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

07/06/2024 - Open-source tools for Air Traffic Management modelling and research

MERCURY

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System performance due to stakeholders' decisions

The ATM system is complex, with many different actors

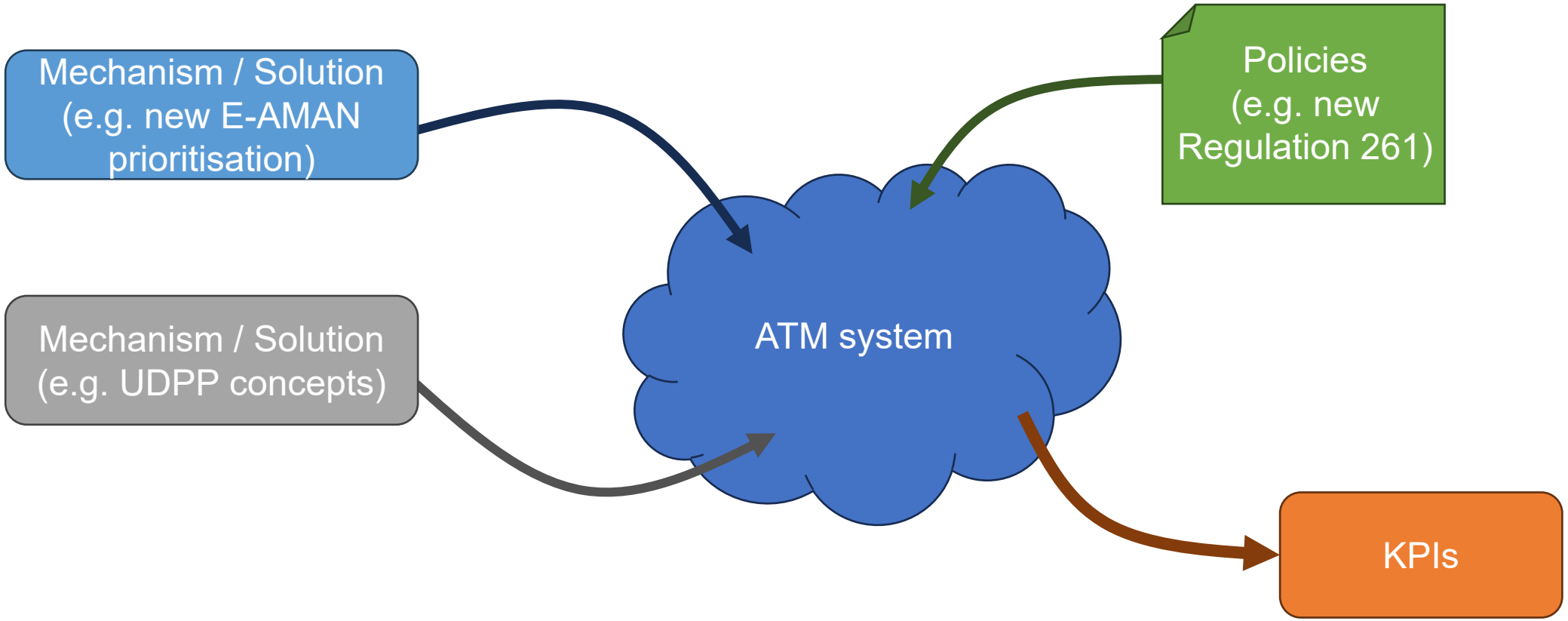
- Airlines
- Crew (flight)
- Airports (arrival managers, departure managers)
- Network Manager
- …

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

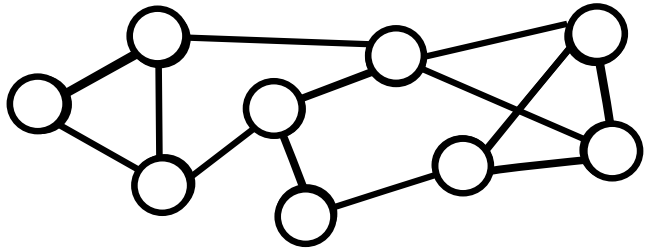
Different stakeholders, different system perception

