

# CASSIOPEIA

*Complex Adaptive Systems for Optimisation of Performance in ATM*

## The simulation platform for CASSIOPEIA

Jorge Martín  
Software architect - INNAXIS  
7<sup>th</sup> Nov 2016



# Introduction

System that implements the CASSIOPEIA agent model and reproduces its behavior in different scenarios.



# Platform requirements

## Functional

The simulation platform shall:

- Simulate the CASSIOPEIA agent model.
- Post-process the results of the simulation

## Non functional

The components of the platform shall be:

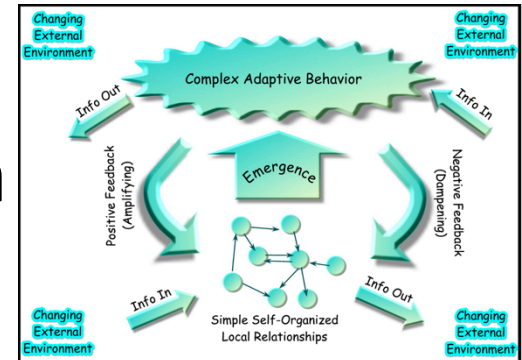
- Reusable
- Scalable

# CASSIOPEIA agent model

CASSIOPEIA reproduces part of the ATM complex adaptive system

Challenges:

- Heterogeneous data sources
- Agents with limited perception
- Changing shared environment
- Feedback loops when negotiating
- Restricted time for negotiating



# Heterogeneous data sources

Initial simulation data is taken from a MySQL database.

Why?

- Some steps of the preprocessing are human assisted
- Size optimizations



# Agent with limited perception

Jadex provide a BDI agent framework for defining agents with limited perception that performs actions in response to interactions or desires.

- Beliefs: Things the agent know
- Desires: Why tasks are performed
- Intentions: Tasks the agent perform

Airport
- simulationDCI4HD2D: DCI4HD2DSimulation - flights: List<DCI4HD2DFlight> - arr_slots1: Map<Long, String> - arr_slots2: Map<Long, String> - arr_prop: Queue<SlotRequest> - dep_slots1: Map<Long, String> - dep_slots2: Map<Long, String> - next_assign: Long
+ initAMANassignmentPlan(Initialization): void + bookAMANrequestPlan(requestSlotsSelection): requestSlotSelection + getFreeSlotsPlan(requestFreeSlots): requestFreeSlots + assignEarliestDepSlotPlan(requestDelay): informDelay

# Changing shared environment

The perception of flight plans is shared between agents

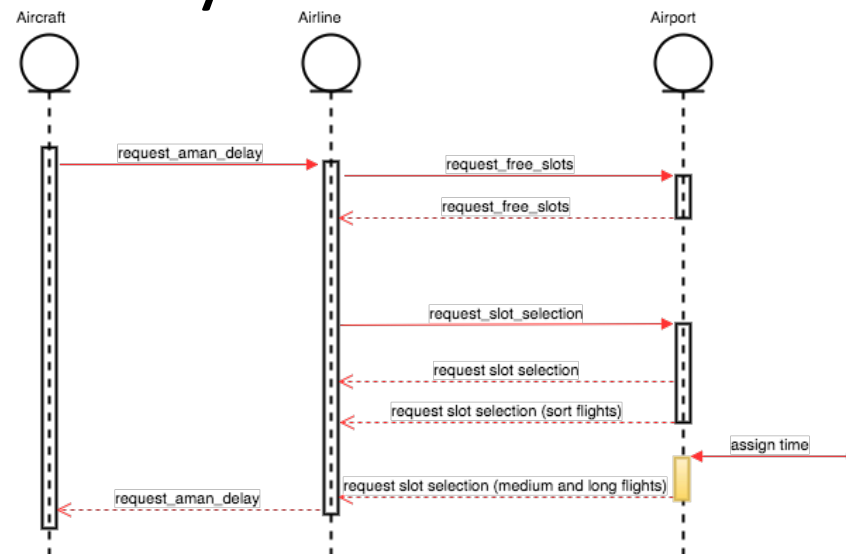
Environment changes over time stochastically. Commons math library has implemented most used probability distributions.

commons  
[*Math*]<sup>TM</sup>

# Feedback loops when negotiating

Adaptability by collective behavior

A group of agents can cooperate synchronously or asynchronously.





# Restricted time for negotiations

Agents perform actions

- In response of an agent interaction.
- In response of a flight plan event

JADEX provides a discrete event simulation engine to improve performance when simulating at discrete events only

# Simulation results post-processing

Two different types of results:

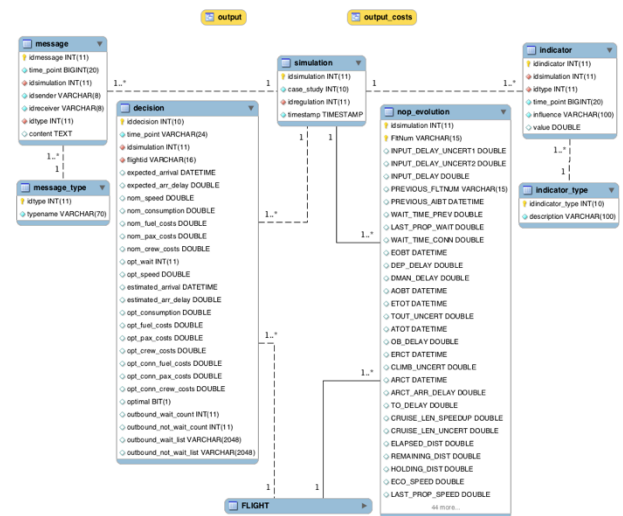
- Microscopic results: For validation and verification of the model.
- Performance indicators: For quantification of scenario performance

# Microscopic results

- Selected speed at certain times with delay costs
- Flight delays for each flight phase
- Final times for each flight phase

Micro analysis data is stored in a relational database. Why?

- Powerful query engine
- Reduce storage requirements



# Performance indicators

The platform generates performance indicators because there are more results than a person can handle!

- Global indicators, i.e departure delay
- Aggregated indicators, i.e. per airline type

Descriptive analysis using Commons math library



# Performance indicators

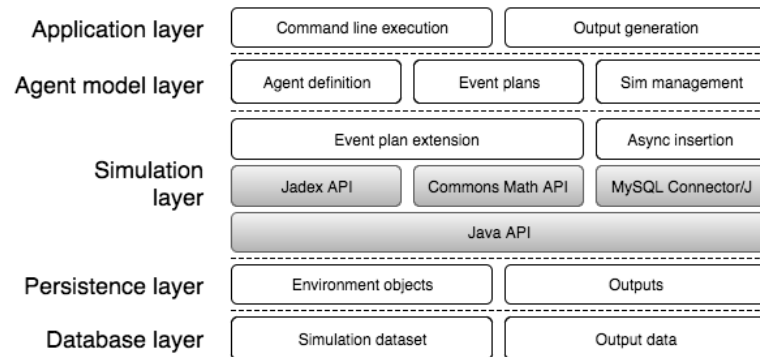
Performance indicators are stored in CSV files

- Supported by most data analysis tools: R, Excel, Matlab
- Easy to generate

# Reusability

Improve the model iteratively by using:

- Modular architecture.



- General tables for all case studies.
- Open source technologies

# Scalability

Able to put more resources to simulate the scenarios on time.

How is obtained?

- Separation of simulation data and processing.
- Separate thread for storing data in database
- Batch simulation.



Thank you for your time and  
interest!

I will happily address any questions you may have in the questions  
panel.