Project Overview

Guglielmo De Angelis
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Unione europea

who i am

- name: Guglielmo
- surname: De Angelis

- group:
  - SaKS: SOFTWARE AND KNOWLEDGE-BASED SYSTEMS
  - http://saks.iasi.cnr.it

- topics:
  - software engineering
  - service oriented architecture
  - software testing
  - (software) model-driven engineering

roadmap

- project overview
- objectives and challenges
- solutions dimensions
- current status
- resources

facts-sheet

OPENNESS (OPtimal bEhavior iN paNdEmic ScenarioS) is an research project founded by Regione Lazio

- Financing Framework: POR FESR LAZIO 2014 – 2020
- Call: “Gruppi di Ricerca 2020”
- Line: Security and Safety
- ERC Panels (may 2020):
  - PE1-20 (Control theory, optimisation and operational research)
  - PE6-3 (Software engineering, programming languages and systems)
  - PE6-11 (Machine learning, statistical data processing and applications using signal processing)
  - LS7-9 (Public health and epidemiology)
- Start Date:
  - (official) 15th April 2021
  - (kick-off) 1st July 2021
- End Date: (current official) 14th April 2023

consortium

- partners
- collaborators

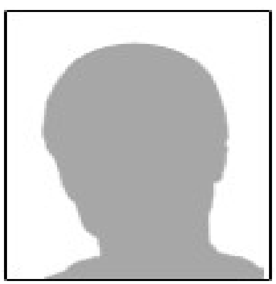
the team @ iasi

Emanuele De Angelis

Guglielmo De Angelis

Corrado Possieri

Maurizio Proietti



Barbara D’Alessandri

Eduardo Antonio De Los Santos Nunez (AR PostDoc)

Federico Oliva (AR)

other teams

- UCSC
  - Stefania Boccia
  - Lara Maria Corona
  - Roberta Pastorino
  - Angelo Pezzullo
  - Gualtiero Ricciardi
  - Cosimo Savoia
- IEIIT-CNR
  - Marta Lenatti
  - Maurizio Mongelli
  - Alessia Paglialonga
  - Vittorio Rampa
- STAM
  - Pietro De Vito
  - Deborah Hugon

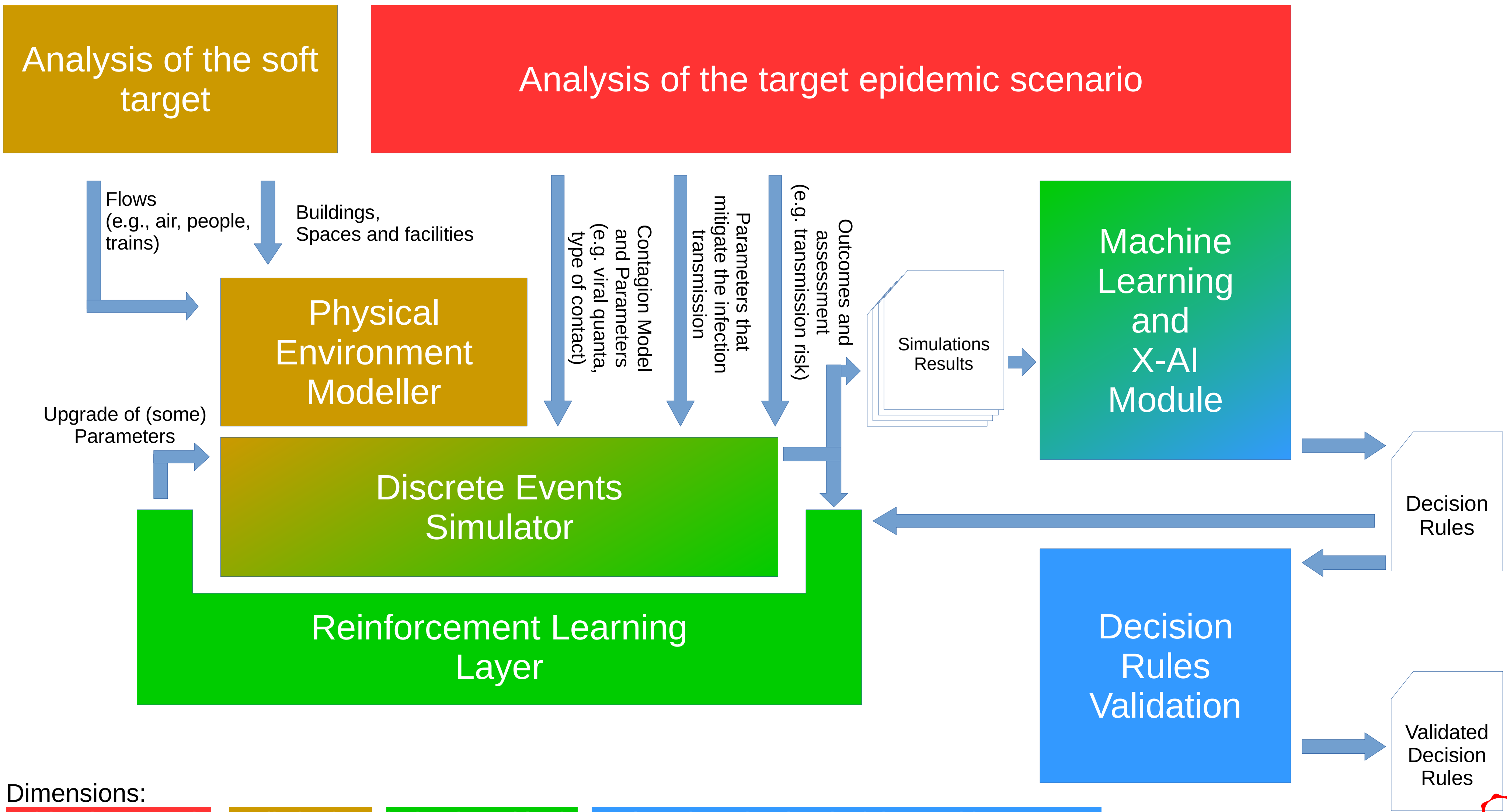
objectives and challenges

- investigate AI solutions to govern soft targets in pandemic scenarios
  - squares, theatres, subway stations, commuting zones of urban areas, etc.
- provide a reference framework and a set of supporting tools for analysing and controlling epidemic scenarios
- supporting the decision making process of those who are in charge of defining strategies to prevent the spread of infective diseases
- vertical demonstrator in the project
  - COVID-19 and the transmission of the SARS-CoV-2 virus
  - Roma Termini train station (platforms area)

