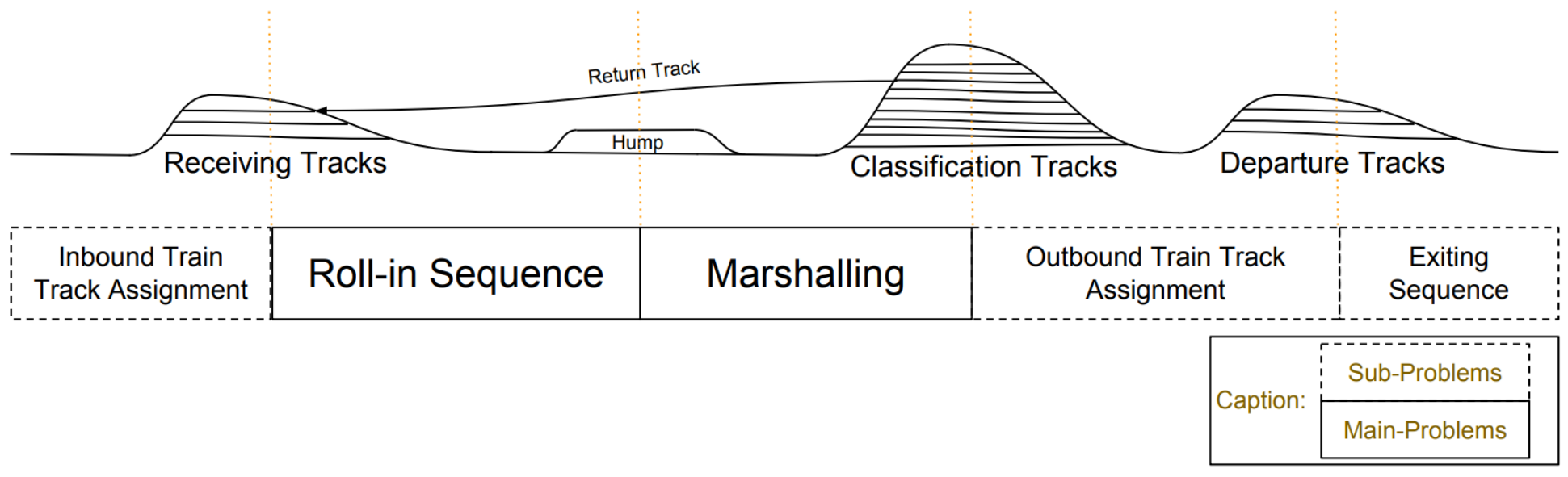
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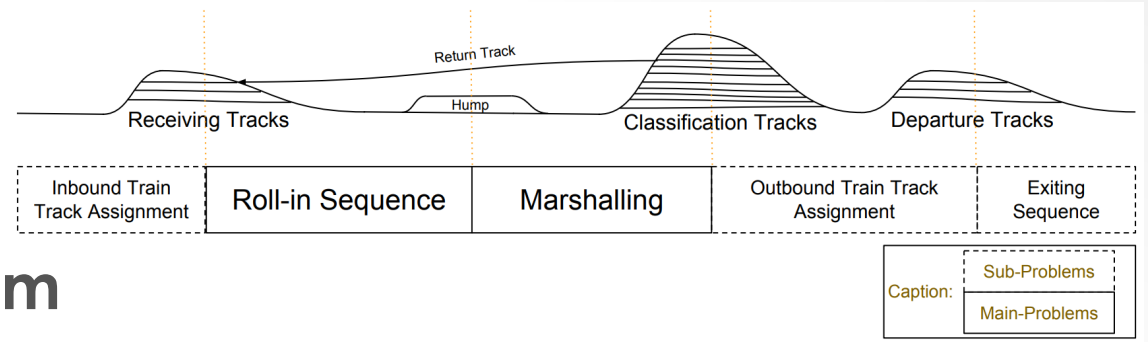
Strategies for integration with the network

