



13th SESAR Innovation Days

**Mercury – An open-source platform for the evaluation of
air transport mobility**



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Decision-making on ATM performance

System performance due to stakeholders' decisions

The ATM system is complex, with many different actors

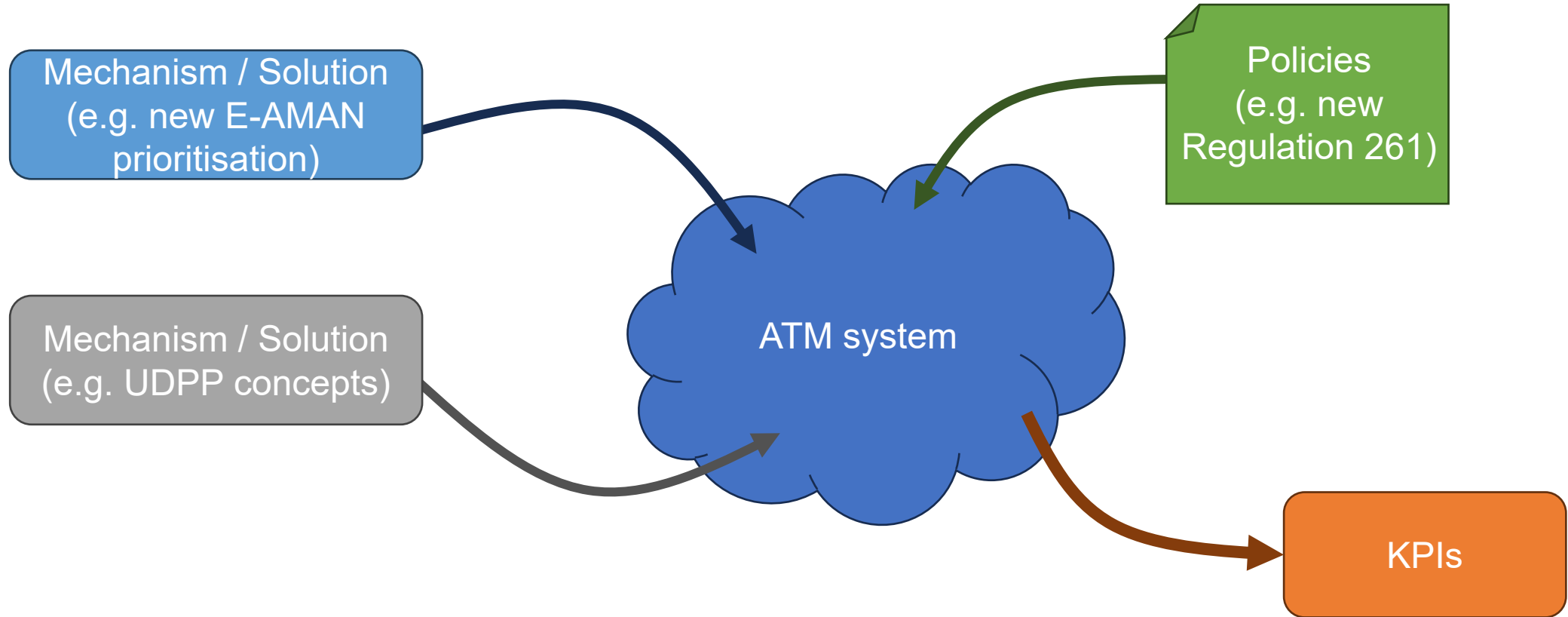
- Airlines
- Crew (flight)
- Airports (arrival managers, departure managers)
- Network Manager
- ...