dimensions in the space of our solution

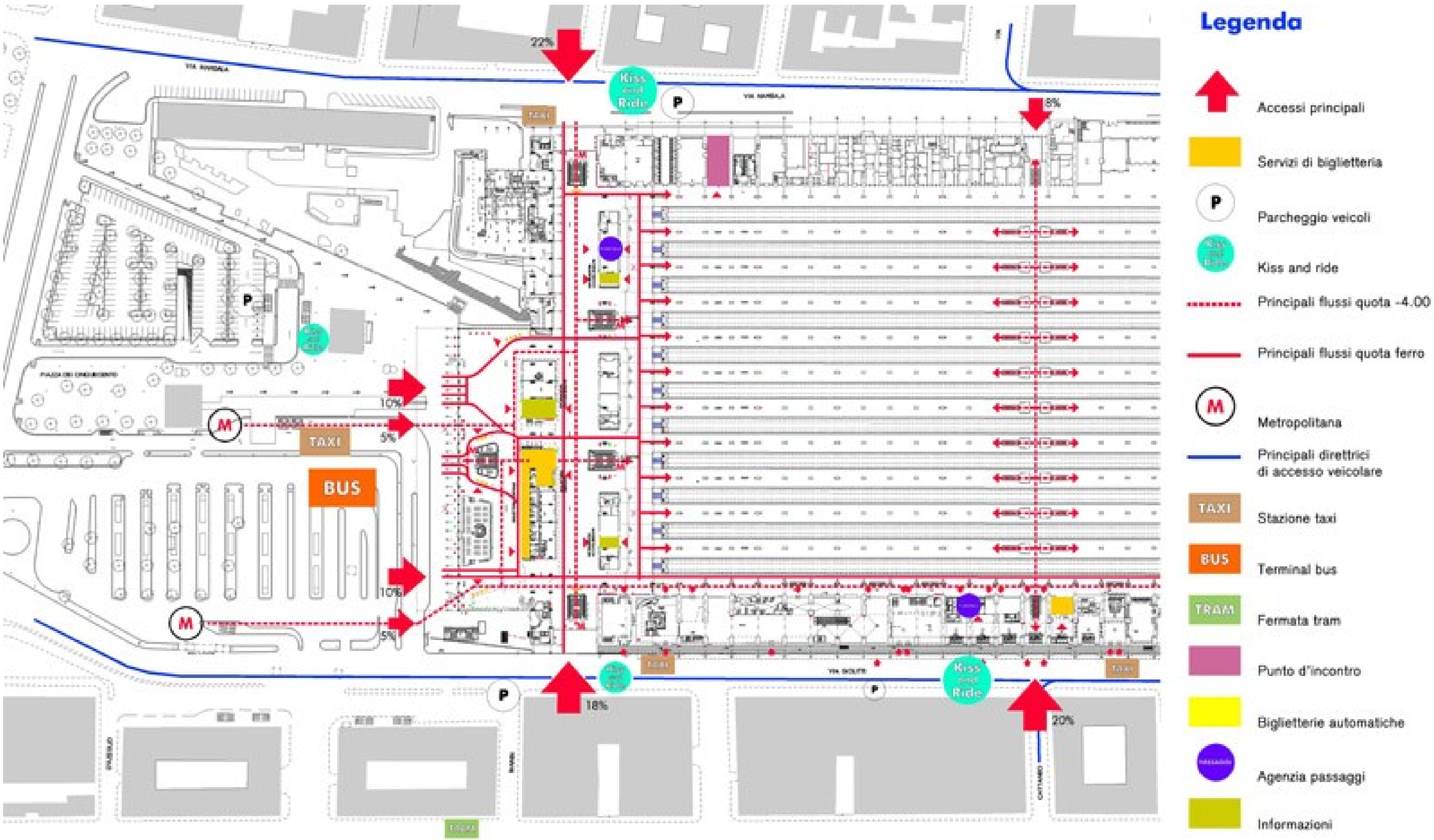
- epidemic scenario
  - diffusion indexes of the considered infections
  - evidences from the scientific literature and trails
  - definition of the main variables to consider
  - definition of the target outcomes
- realistic data
  - reproduction of the physical environment
  - reproduction of the agents that carries and transmits the infectious pathogen
  - definition of the parameters for a considered scenarios
  - randomized evolution of the considered variables
  - impact of the variables evolution on the considered scenario
- behavioural logic
  - forecast target outcomes
  - learn relations on the observed data
  - suggest constraints on the variable, or on the parameters of the scenario
  - analyse the impact of the suggested constraints
- explanations for the decision-making process
  - human-readable synthesis of the learned relations
  - completeness of the learned relations
  - robustness of the learned relations