Reactionary delay

Flight

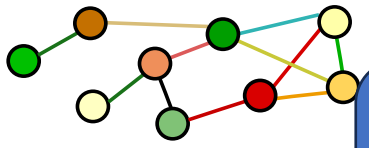
Passenger

Passenger connectivity

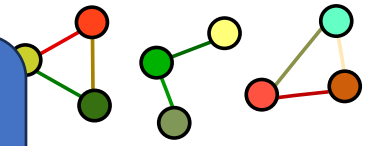


DOMINO

Flight network perspective



Passenger network perspective



- Network metrics
- Capturing distribution KPIs for stakeholders

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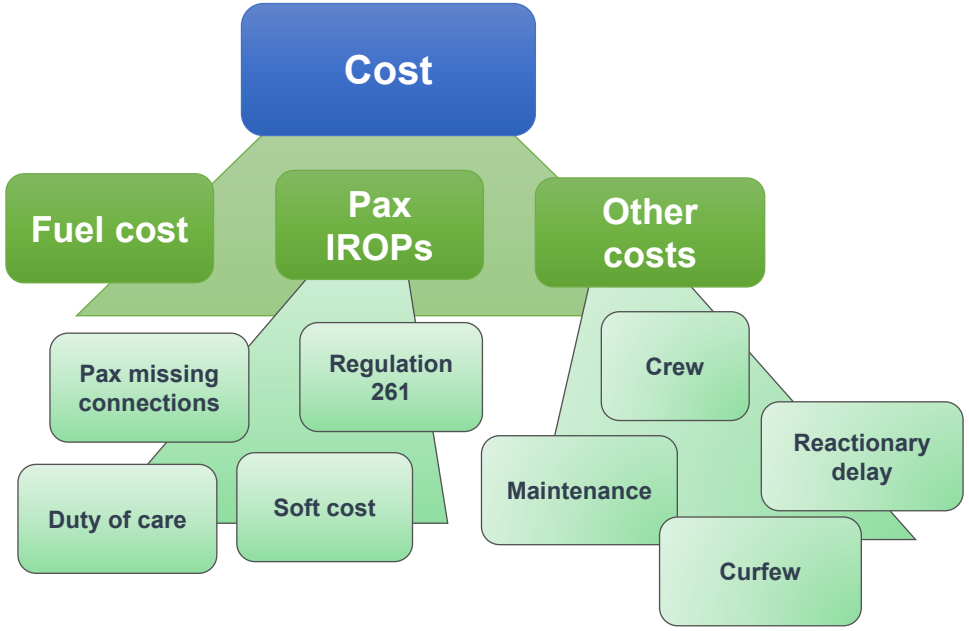
Actors have different objectives

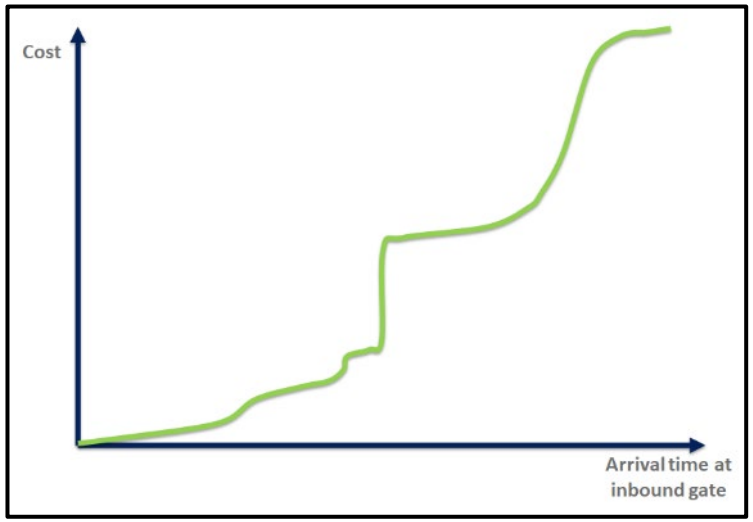
Stakeholders' decisions shape the system

- 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

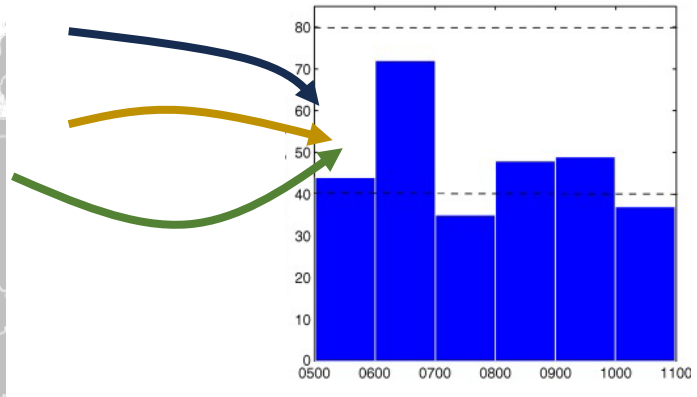




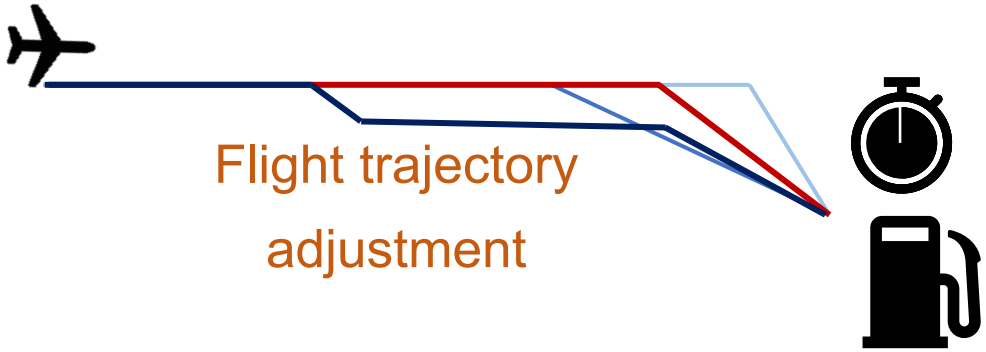
- Non-linear
- Difficult to estimate
- Subject to uncertainties

Airlines have diverse and complex decisions

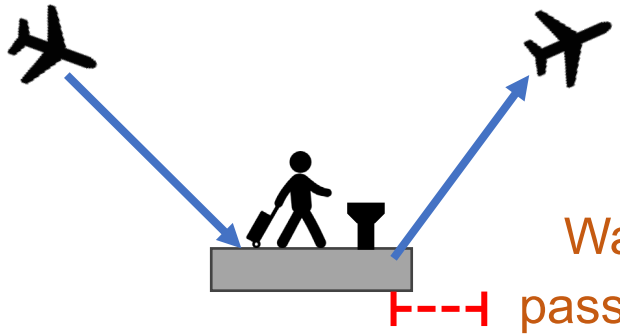
- Day(s) prior operations airlines plan their flights
- During the day of operations actions to maintain flow of flights (and passengers)
- Decisions cost-driven (and complex)