Actors make decisions throughout the day with various objectives in mind

- Local objectives optimisation
- Cooperation but also competition

Changes in behaviour due to changes in mechanisms and policies

System performance due to stakeholders' decisions



The need for modelling not only flights

Different stakeholders, different system perception

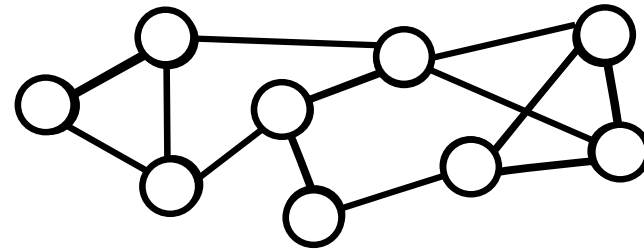
Reactionary
delay

Flight 

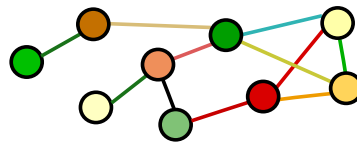
Passenger



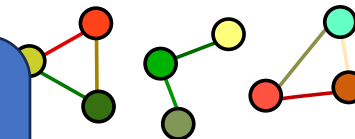
Passenger
connectivity



Flight network perspective



Passenger network perspective



- Network metrics
- Capturing distribution KPIs for stakeholders

DOMINO 

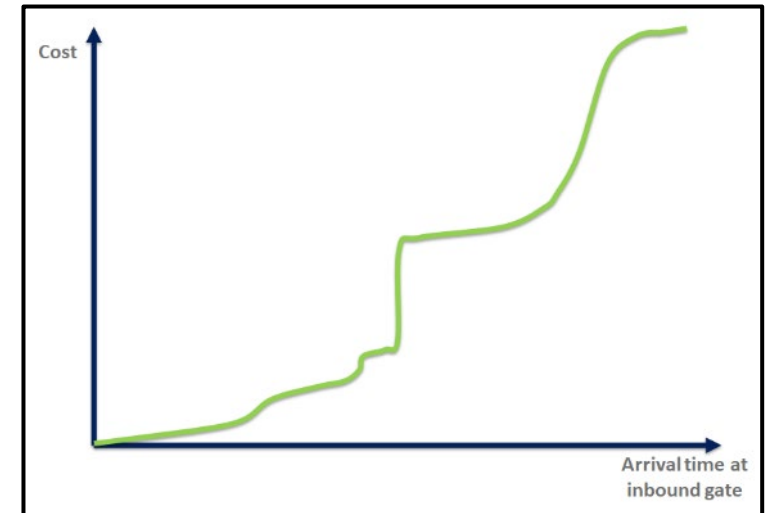
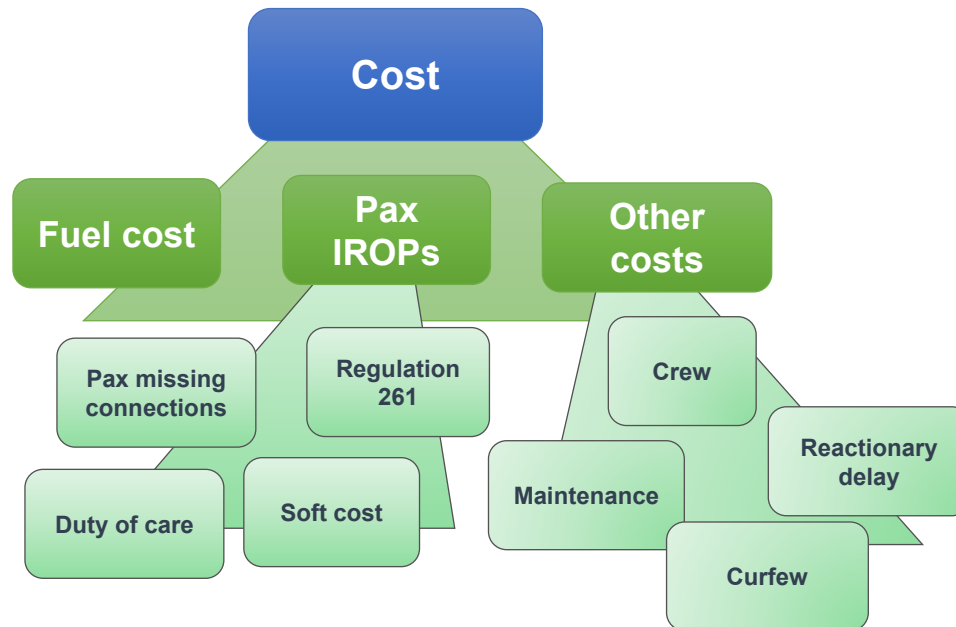
Actors have different objectives

Stakeholders' decisions shape the system

- E-AMAN
 - Maintain runway capacity
 - Maximise throughput
 - Reduce holdings
 - Prioritise flights
 - ...
- DMAN
 - Maintain runway capacity
 - ...
- Network Manager
 - Maintain network capacity
 - Prioritise flights
 - ...
- Airlines
 - Keep operations running smoothly
 - Keep delays to a minimum
 - Avoid extra costs
 - ...
- ...

Airlines are (mostly) cost minimisation-driven

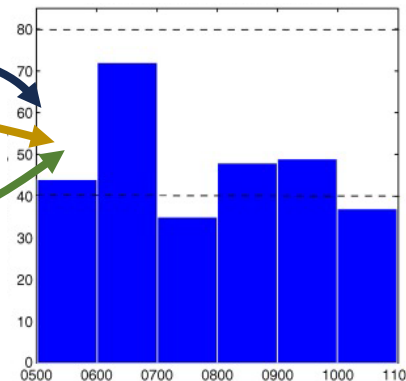
- Day(s) prior to operations airlines plan their flights
- During the day of operations actions to maintain flow of flights (and passengers)
- Decisions cost-driven



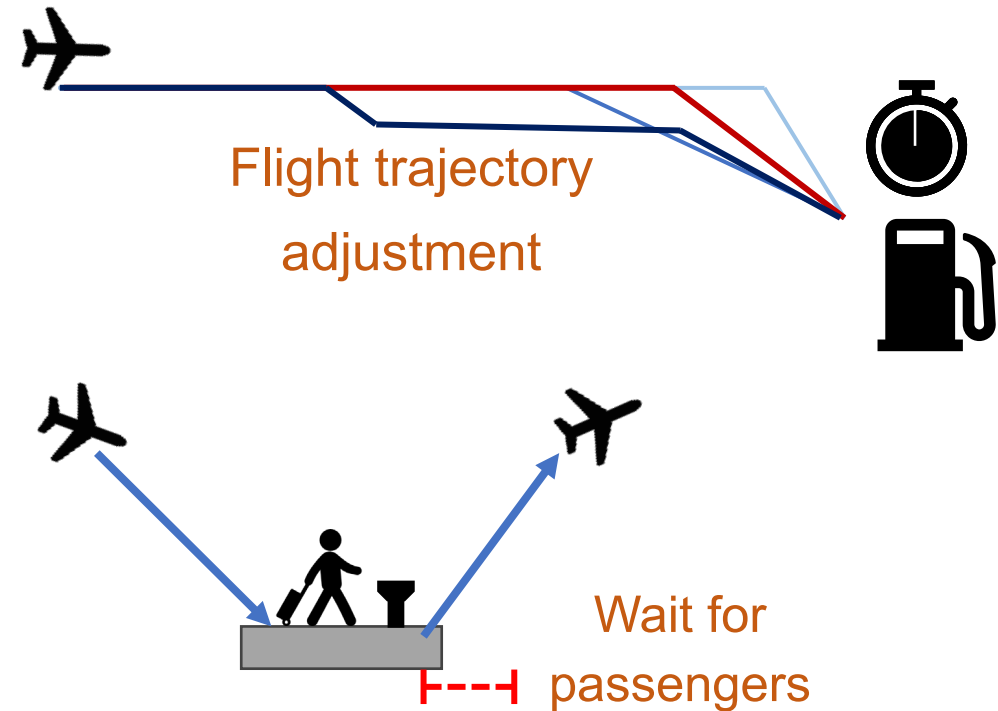
- Non-linear
- Difficult to estimate
- Subject to uncertainties