sketch of the solution

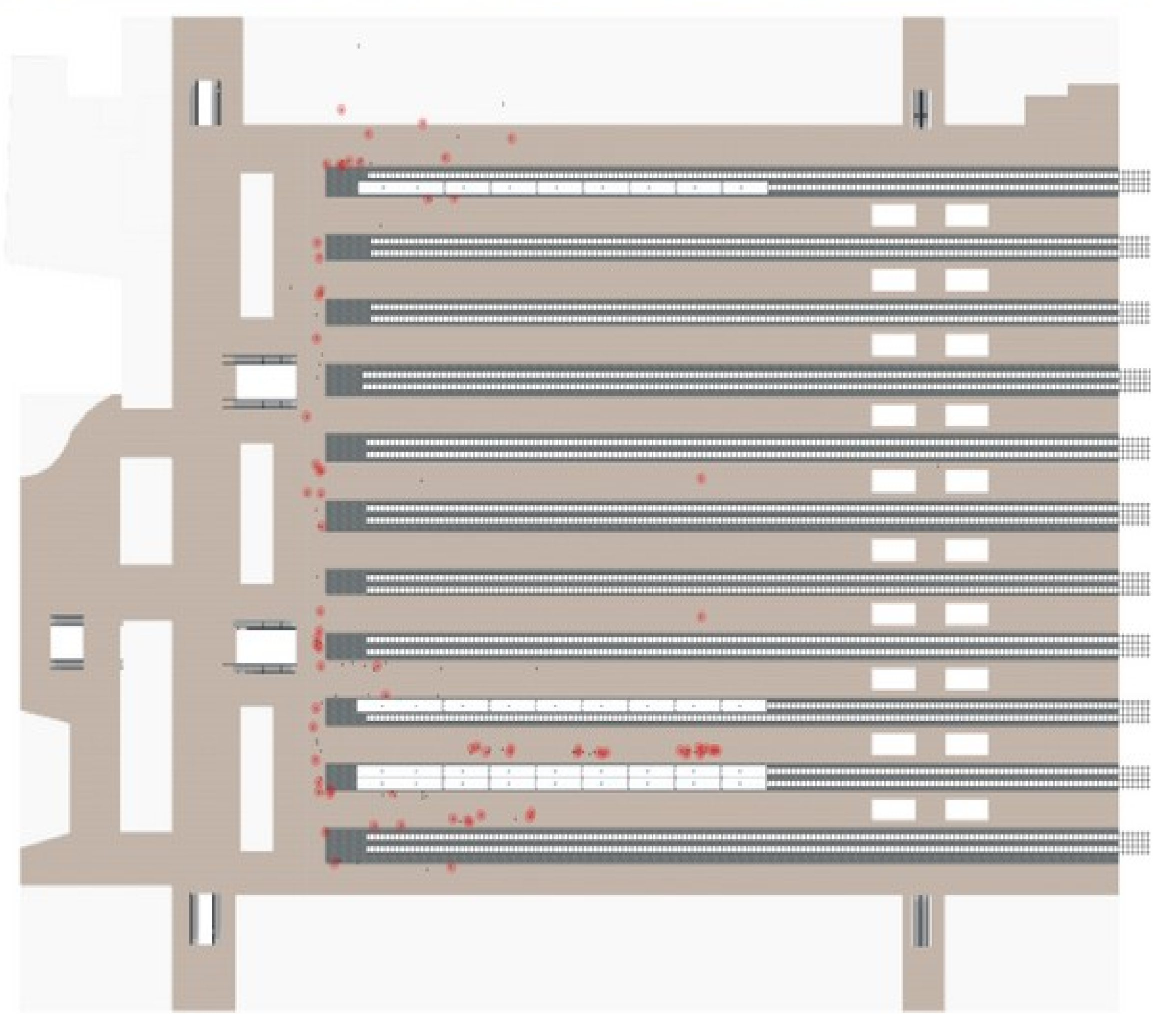


Dimensions:
epidemic scenario realistic data behavioural logic explanations for the decision-making process

vertical demonstrator:
Roma Termini and SARS-CoV-2 virus



modelling of the physical environment – 2D



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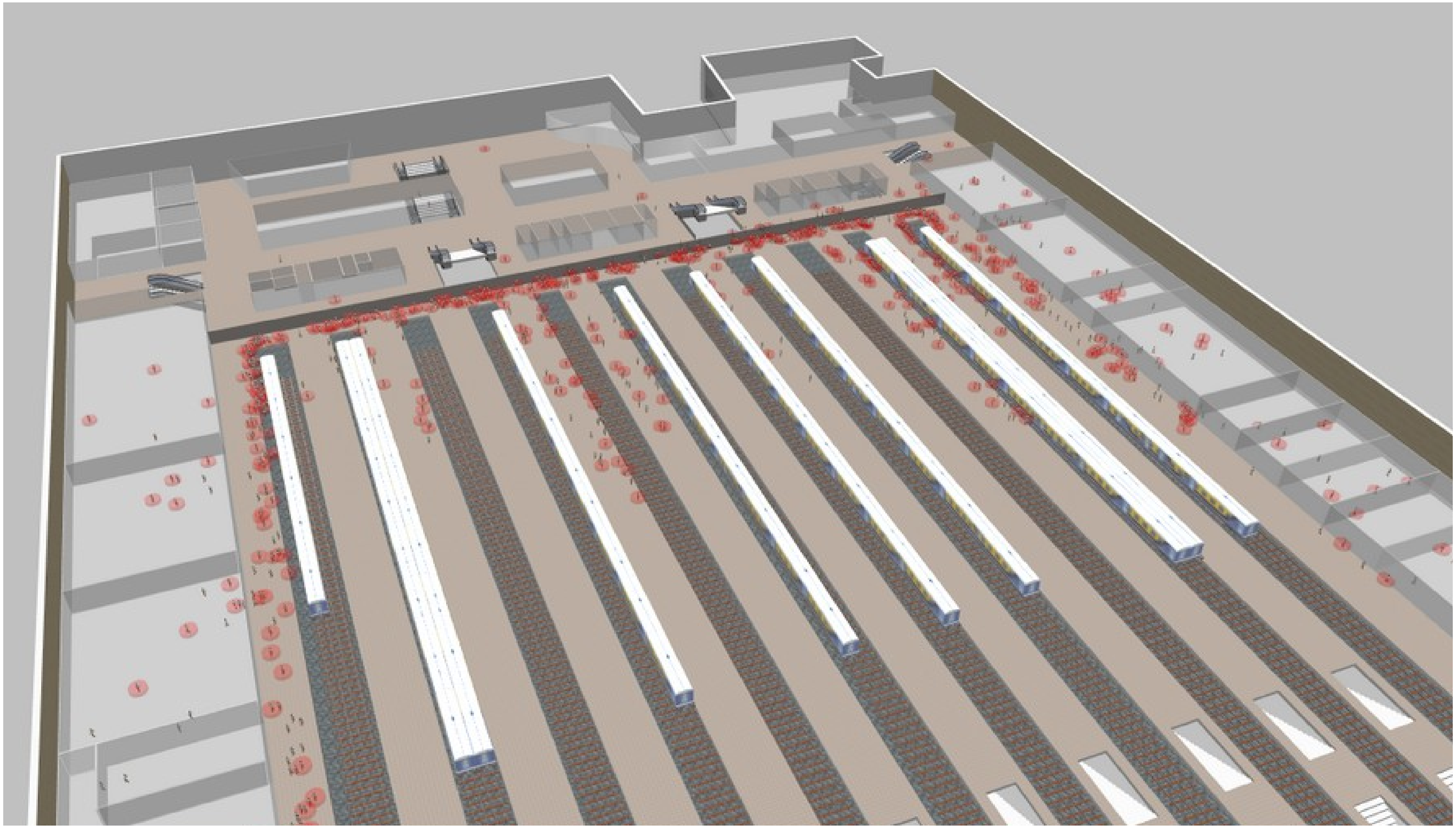
modelling of the physical environment – 3D