Flight prioritisation in ATFM regulations



Flight trajectory adjustment



Wait for passengers

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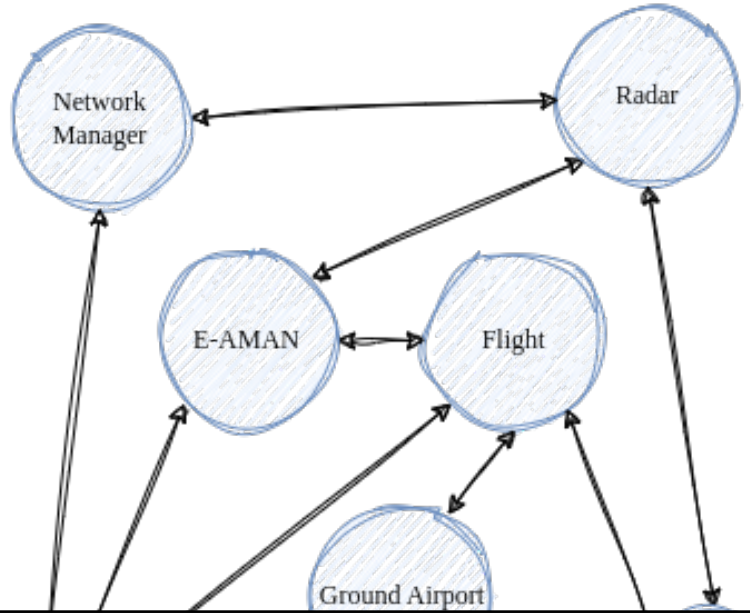
Mercury

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

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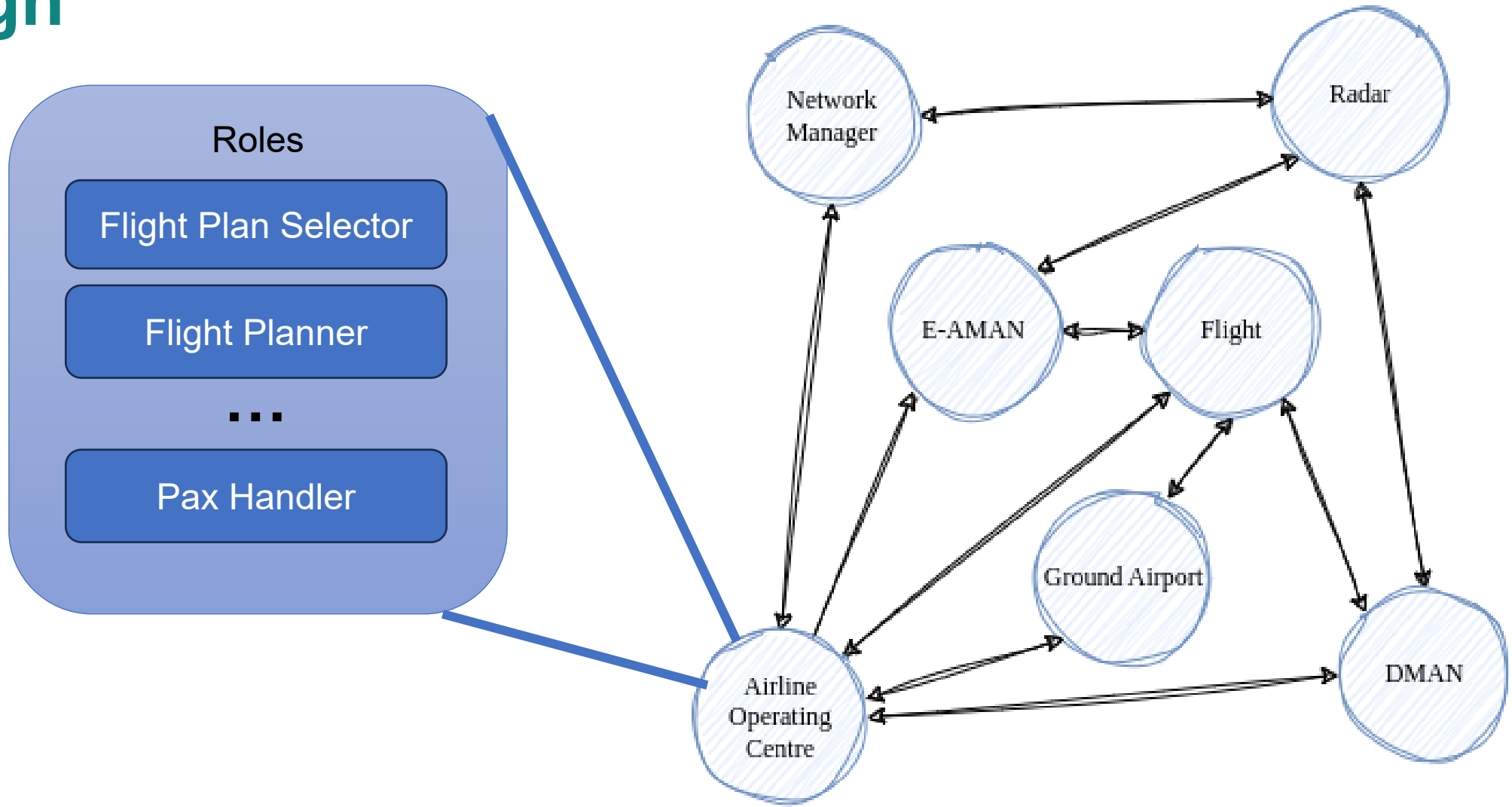
Agents and roles