Airlines have diverse and complex decisions

- Day(s) prior operations airlines plan their flights
- During the day of operations actions to maintain flow of flights (and passengers)
- Decisions cost-driven (and complex)



Flight prioritisation in ATFM regulations

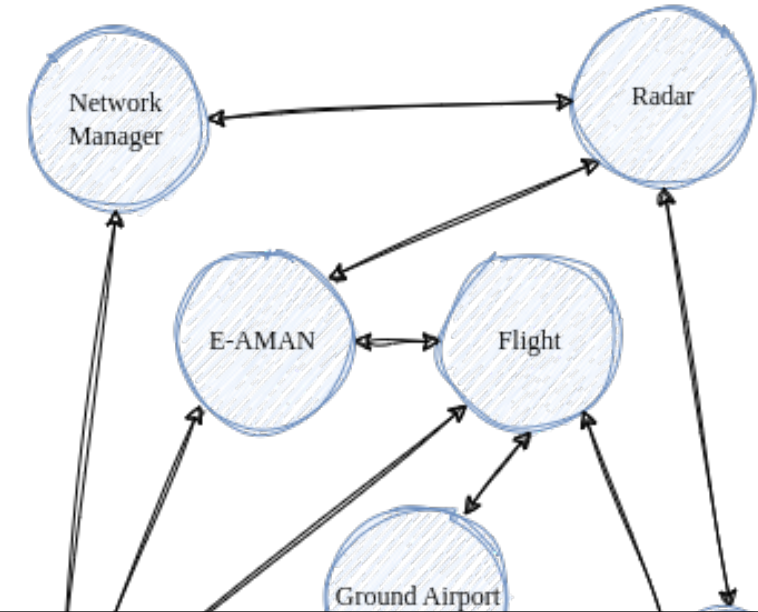


Mercury



Flight and passenger mobility model

- Agent-based model
- Describing main components of ATM system
- Tracking individual flights and passengers
- Multimodality and door-to-door estimation capabilities
- 1 day of operations at ECAC level (27k flights, 3M pax)
- Developed in various European projects over 10 years
- Open source



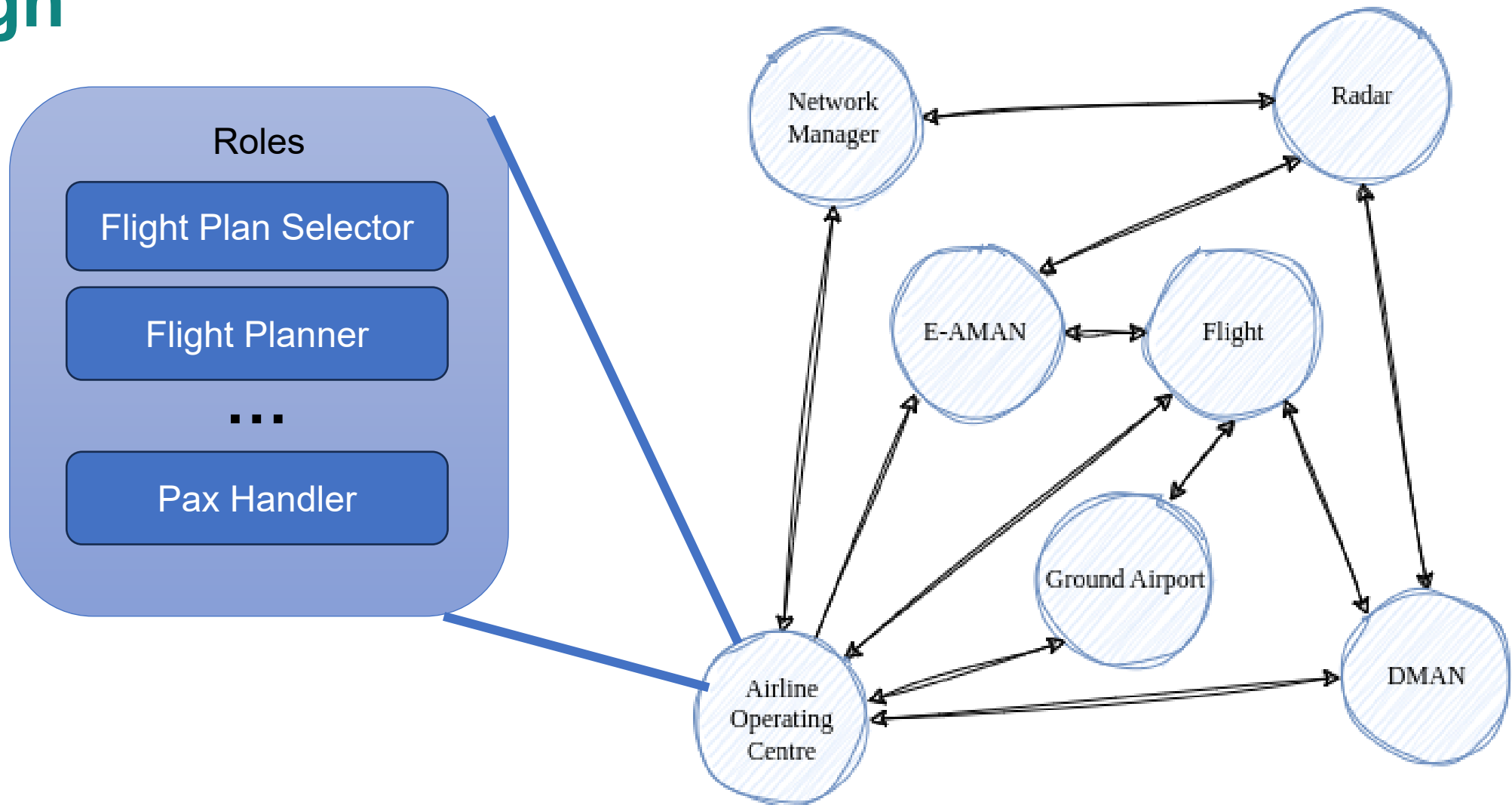
Computation requirements

- 1 day of operations simulation (ECAC region ~27K flights, ~3.4M pax):
 - ~ 8GB RAM
 - ~25 minutes baseline scenario (Intel i7-4790 @3.60GHz)
- **Individual low-level metrics** for different stakeholders