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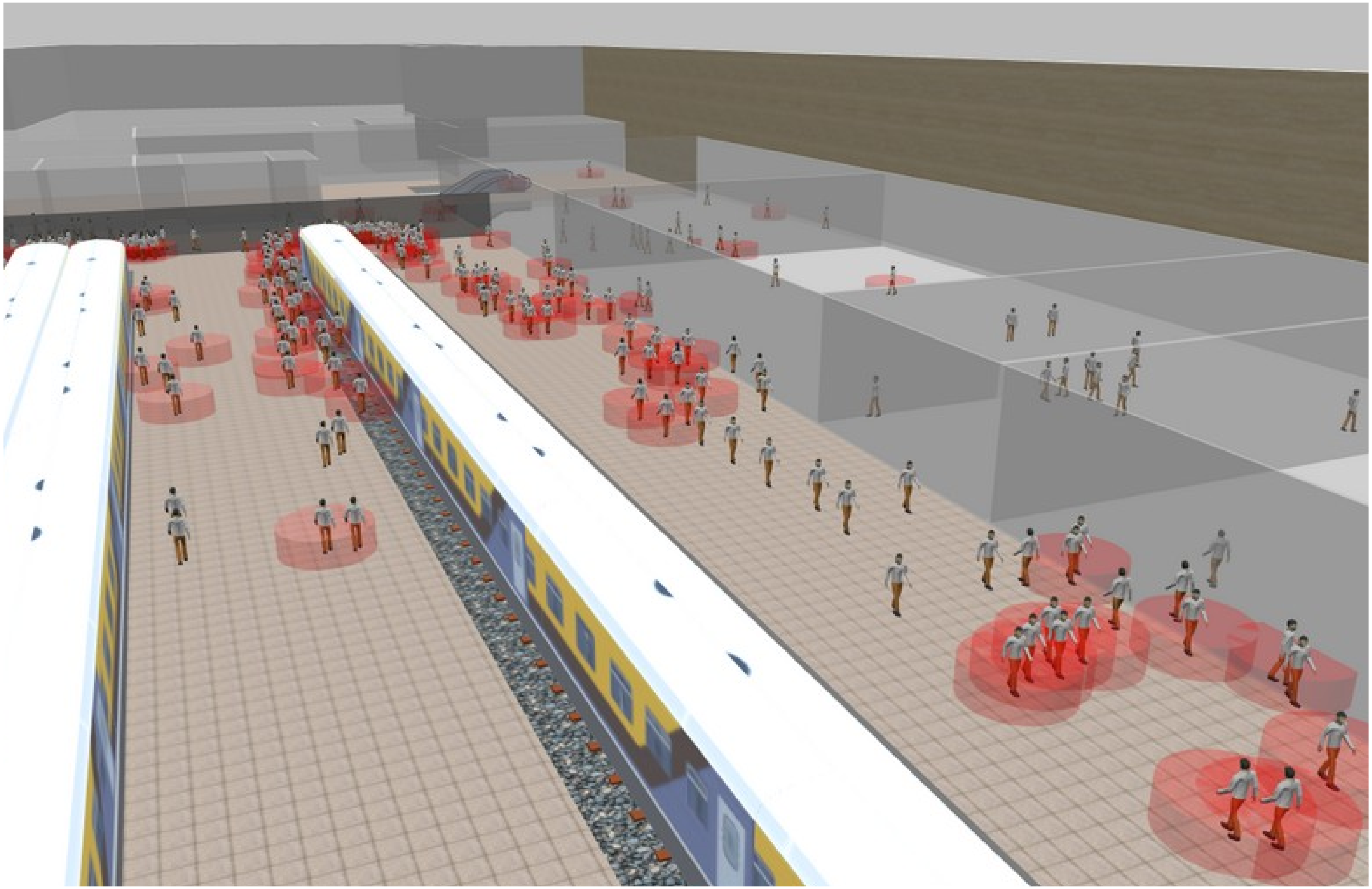

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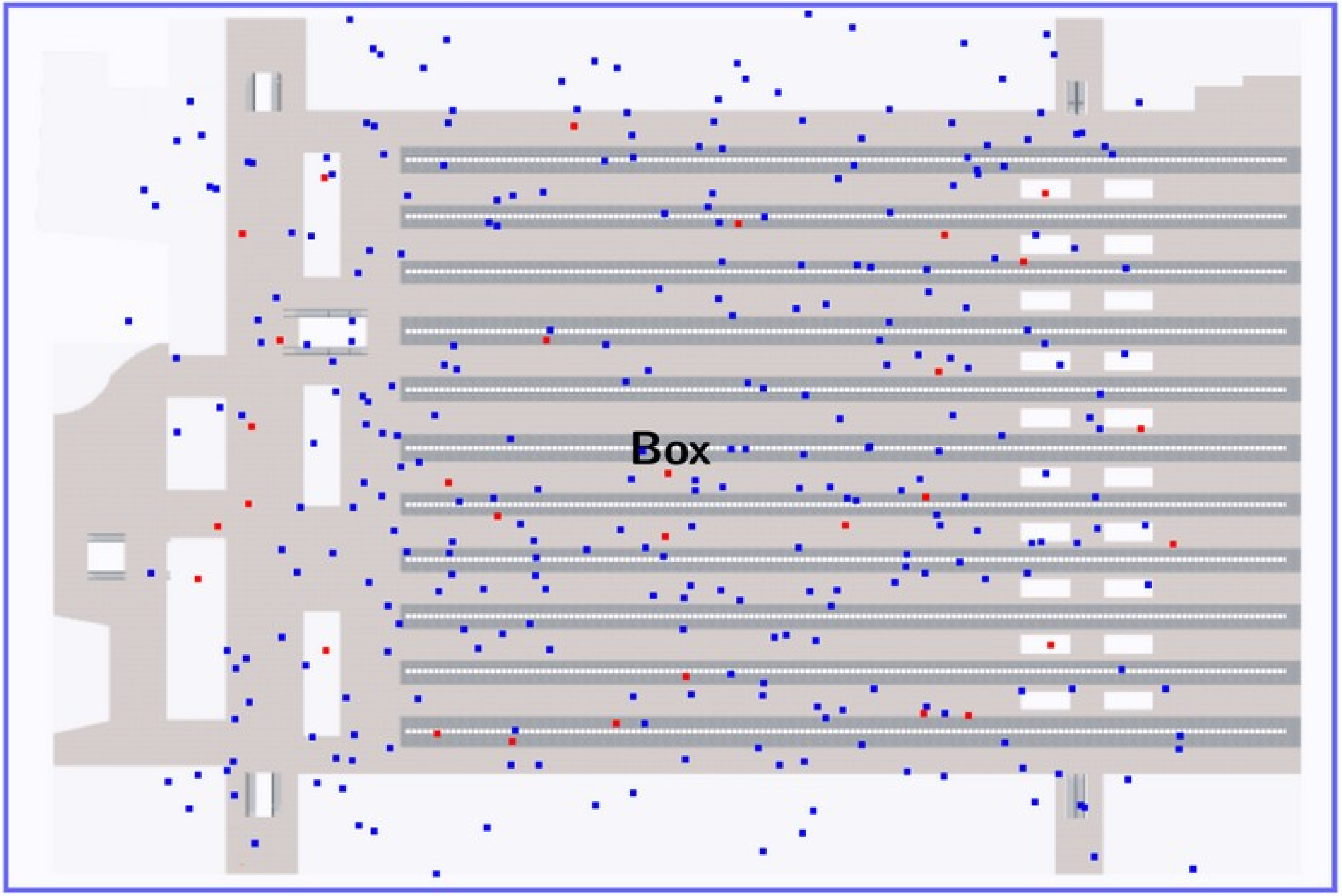
contagion model: state of the art