Design



Communication and simulation

Messaging, events and interactions

Discrete-event simulator

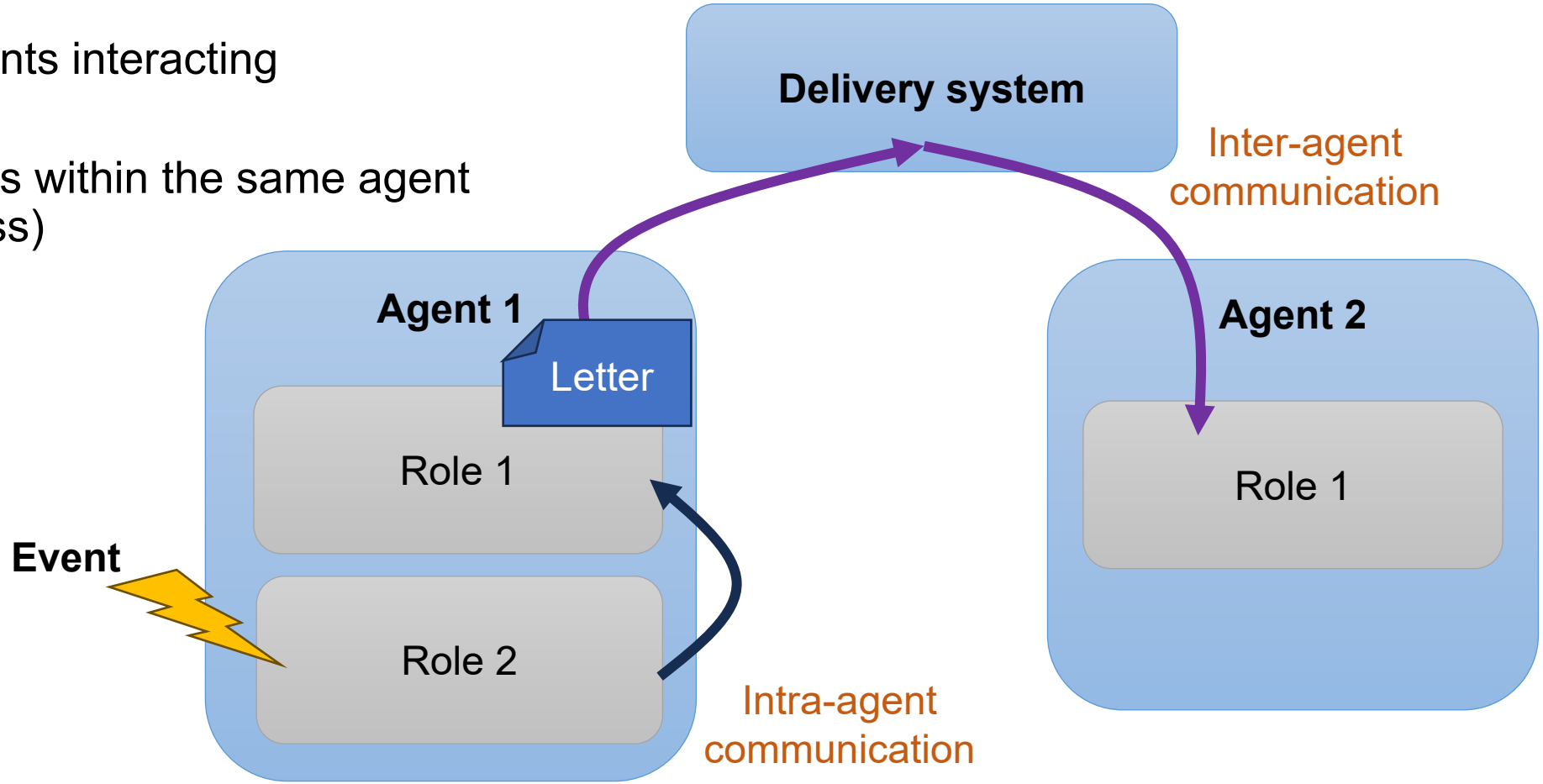
- Roles are triggered by events with might trigger interaction (messages) with other agents
- Concurrence is possible
- Events can be generated, modified, cancelled (as needed)
- Events track main operational milestones:
  - Flight plan submission
  - Push-back
  - Take-off
  - …
- Use of resources (e.g.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