Agents and roles

Design



Communication and simulation

Messaging, events and interactions

Discrete-event simulator

- Roles are triggered by events with might trigger interaction (messages) with other agents
- Concurrency is possible
- Events can be generated, modified, cancelled (as needed)
- Events track main operational milestones:
 - Flight plan submission
 - Push-back
 - Take-off
 - ...
- Use of resources (e.g. aircraft)

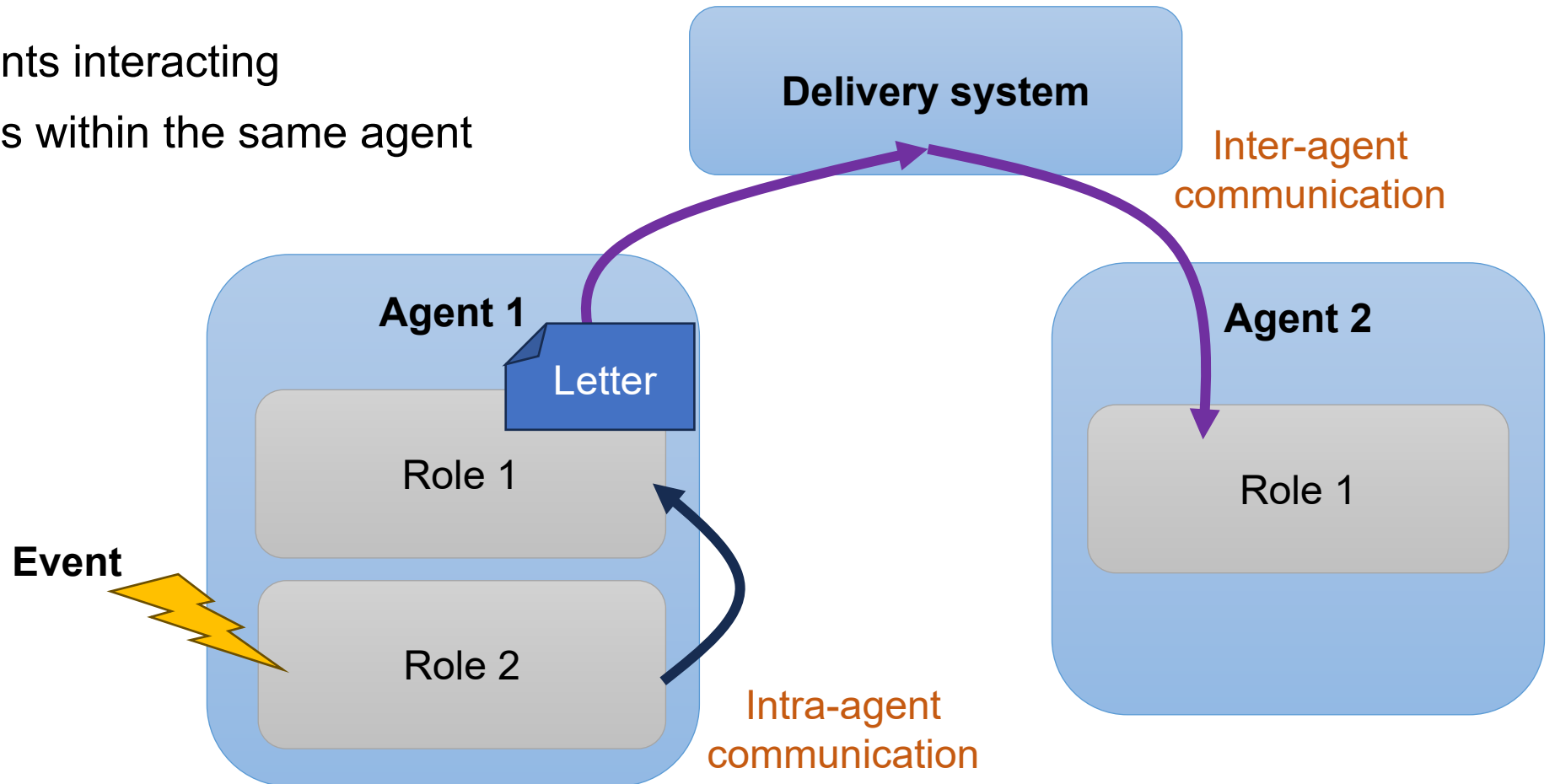


Communication and simulation

Messaging, events and interactions

Communications

- Inter-agents: two agents interacting
- Intra-agents: two roles within the same agent



Performance assessment of ATM solutions

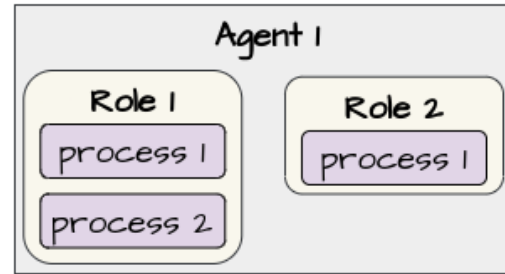
Two possibilities for new concept assessment:

- Replacing functionalities within agents and roles, or
- Micro-service communication approach.