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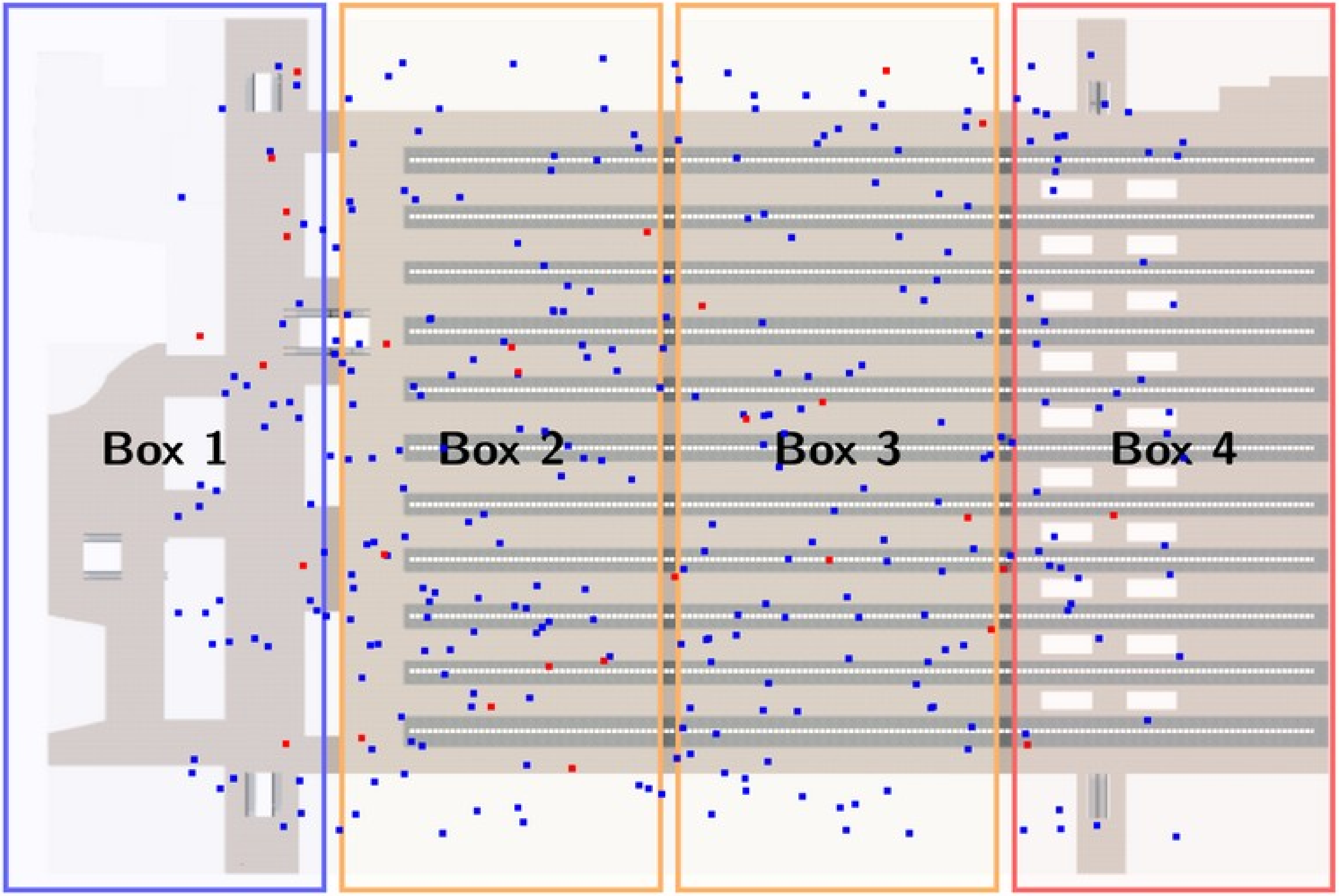
contagion model: refined version



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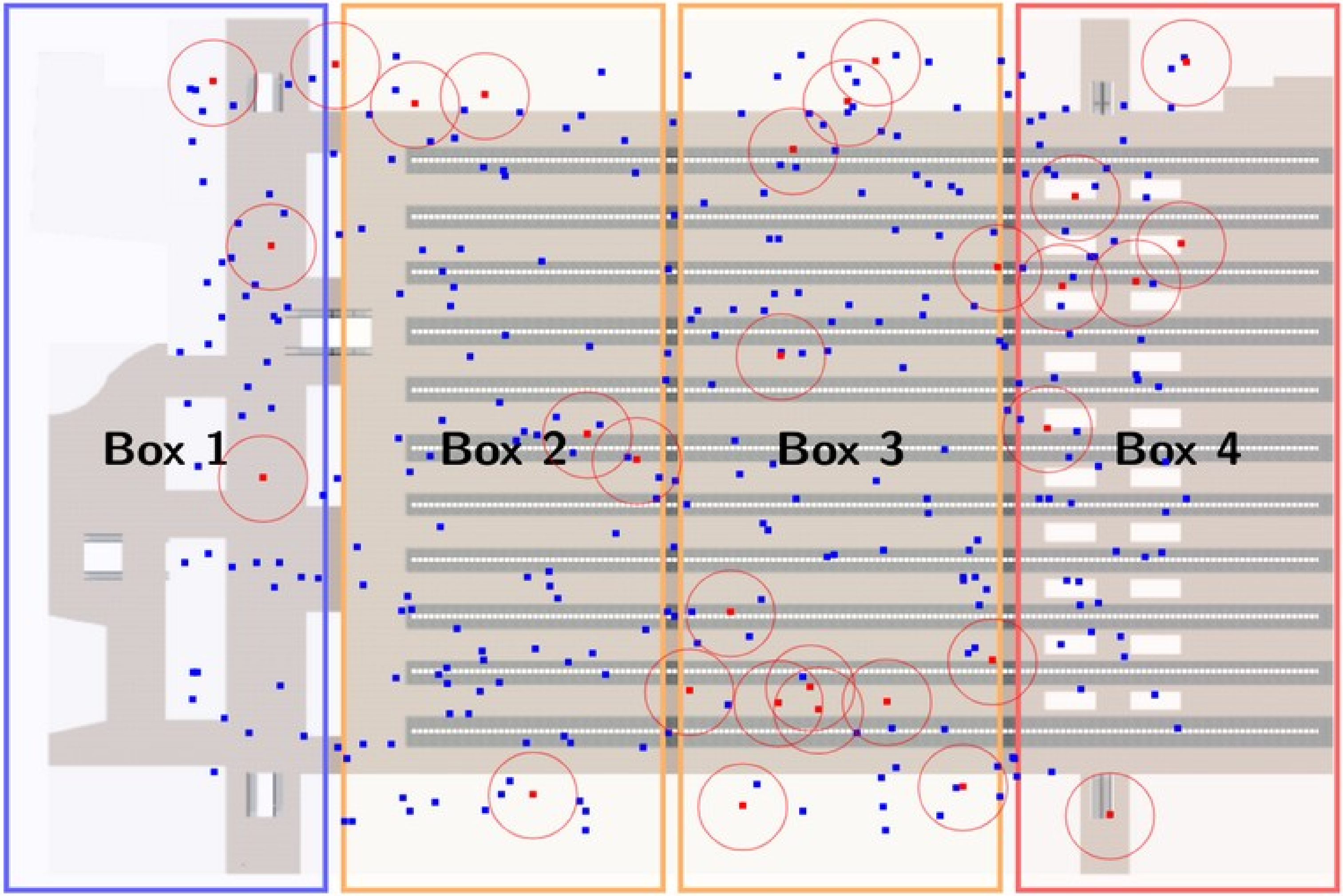
contagion model: current approach