Integrated optimization and simulation framework

YARD OPTIMIZATION PROBLEMS



YARD OPTIMIZATION MODEL



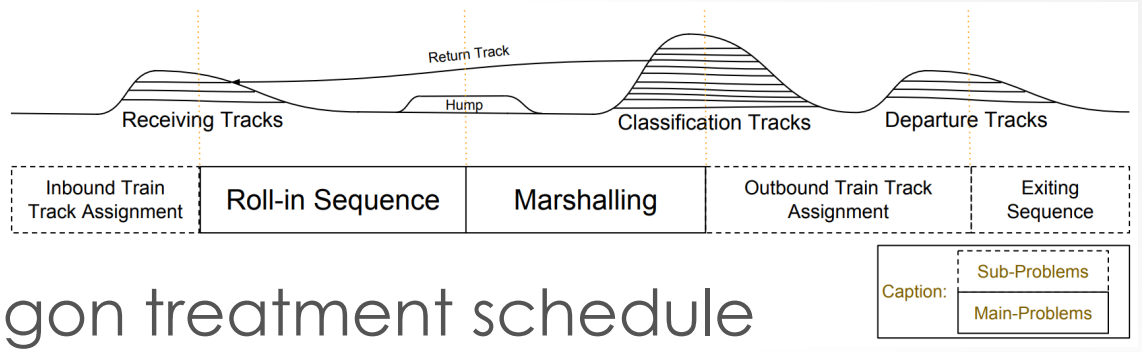
We consider the **overall problem**

There is **no existing approach** for more than two problems

In addition:

- we optimize the **resource schedule**:
  - Shunting locomotives
  - Yard personnel
- we consider shunting locomotive **movements**

YARD OPTIMIZATION ALGORITHM



- **Iterative approach**
- **Stochastic choice** of train/wagon treatment schedule
- **Stochastic assignment** of resources for train/wagon treatment

Objectives:

1. Minimize total **delay** of train departures
2. Minimize **time in yard** of wagons

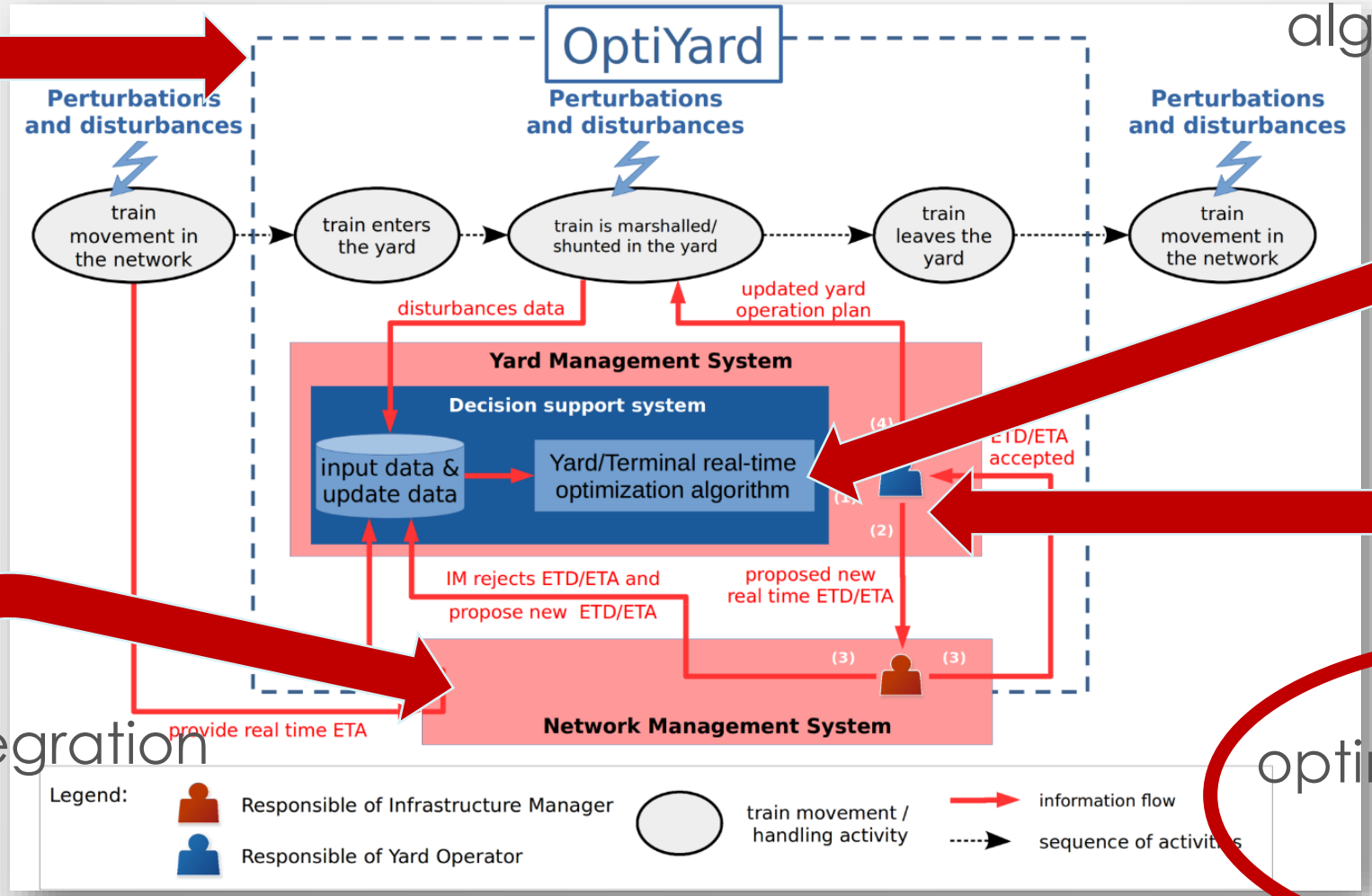
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CLOSED-LOOP FRAMEWORK

