

A Meta-model of a Multi-Paradigm Approach to Smart Cyber-Physical Systems Development

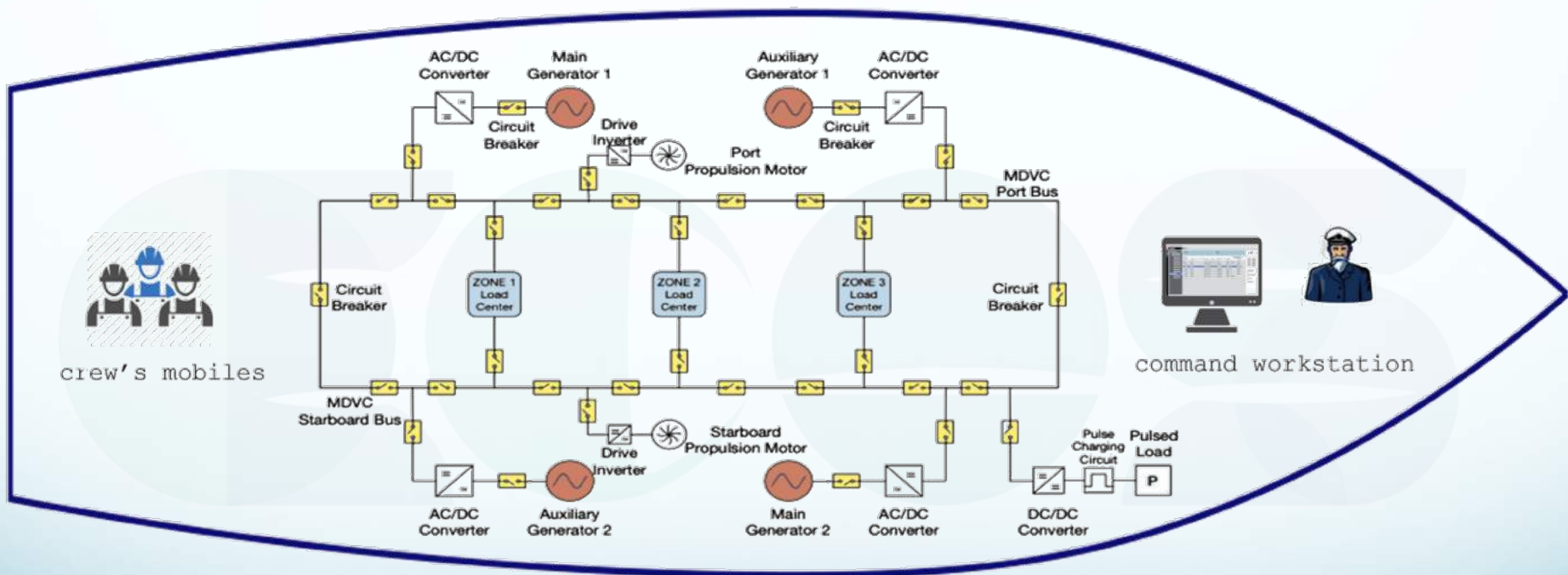
M. Cossentino, S. Lopes, G. Renda, L. Sabatucci, F. Zaffora

The Objective

- Developing a **Smart CPS**
 - flexible solutions
 - **heterogeneous** technologies and frameworks
- Case study application:
Shipboard Power System (SPS) reconfiguration

The Problem

Shipboard Power System (SPS) Reconfiguration



The Problem Requirements



The Problem

Requirements

The CPS here developed for a SPS should:

- be **smart**, i.e. the system should show a reasoning aptitude (agent-oriented paradigm)
- be **adaptive**, that means the system can efficiently adapt to environmental changes
- be **predictive**, i.e. it can foresee changes in its behavior for possible changes in the context
- be **distributed**: the system is heterogeneous and its parts are located in different places so it is able to maintain the connection
- face **realtime** event, so the system is able to promptly react to changes

Agents and Actors

Which framework is better choosing?