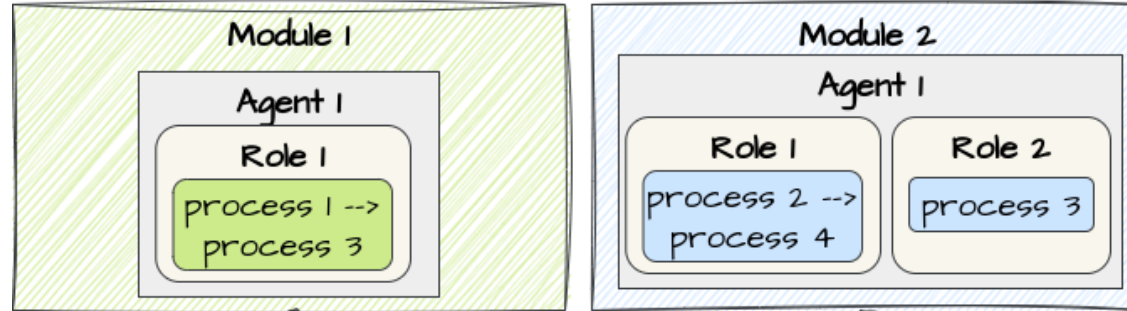
Modules – Replacing functionalities

Performance assessment of ATM solutions (1)

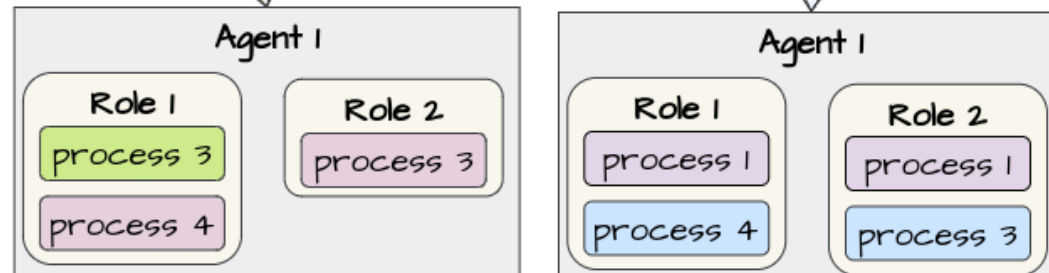
----- Default behaviour -----



----- Modules available -----



----- Instantiation of Modules -----



External communication

Performance assessment of ATM solutions (2)

- Re-routing of message/s to external system
- First approach in BEACON (HMI for human-in-the-loop simulation)
- Current work on standardisation of messages and communication channels
- External API allowing also inspection and requests for information from Mercury