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soft target parameters – 1

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soft target parameters – 2

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parameters about the contagion model – 1

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parameters about the contagion model – 2

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results from a simulation

A2:AMJ2 | 900.0

	A	B	C	D
1	SimulationTime	Passengers	Positives	Contacts
176	2640.0	364.0	178.0	17.0
177	2650.0	361.0	176.0	17.0
178	2660.0	361.0	176.0	17.0
179	2670.0	360.0	175.0	17.0
180	2680.0	396.0	197.0	17.0
181	2690.0	396.0	197.0	17.0
182	2700.0	470.0	235.0	17.0
183	2710.0	470.0	235.0	17.0
184	2720.0	532.0	267.0	17.0
185	2730.0	532.0	267.0	18.0
186	2740.0	528.0	264.0	18.0
187	2750.0	524.0	263.0	17.0
188	2760.0	524.0	263.0	17.0
189	2770.0	524.0	263.0	17.0
190	2780.0	524.0	263.0	18.0
191	2790.0	524.0	263.0	20.0
192	2800.0	523.0	263.0	19.0

F157

	A	B	C	D
1	SimulationTime	No Mask	Mask	FFP2
140	2280.0	0.0	59.0	23.0
141	2290.0	0.0	59.0	23.0
142	2300.0	0.0	59.0	23.0
143	2310.0	0.0	59.0	23.0
144	2320.0	0.0	86.0	33.0
145	2330.0	0.0	88.0	33.0
146	2340.0	0.0	88.0	33.0
147	2350.0	0.0	88.0	33.0
148	2360.0	0.0	88.0	33.0
149	2370.0	0.0	112.0	46.0
150	2380.0	0.0	112.0	46.0
151	2390.0	0.0	112.0	46.0
152	2400.0	0.0	111.0	46.0
153	2410.0	0.0	164.0	67.0
154	2420.0	0.0	164.0	67.0
155	2430.0	0.0	187.0	81.0

	A	B
1	SimulationTime	Infection Risk
254	3420.0	0.025510204081632654
255	3430.0	0.024752475247524754
256	3440.0	0.024509803921568627
257	3450.0	0.024509803921568627
258	3460.0	0.02830188679245283
259	3470.0	0.028037383177570093

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composition of the dataset

- the results of a simulation are automatically analyzed and processed
  - goal: to minimize the average cumulative risk
  - how: changing and retrofitting some parameters in the simulator
    - social distancing
    - parameters of the envrionmental boxes (e.g. ventilation parametres)
    - getes opening and closing
    - train frequencies
    - kind of protection devices

- several iterations across randomized simulations with the same parametes
  - 1 simulation = 1 record of the dataset
  - 1 outcome → 3 admissible values:
    - Low Risk of Infection
    - Medium Risk of Infection
    - High Risk of Infection

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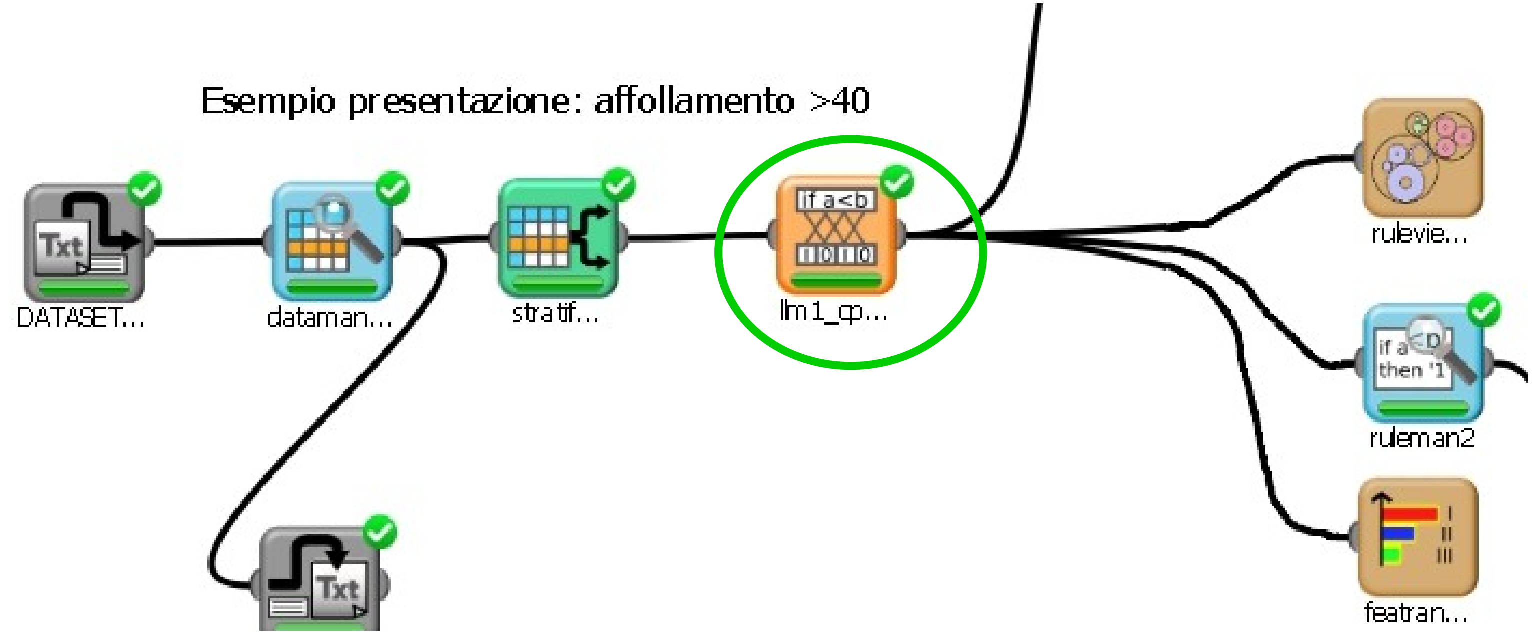
machine learning and x-ai phase