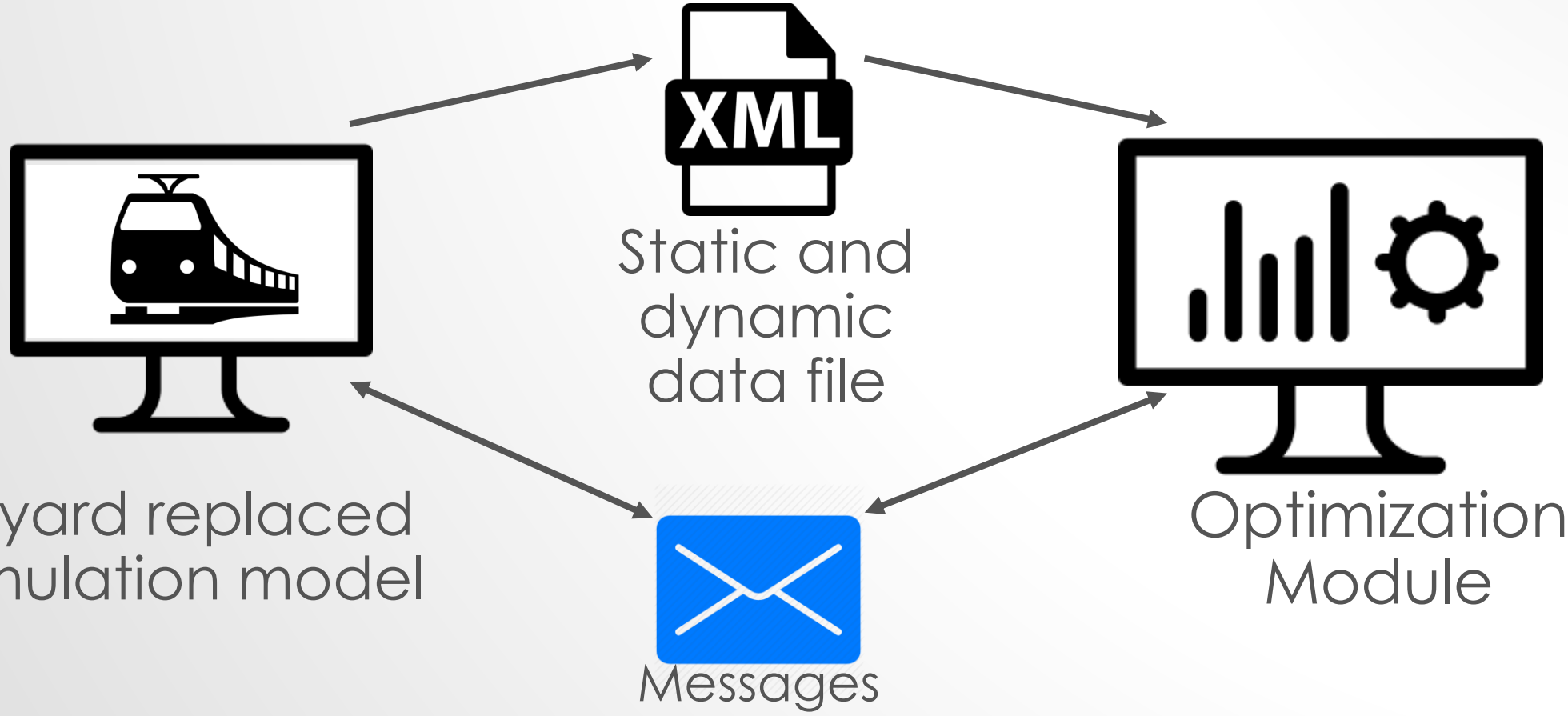
Simulation replaces **reality**

The simulator asks the optimization for all **track and resource assignment**

With predefined periodicity:

- the simulator communicates the **current state of the yard**
  - Present trains and wagons, with positions
  - Operations started
  - Resources location and activity
  - Forecast arrival trains
- the **optimization runs** based on the new state and **updates** assignments