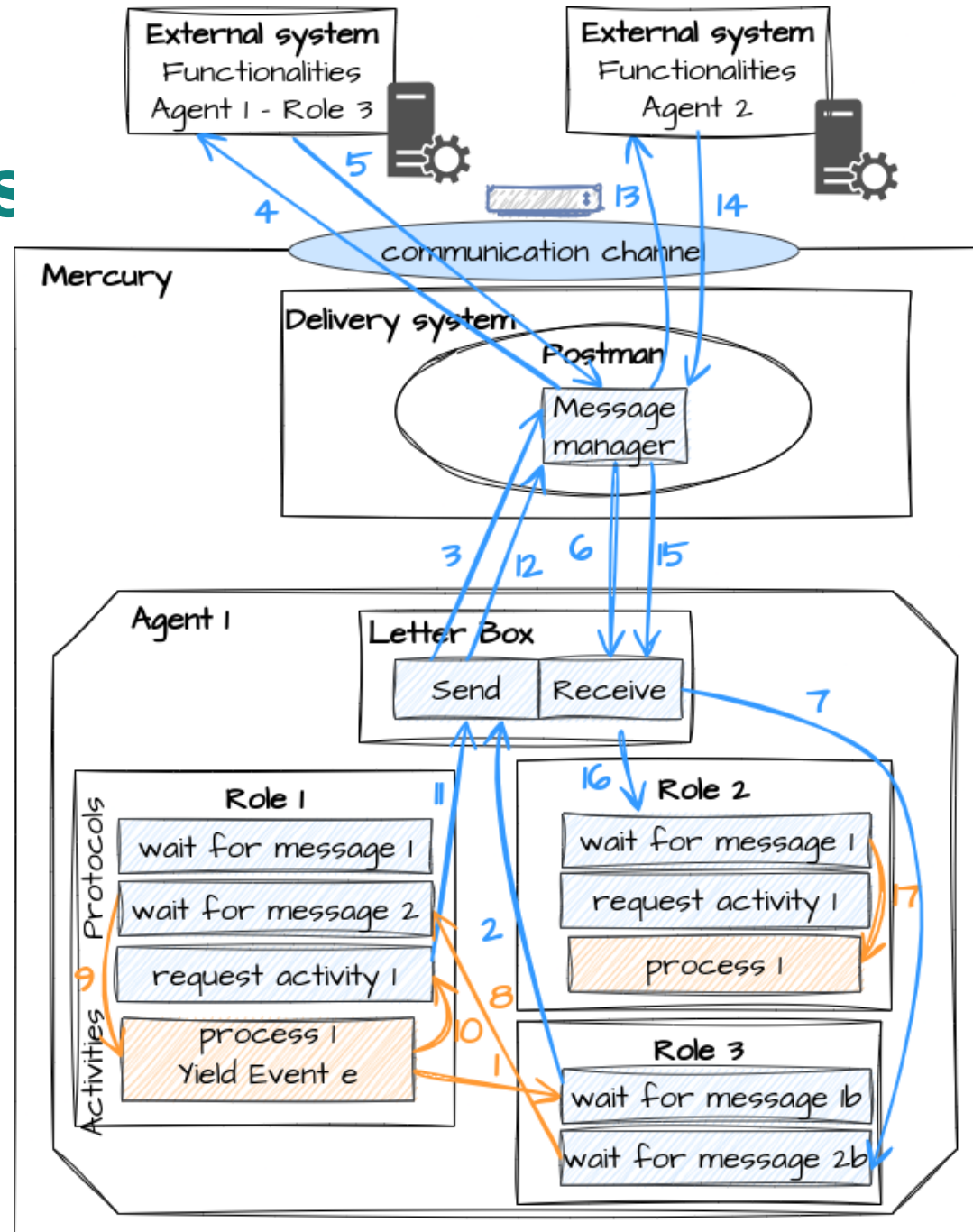
Under
development

External communication

Performance as

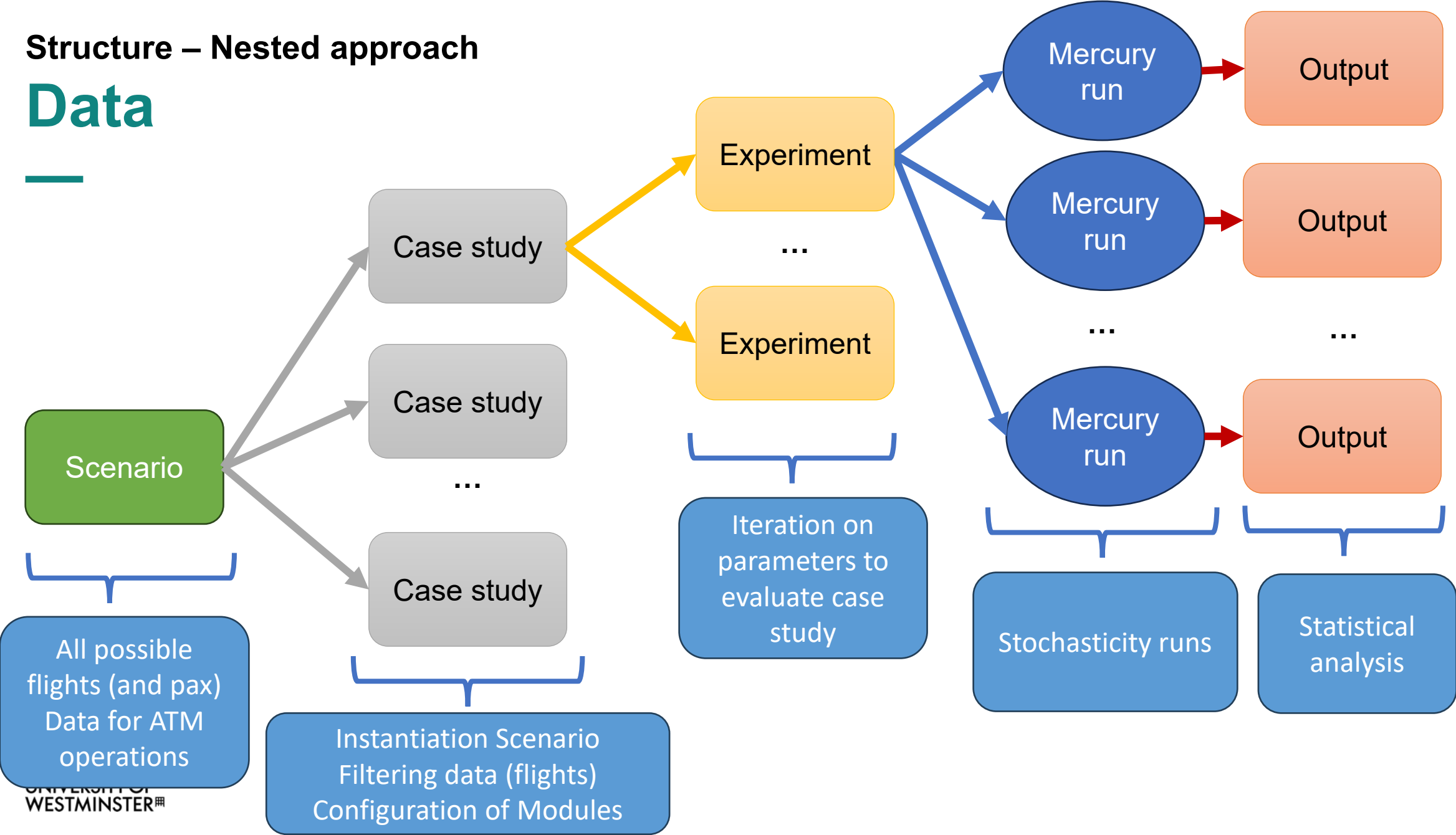
ions (2)