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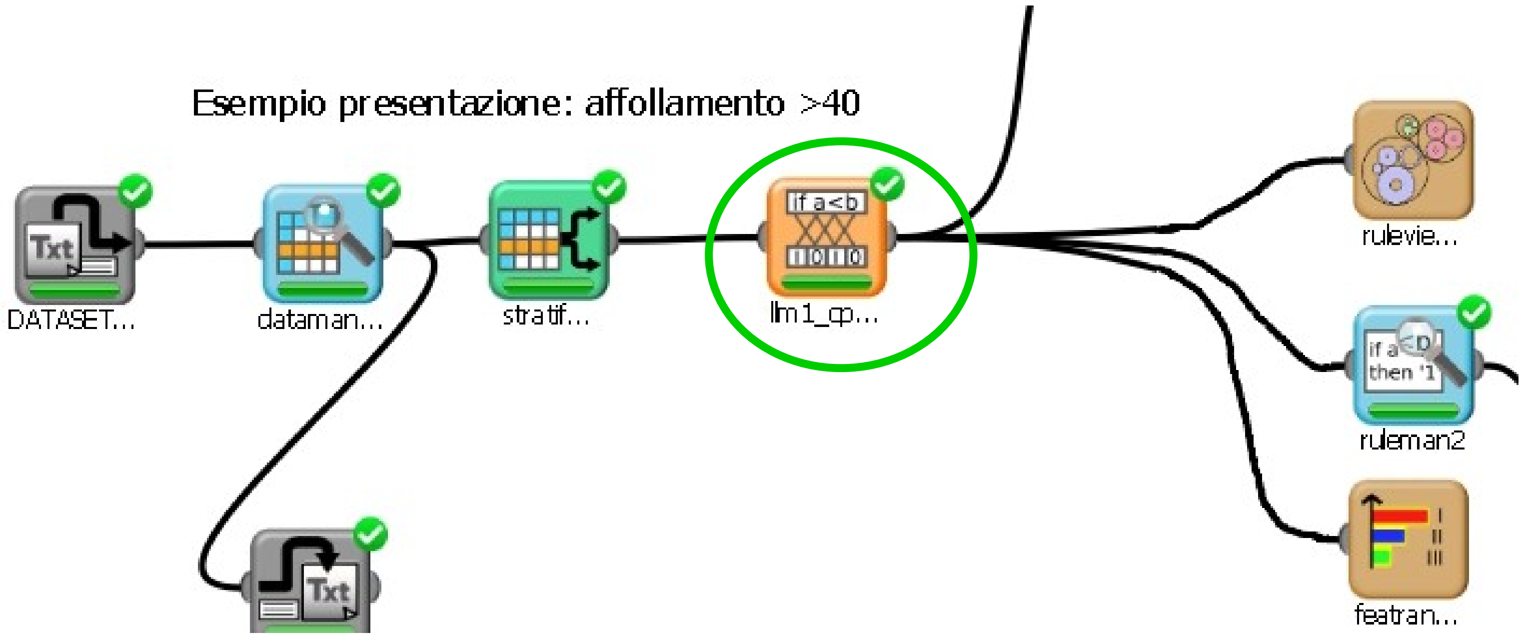
machine learning and x-ai phase



- tecnica di X-AI nativa
  - Logic Learning Machine (LLM)
- sintesi di regole decisionali di tipo

IF (*premise*) **THEN** (*consequence*)

AND Clause

output classification

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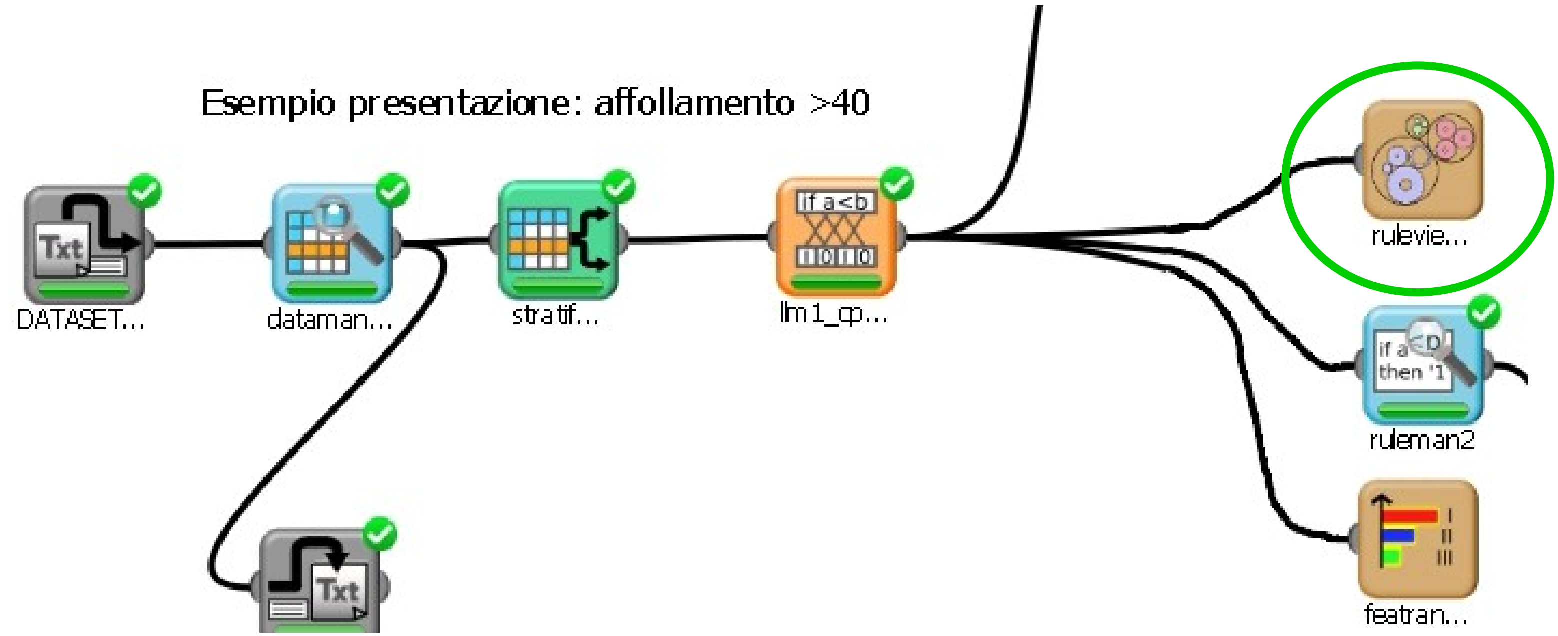
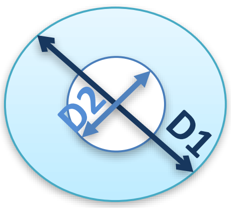