SIMULATION-OPTIMIZATION COMMUNICATION AND DATA



DATA EXCHANGE VIA XML FILES

Static data

Based on the yard simulation model, exported once at the **beginning of the process**

Infrastructure, Departure timetable, Possible sequences of operations, …

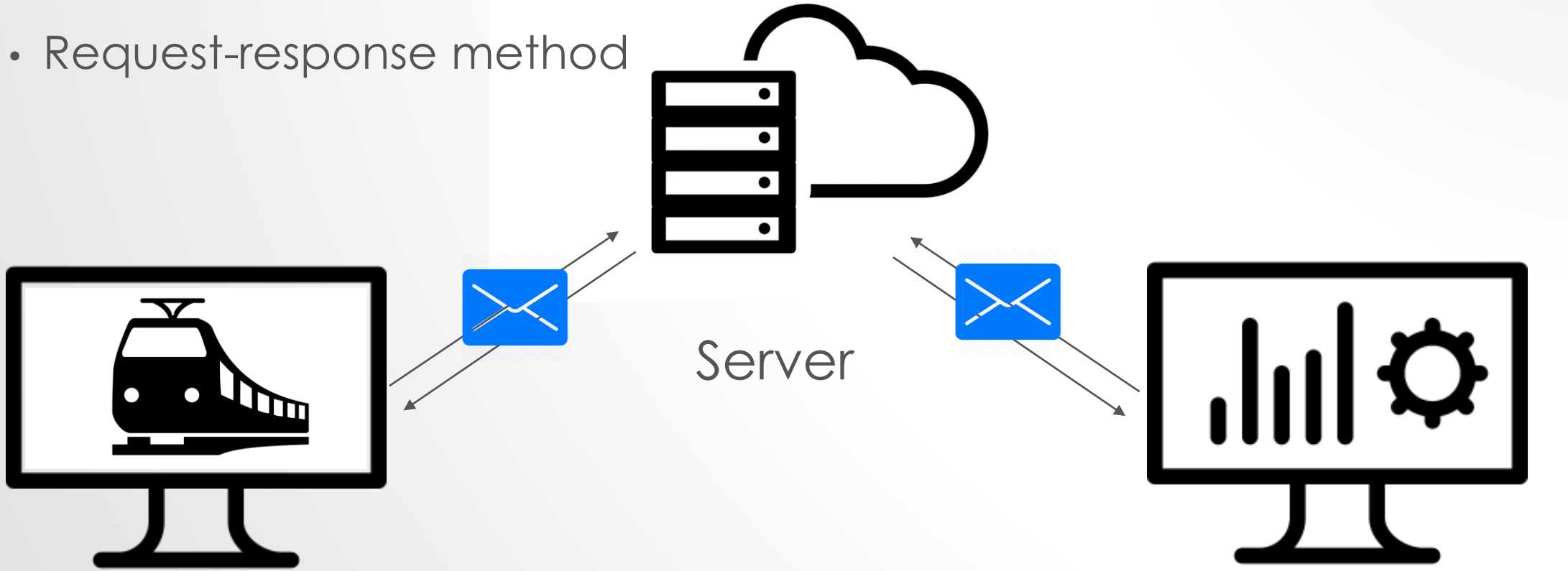
Dynamic data

Based on current situation, exported **during operations**

State of resources (tracks, personnel, locomotives), Ongoing operations, Arrival of inbound trains, Positions of wagons, …