Use each framework **strength points** for the most suitable task.
Then, choose all!

Jason, Jade, Akka, Cartago, Moise.
Why these frameworks and not others?

ECOS

- long-time experience
- Java-based
- Open-source
- Both academic and industrial development



Multi-paradigm Strategy



Jason's reasoning

- **BDI reasoning**
- The communication among Agents is an action that has a Propositional Content and a Performative

Jade's communication protocols

- Fully **FIPA** compliant
- Specific aptitude to finite state-machine and interoperability due to protocols-oriented communications

Akka's hierarchy

- **Father-sons** hierarchy
- Reactive Actor
- Parallel, asynchronously communication
- efficiency, distribution, scalability and failures control

Cartago's environment

- Executing **artifact**-based environments
- Human-based cooperative environment

Moise's organization

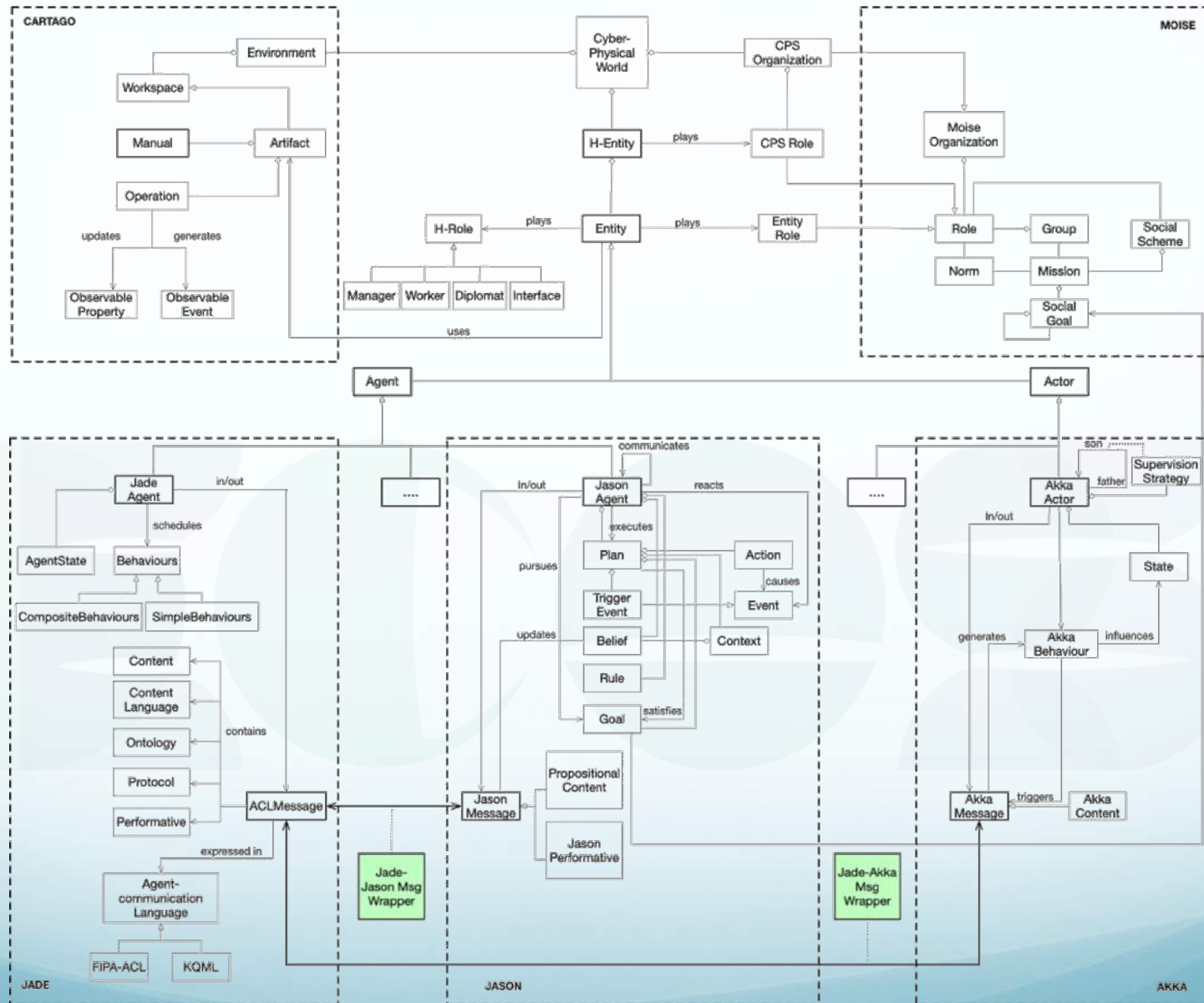
- Strong **organization** to pursue a goal
- Social scheme