- for each rule, we consider
  - the rate of coverd items in the data set
  - the rate of errors wrt the data set



D1 = Covering

D2 = Error

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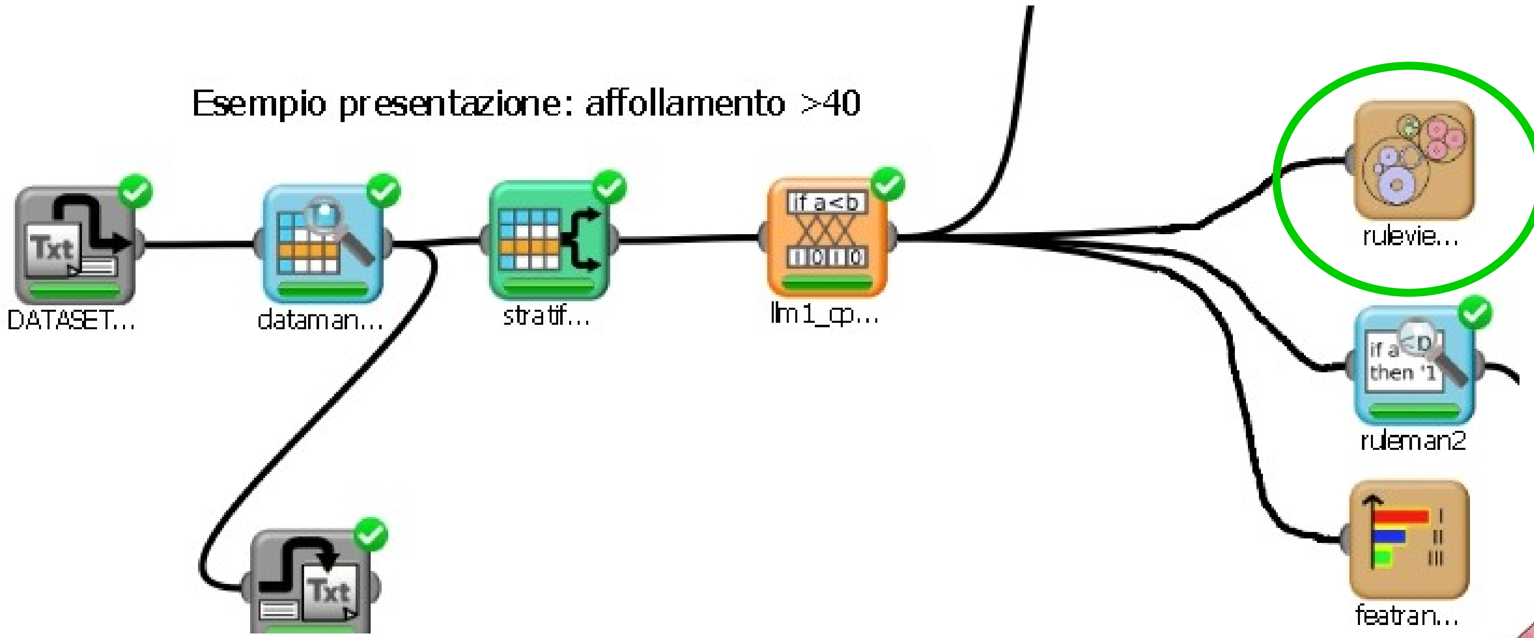
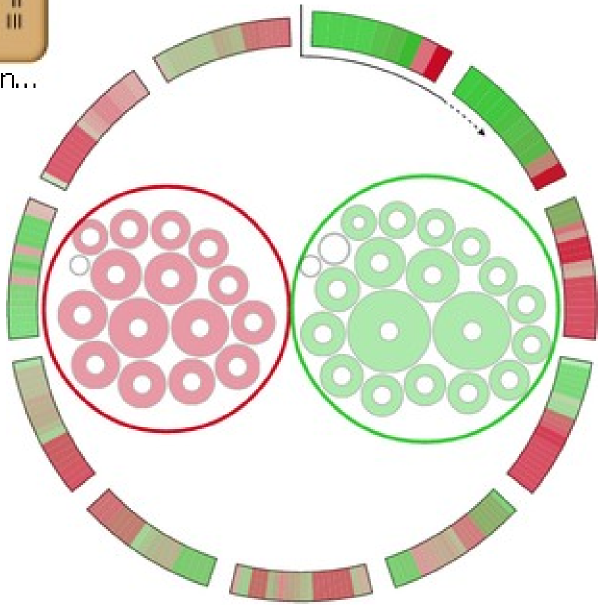
machine learning and x-ai phase





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explainations for the decision process – rules synthesis

```c
#include <string.h>
const char *ApplyRules(float arriviGate1Ascensore2, float arriviGate2, float direzioneDest1_2, float
  if ((rateAcquistoBiglietto > 0.135238) && (rateScaleP3_MAGG_P2 <= 0.120986) && (rateScaleP2_MAGG_P
    return "Low Risk";
  if ((arriviGate1Ascensore2 > 0.399016 && arriviGate1Ascensore2 <= 5.293854) && (arriviDaTrenoVsDes
    return "Low Risk";
  if ((arriviGate1Ascensore2 > 0.412199 && arriviGate1Ascensore2 <= 5.137070) && (direzioneDest1_2 >
    return "High Risk";
... ...
  if ((arriviGate1Ascensore2 > 1.628337) && (arriviGate2 <= 666.432703) && (rateValidazioneBiglietto
    return "Low Risk";
  if ((rateValidazioneBiglietto <= 0.376976) && (rateAcquistoBiglietto > 0.155286) && (rateAscensore
    return "Low Risk";
  if ((rateScaleP1_MAGG_P0 <= 0.833470) && (rateScaleMobiliP0_MAGG_P2 > 0.996470 && rateScaleMobiliP
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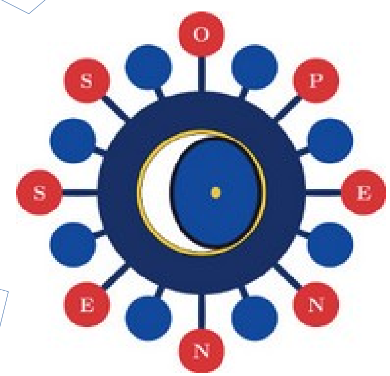
explainations for the decision process – rules validation



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}
```

- informal description of some objectives of the validation
  - Safety: applying R does not lead to a bad state.
  - Consistency: applying R does not violate laws of the application domain.
  - Robustness*: small perturbations of the inputs do not change the output.
  - Equivalence*: applying R to two different inputs does not change the output.
  - Monotonicity*: applying R to a larger input produces a larger output.

*relational property: relation between two applications of R

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