DATA EXCHANGE VIA MESSAGES

- Client-server architecture
- Request-response method



DEFINITION OF THE INTEGRATED FRAMEWORK OF OPTIMIZATION AND SIMULATION

- Information for decision-making situations in simulation (e.g., resource assignment)
- JSON format

Request:


```
{
  "id_message": 1,
  "id_message_type": 1,
  "id_technology": 10,
  "id_train": 12,
  "id_act": 1090006000,
  "id_resource": -1
}
```


Response:


```
{
  "id_message": 1,
  "id_message_type": 1,
  "id_technology": 10,
  "id_train": 12,
  "id_act": 1090006000,
  "id_resource": 42
}
```

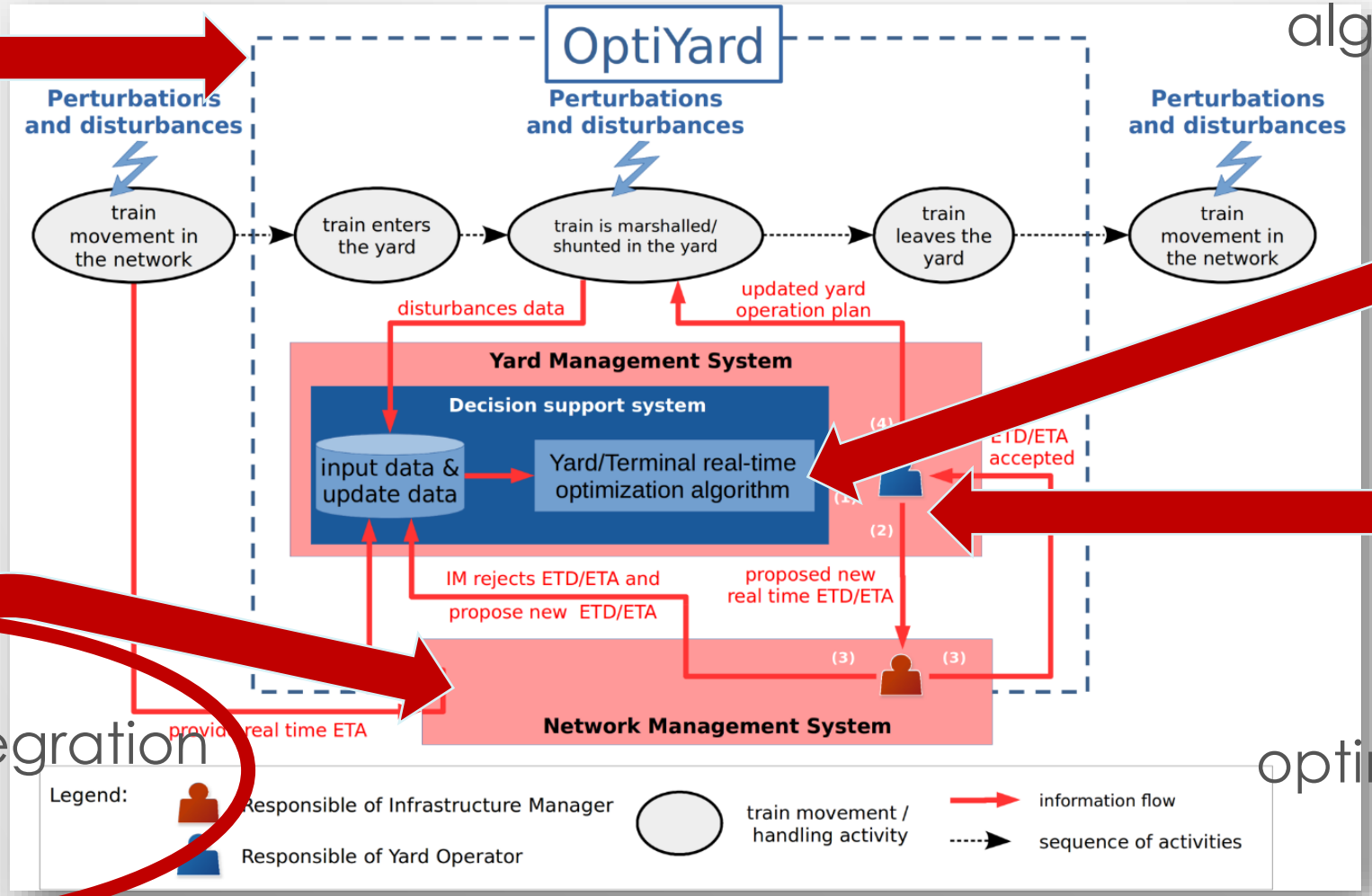
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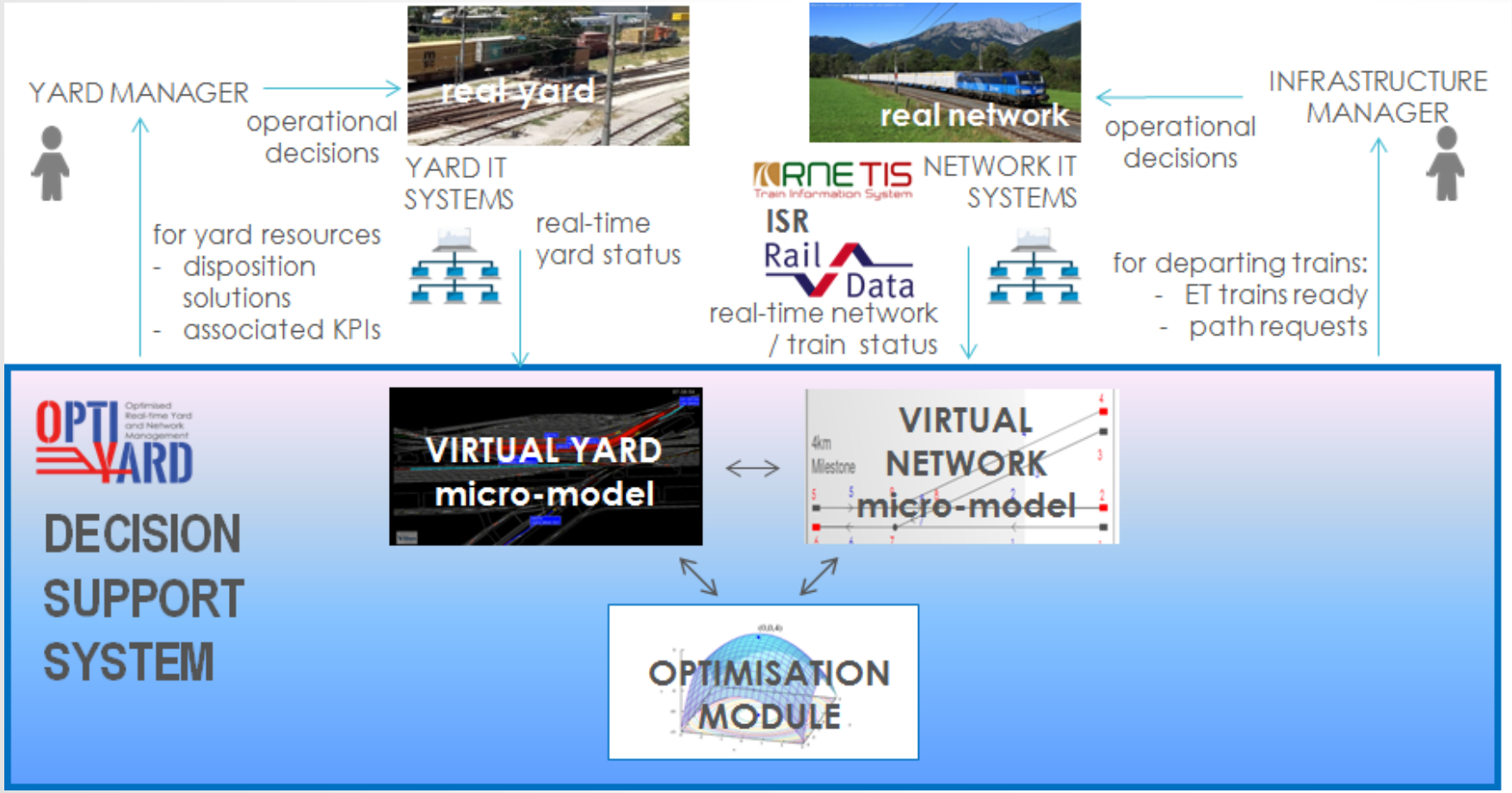
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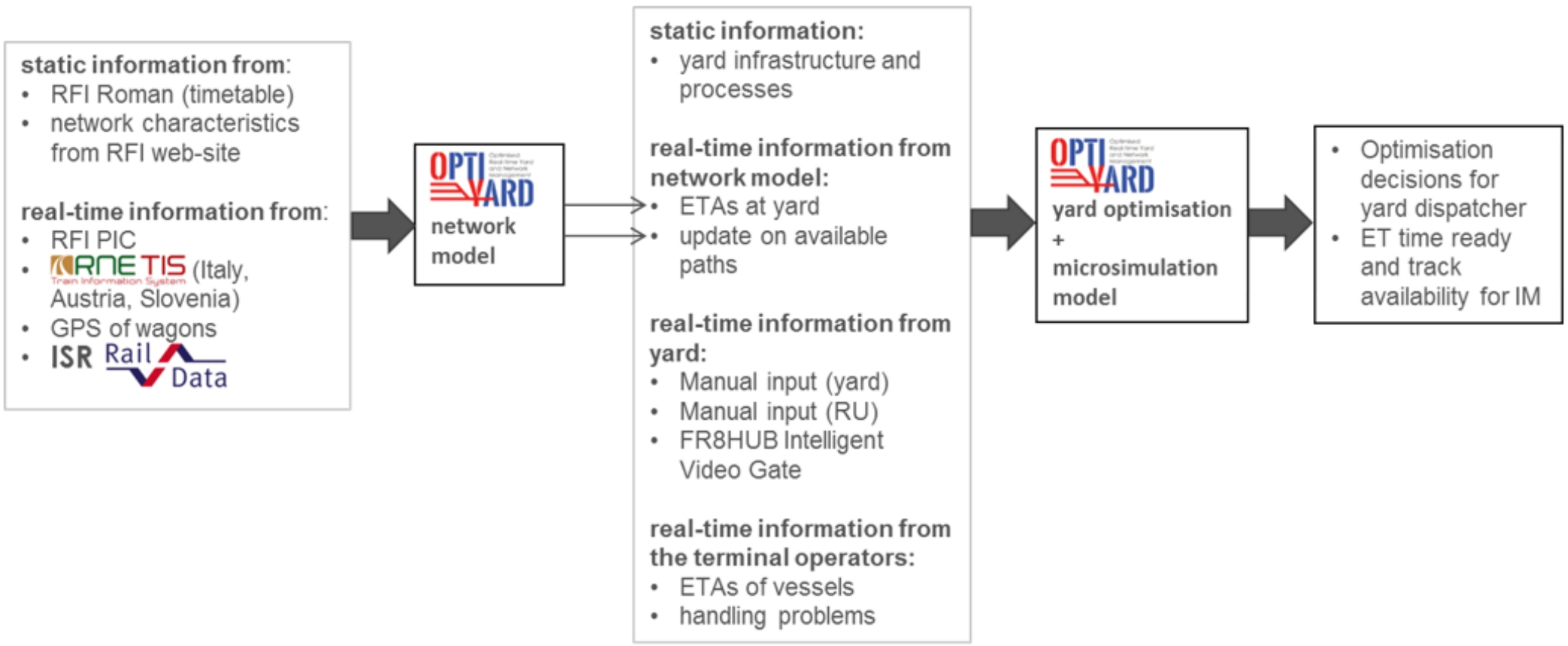