How is it possible to make different frameworks
communicate?

The H-Entity

The H-Entity, where ‘**H**’ stands for ***heterogeneous***, holds the entire philosophy here proposed.

It can be considered as a polyhedral organism composed of frameworks that cooperate by exploiting their **best** qualities and **winning skills**.





The Proposed Framework

The Meta-model: top-down perspective



The Proposed Framework

The Meta-model: top-down perspective

Cyber-Physical
World

ECOS

The Proposed Framework

The Meta-model: top-down perspective



ECOS

The Proposed Framework

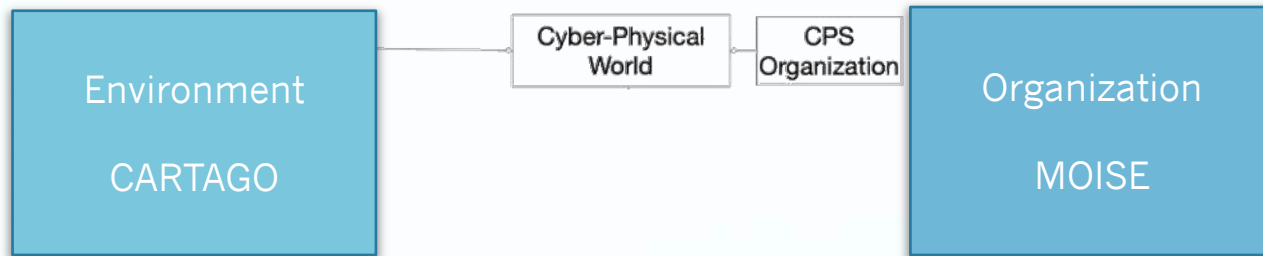
The Meta-model: top-down perspective