Communication and simulation

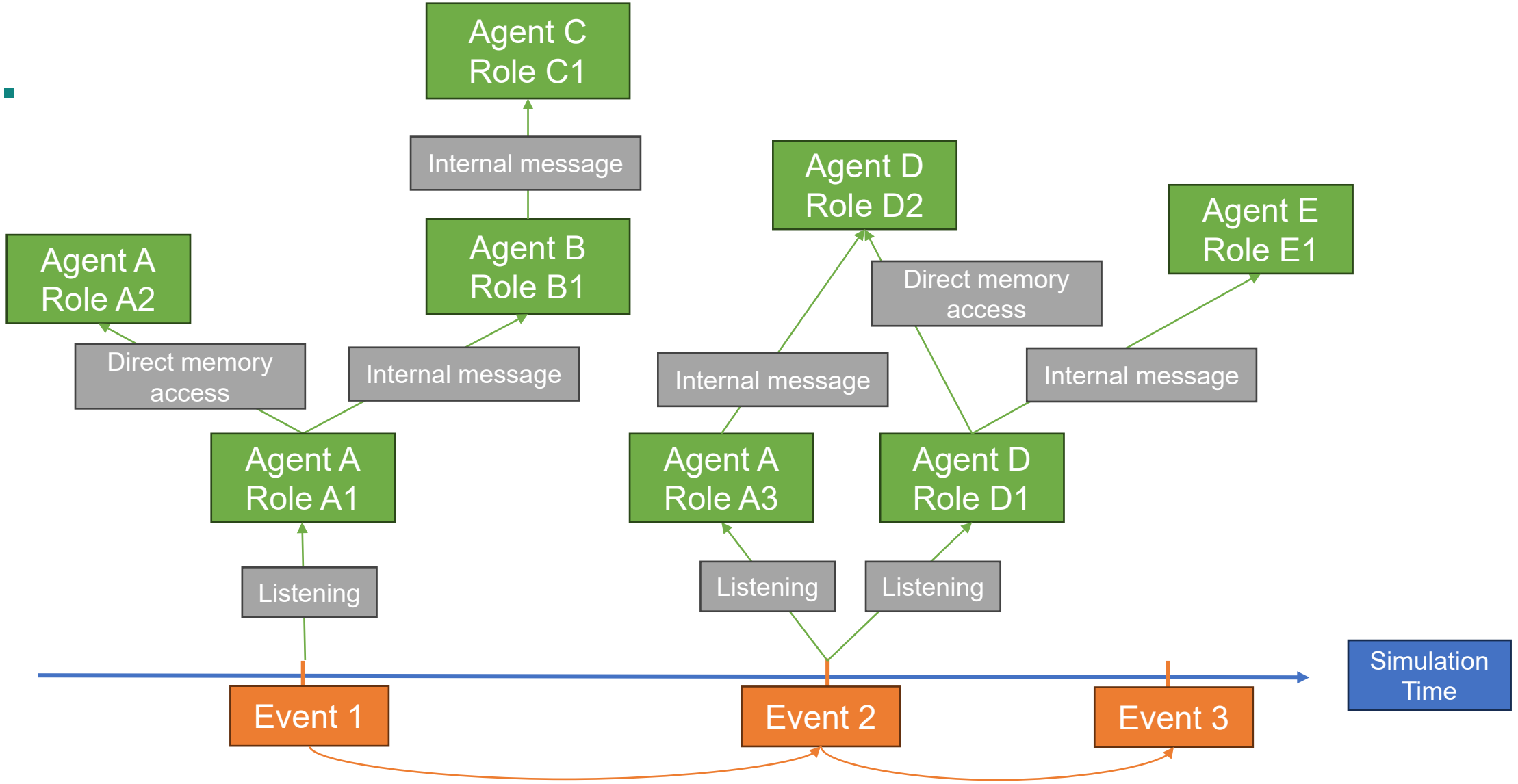
Messaging, events and interactions

Communications

- Inter-agents: two agents interacting (messaging system)
- Intra-agents: two roles within the same agent (direct memory access)