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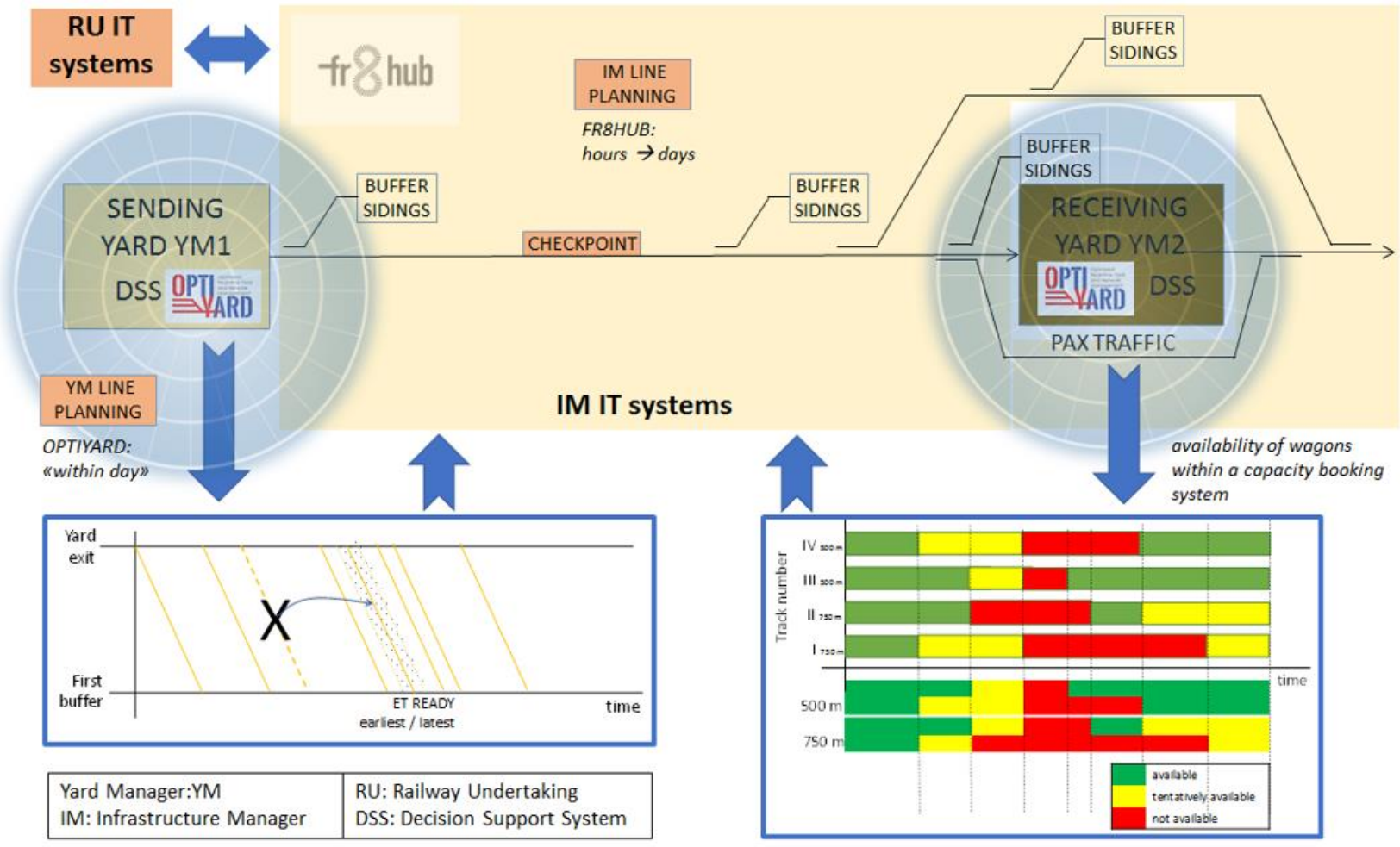
MODEL INTERACTIONS, OVERVIEW



OUTSIDE INPUTS FOR THE OPTIYARD ENVIRONMENT



INPUT-OUTPUT WITH IM AND RU SYSTEMS





QUESTIONS

Thank you for your attention!

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