ECOS

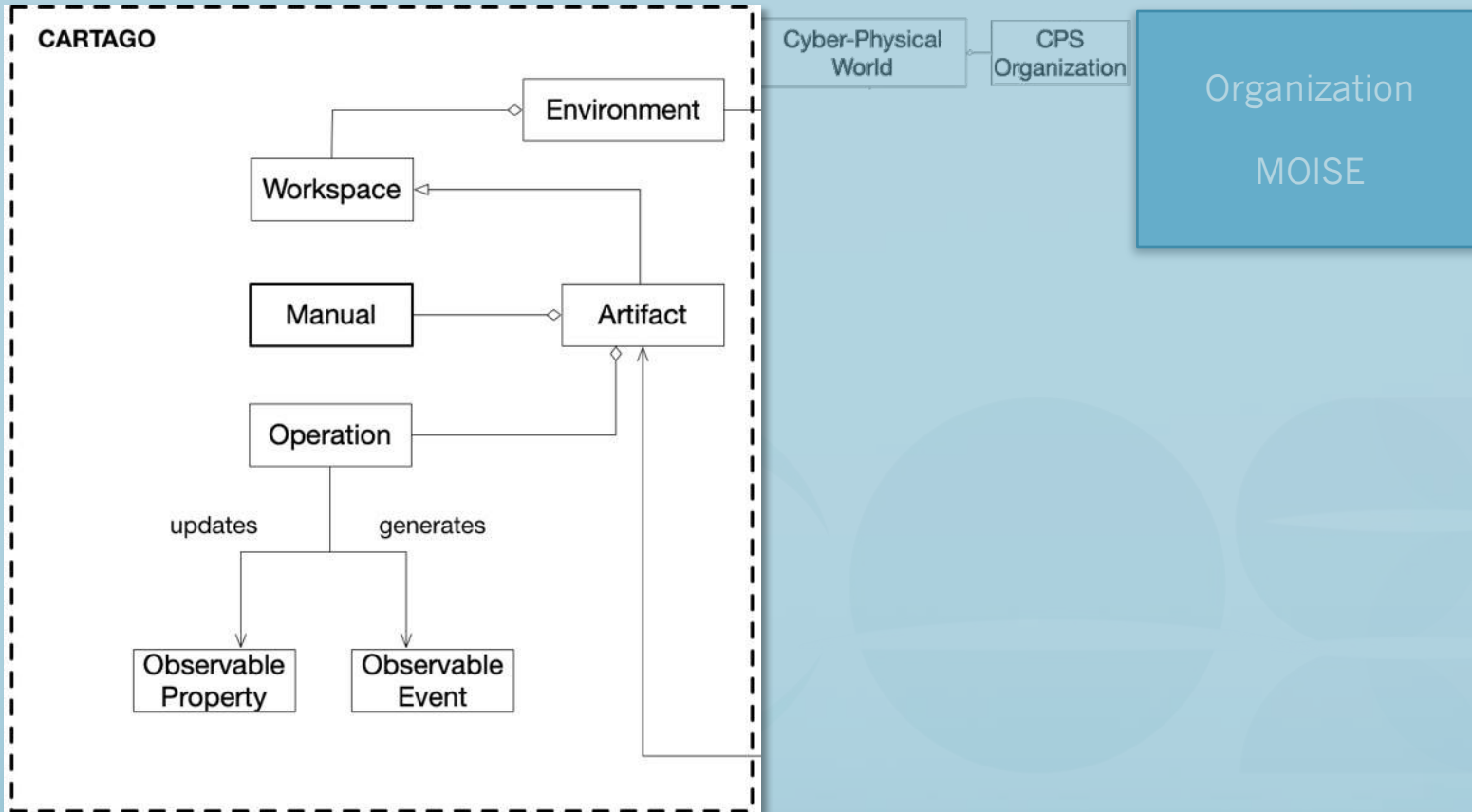
The Proposed Framework

The Meta-model: top-down perspective



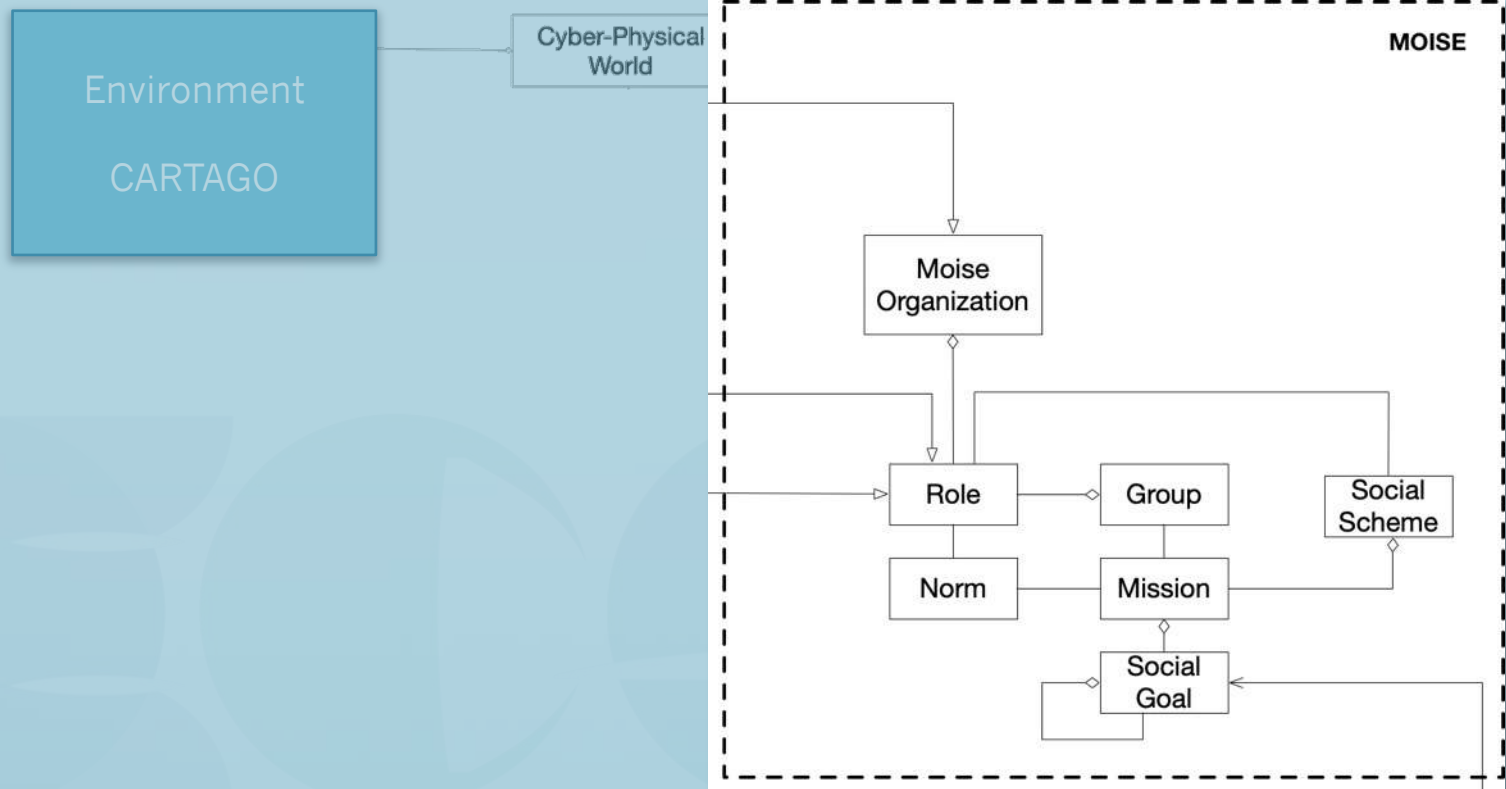
The Proposed Framework

The Meta-model: top-down perspective



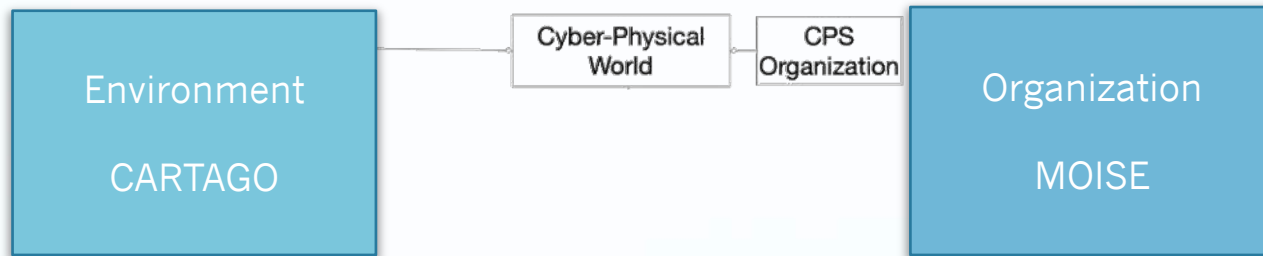
The Proposed Framework

The Meta-model: top-down perspective