- External-Mercury communication example



Structure – Nested approach

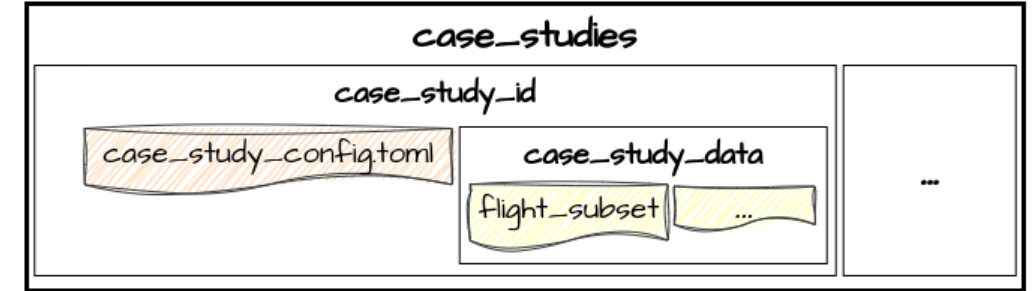
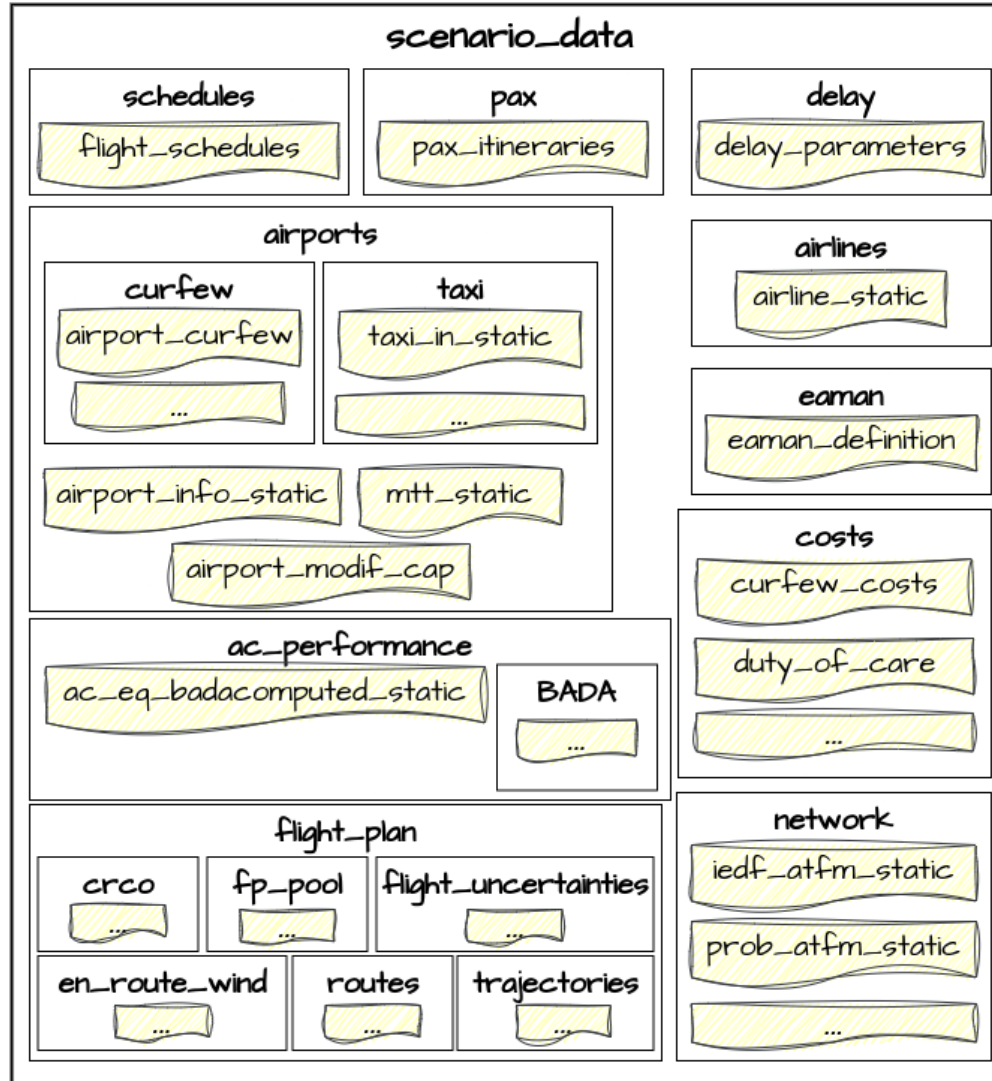
Data



Input Data

scenario=scenario_id

scenario_config.toml



Human-Machine Interface

Facilitate manipulation
input/output data and
configuration

Select scenario:
scenario=0 x ▾

Select case study:
None x ▾

LOAD

Filter by origin:
x All x ▾

Filter by destination:
x All x ▾

Filter by airline type:
x All x ▾

Start and end date for:
sobt ▾

11/09/2014 x 13/09/2014 x

Start and end hour:
0 ▾ 23 ▾

Filter by SQL query:
SELECT * FROM schedules|W| SUBMIT

SAVE SAVE AS

Input

Human-Machine Interface

Home — Mozilla Firefox

Home

127.0.0.1:8050

50%

Mercury Dashboard

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Pages: Home

Select scenario: scenario=0

Select case study: None

LOAD

Filter by origin: All

Filter by destination: All

Filter by airline type: All

Start and end date for: sub: 11/09/2014 - 13/09/2014

Start and end hour: 0 - 23

Filter by SQL query: SELECT * FROM input_of_WHE

SUBMIT

SAVE SAVE AS

id	callSign	origin	destination	date	time
33716	ARG140	SAZ2	LSPF	2014-09-11T13:45:00	2014-09-12T02:45:00
33717	AFK203	RJTT	LFPJ	2014-09-11T13:15:00	2014-09-12T02:00:00
33718	TWY13	RJBA	LTAJ	2014-09-11T13:30:00	2014-09-12T02:00:00
33719	TWY47	RJBB	LTAJ	2014-09-11T13:30:00	2014-09-12T02:35:00
33723	TWY27	ZSPB	LTAJ	2014-09-11T14:45:00	2014-09-12T02:35:00
33724	AEK446	SURE	LDRG	2014-09-11T14:45:00	2014-09-12T02:35:00
33725	TWY10	RK11	LTAJ	2014-09-11T14:30:00	2014-09-12T02:45:00
33727	AFK205	UNBB	LFPJ	2014-09-11T14:35:00	2014-09-12T04:05:00
33728	AEK42	SAZ2	LDRG	2014-09-11T14:35:00	2014-09-12T02:35:00
33729	BW21	WDSJ	EGLL	2014-09-11T14:35:00	2014-09-12T04:05:00