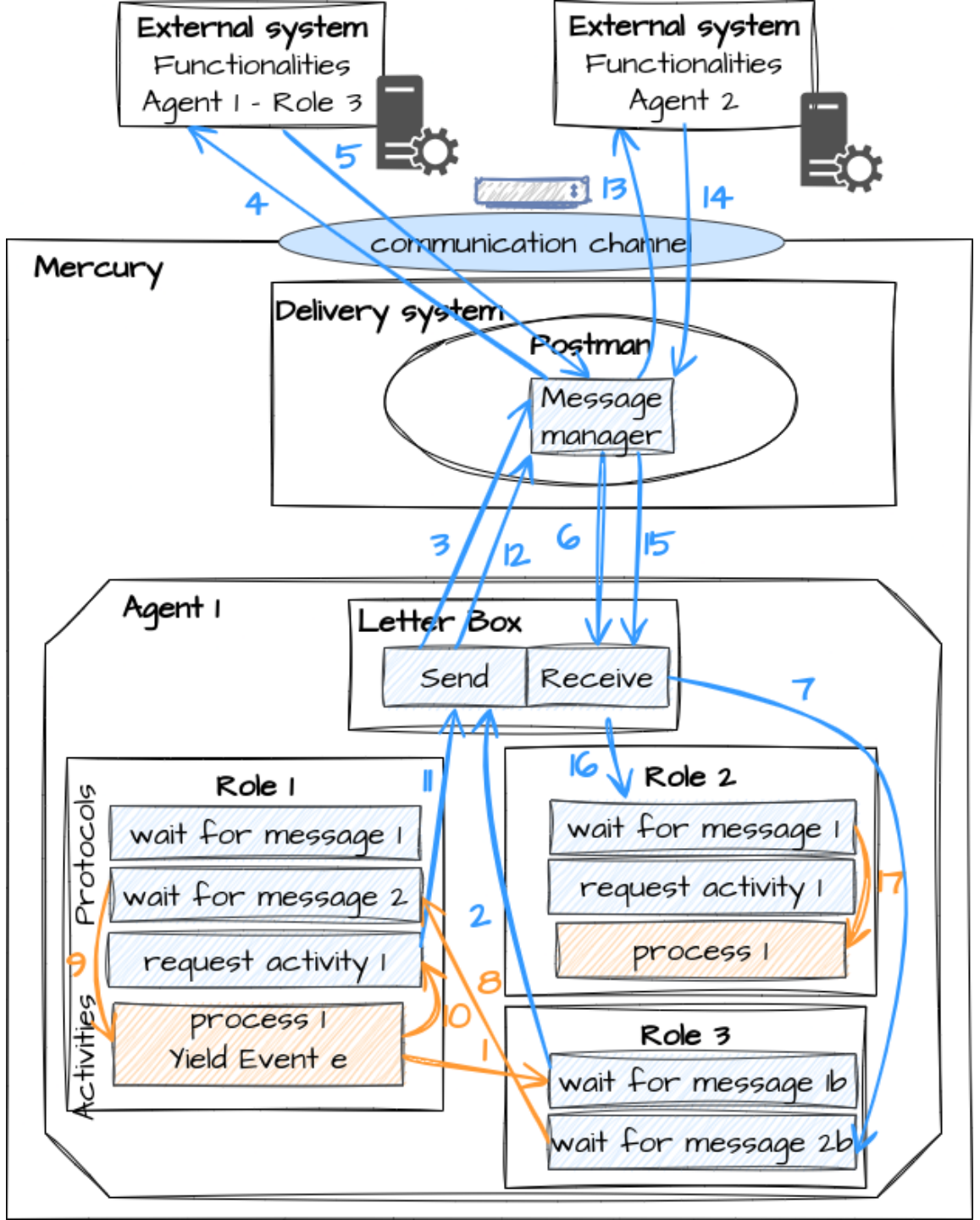


Ex.


Agent C
Role C1
Internal message
Agent B
Role B1
Agent A
Role A2
Direct memory
access
Internal message
Agent A
Role A1
Listening
Event 1
Agent D
Role D2
Direct memory
access
Agent E
Role E1
Internal message
Internal message
Agent A
Role A3
Agent D
Role D1
Listening
Listening
Event 2
Event 3
Simulation
Time

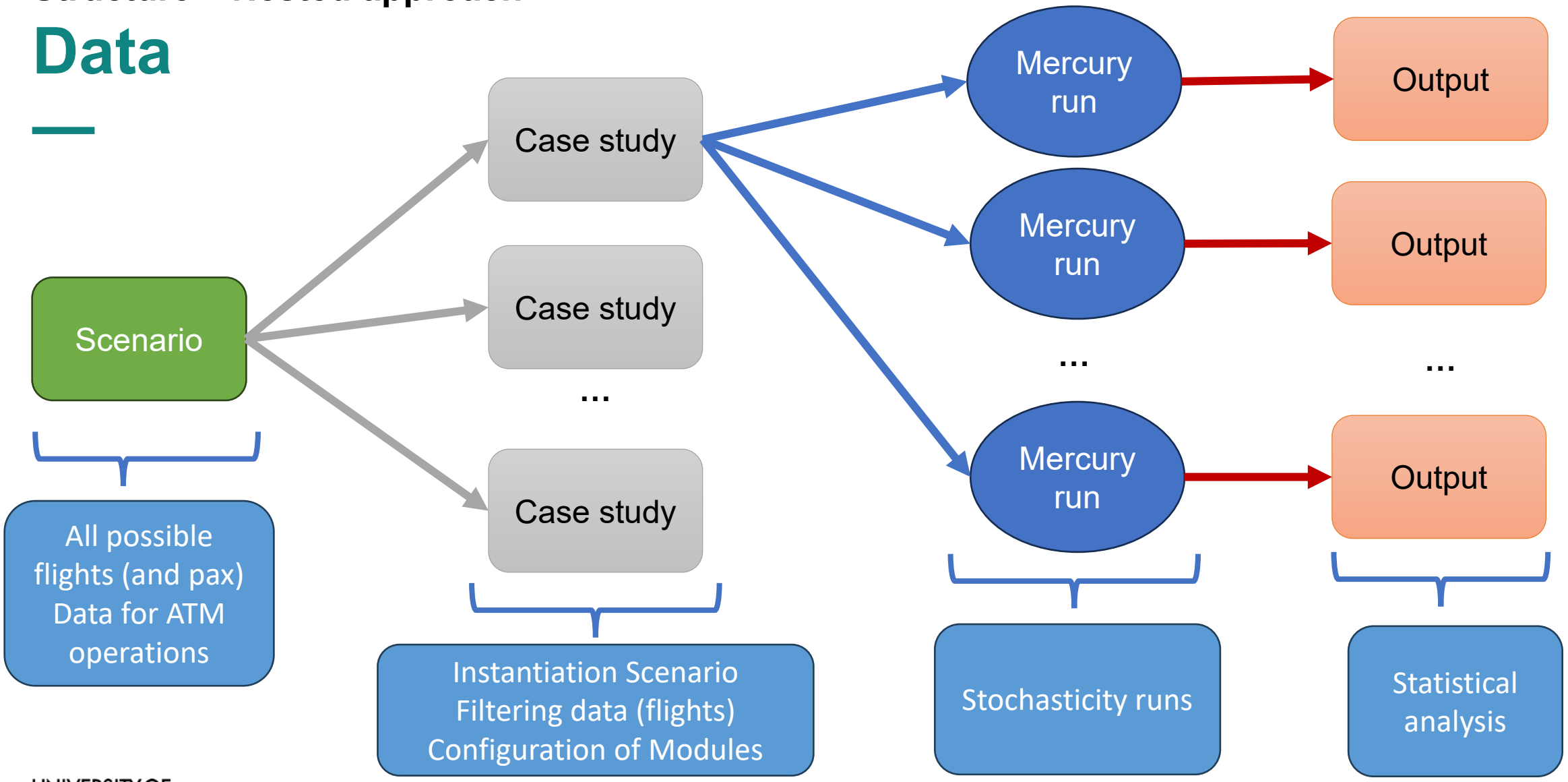
External communication

- External-Mercury communication example
- Uses a special agent (…) called “Notifier”
- Uses rabbitmq or zmq to communicate
- Can communicate with other scripts, dash interfaces, etc, even on different machines (locally or through internet).