Number of flights: 27261

Flights Pax Cost Network Delay Airport FP EAMAN

Number of flights: 27261

Hourly traffic

Parameters:

parameter_name	value
default_holding_altitude	200
default_holding_ff	20
use_trajectory_uncertainty	true
use_wind_uncertainty	true

Airline Parameters:

parameter_name	value
non_ATR_delay_max	0
computation_method	0.15
delay_penalty_max	0.0
threshold_max	200
heuristic_block_size_factor	1.8
smoothness_cp	
fg_anchor	
cancel_override_percent	0.15

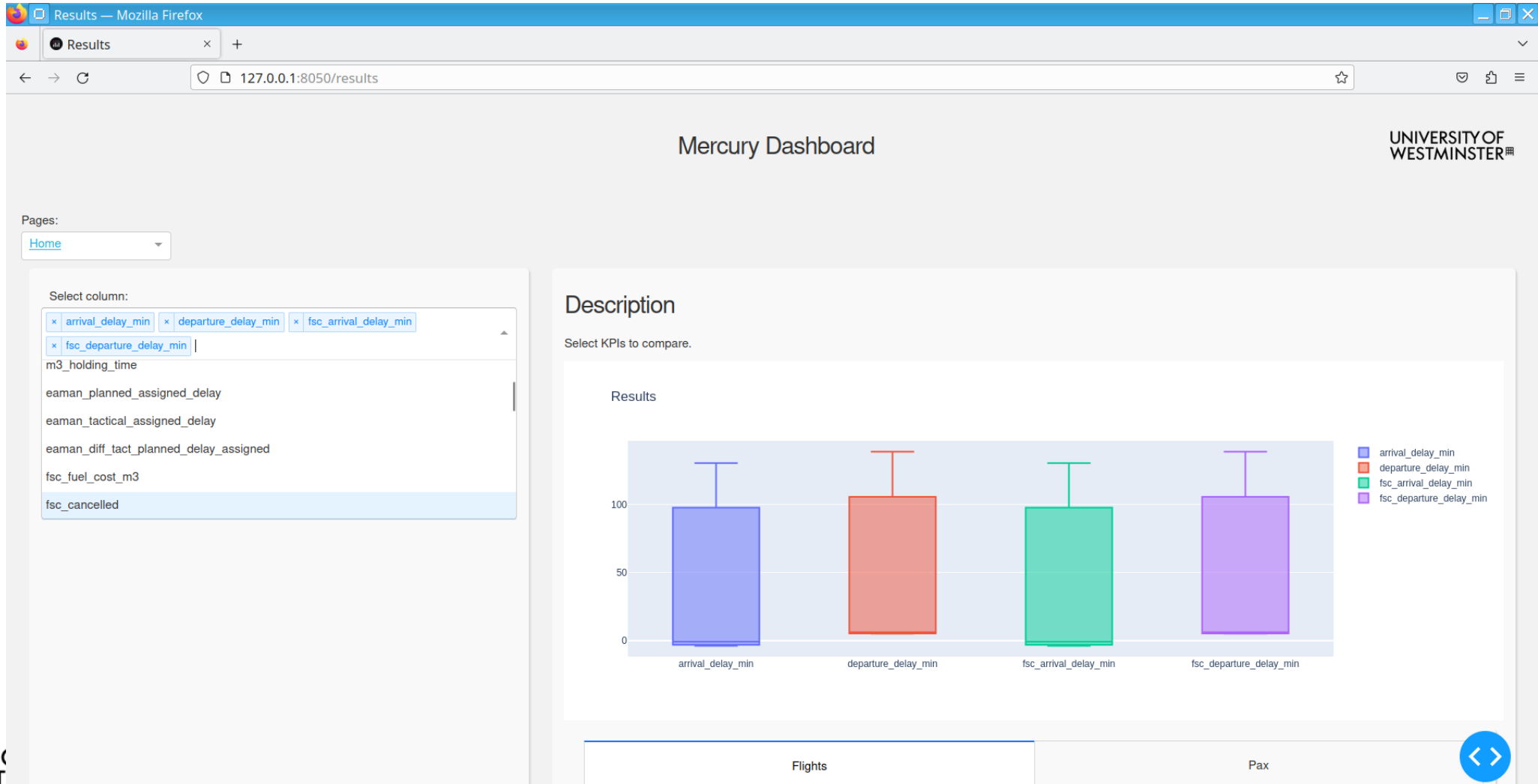
Input

Human-Machine Interface

The screenshot displays a flight search interface with a navigation bar at the top containing tabs for Flights, Pax, Cost, Network, Delay, Airport, FP, and EAMAN. Below the navigation bar, there are two input fields: "Select origin" with the value "LPFR" and "Select destination" with the value "EYVI". The main area is a map of Europe and the Mediterranean region, with several flight routes highlighted in purple. The routes originate from LPFR (Lyon) and terminate at EYVI (Eindhoven). The routes include paths through cities like London, Paris, Amsterdam, and Berlin. A blue double-arrow button is visible in the bottom right corner of the map area.

Output

Human-Machine Interface

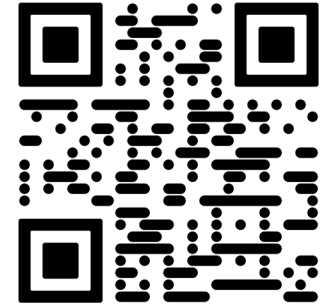


Conclusions

- Multi-agent-based system
- Decisions based on cost estimation
- Event-driven tracking main processes
- Modelling flight and passenger mobility
- Capturing low level indicators (and distributions) for relevant stakeholders
 - Delay, costs, emissions, etc.
- Modular: easy to modify behaviour of element in system
- External communication (micro-service approach)
- Open source (and libraries): Python



<https://github.com/UoW-ATM/Mercury>





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