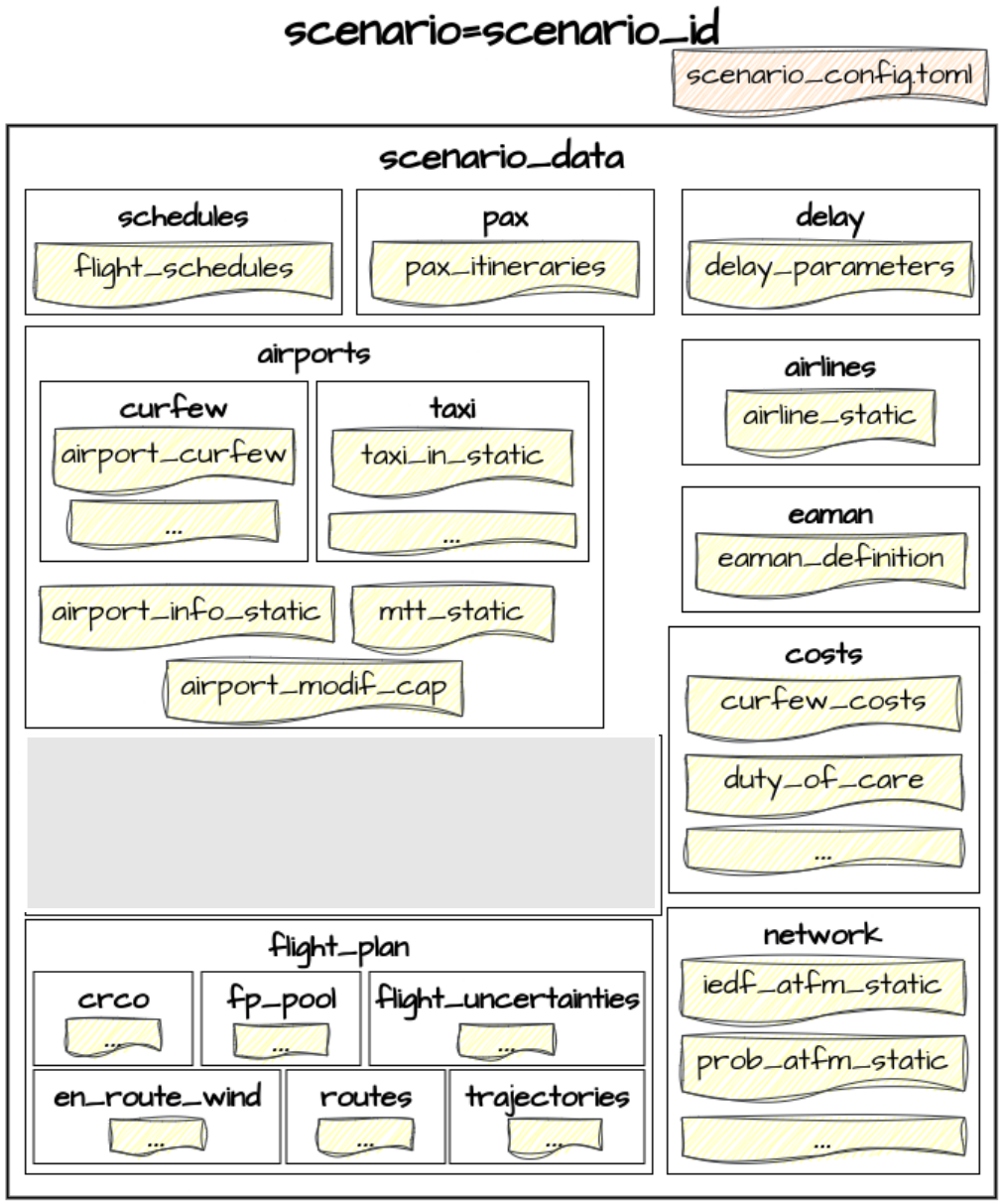
Structure – Nested approach

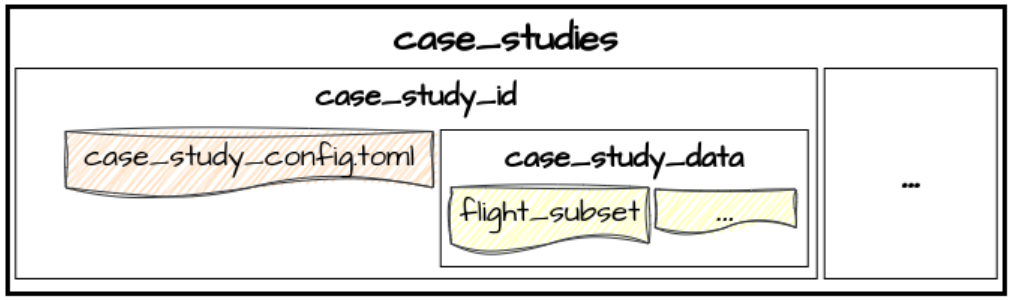
Data



Input

Data

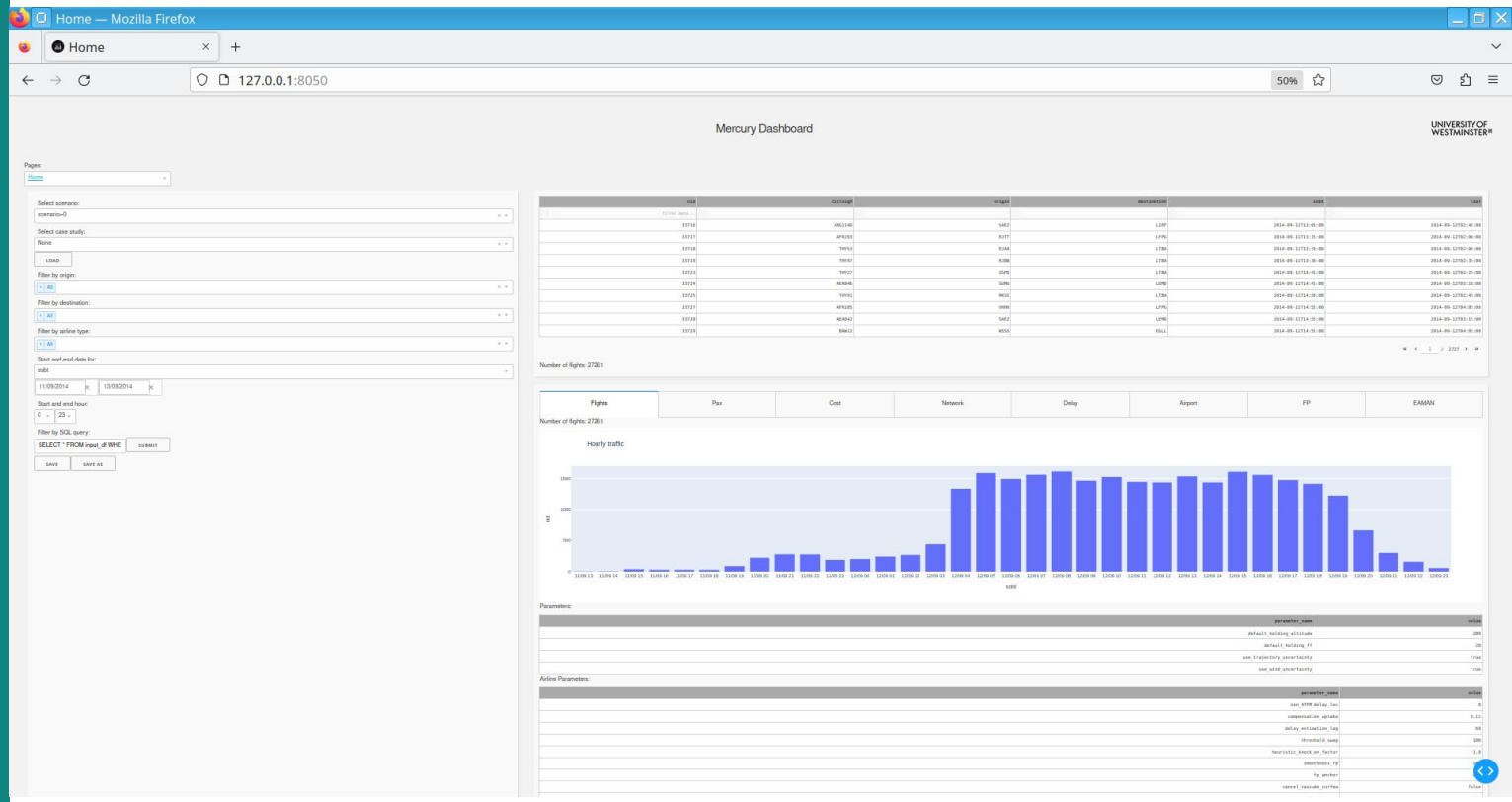

scenario=scenario_id
scenario_config.toml
scenario_data
schedules
flight_schedules
pax
pax_itineraries
delay
delay_parameters
airports
curfew
airport_curfew
...
taxi
taxi_in_static
...
airport_info_static
mtt_static
airport_modif_cap
airlines
airline_static
eaman
eaman_definition
costs
curfew_costs
duty_of_care
...
flight_plan
crco
...
fp_pool
...
flight_uncertainties
...
en_route_wind
...
routes
...
trajectories
...
network
iedf_atfm_static
prob_atfm_static
...


case_studies
case_study_id
case_study_config.toml
case_study_data
flight_subset
...
...

Input

Human-Machine Interface

Facilitate manipulation input/output data and configuration



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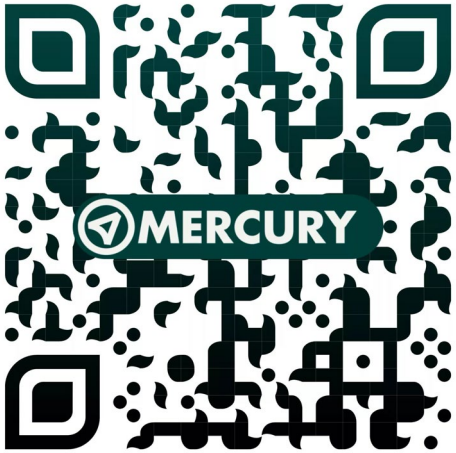

https://github.com/UoW-ATM/Mercury

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