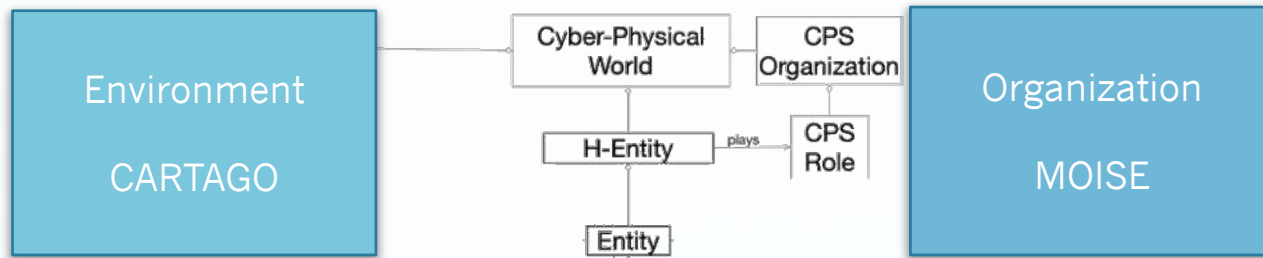
The Proposed Framework

The Meta-model: top-down perspective



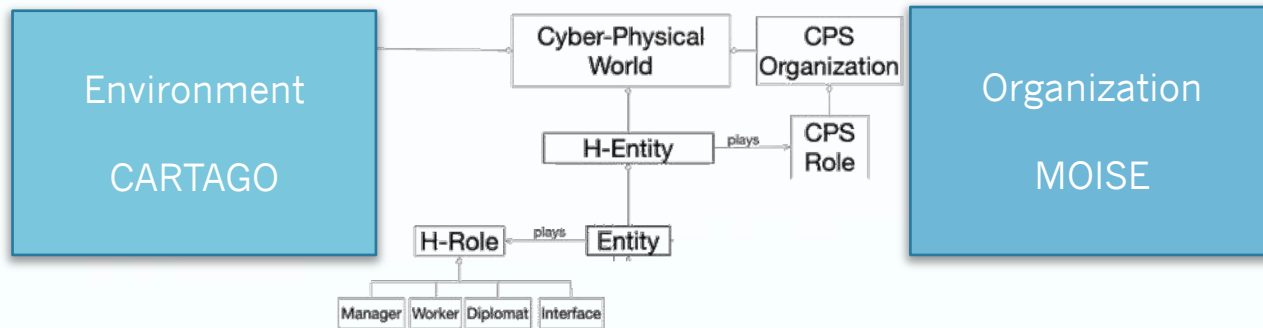
The Proposed Framework

The Meta-model: top-down perspective



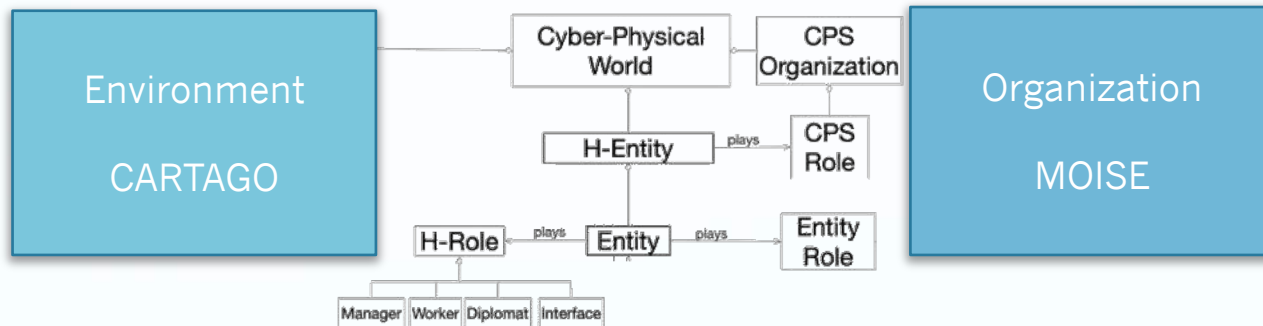
The Proposed Framework

The Meta-model: top-down perspective



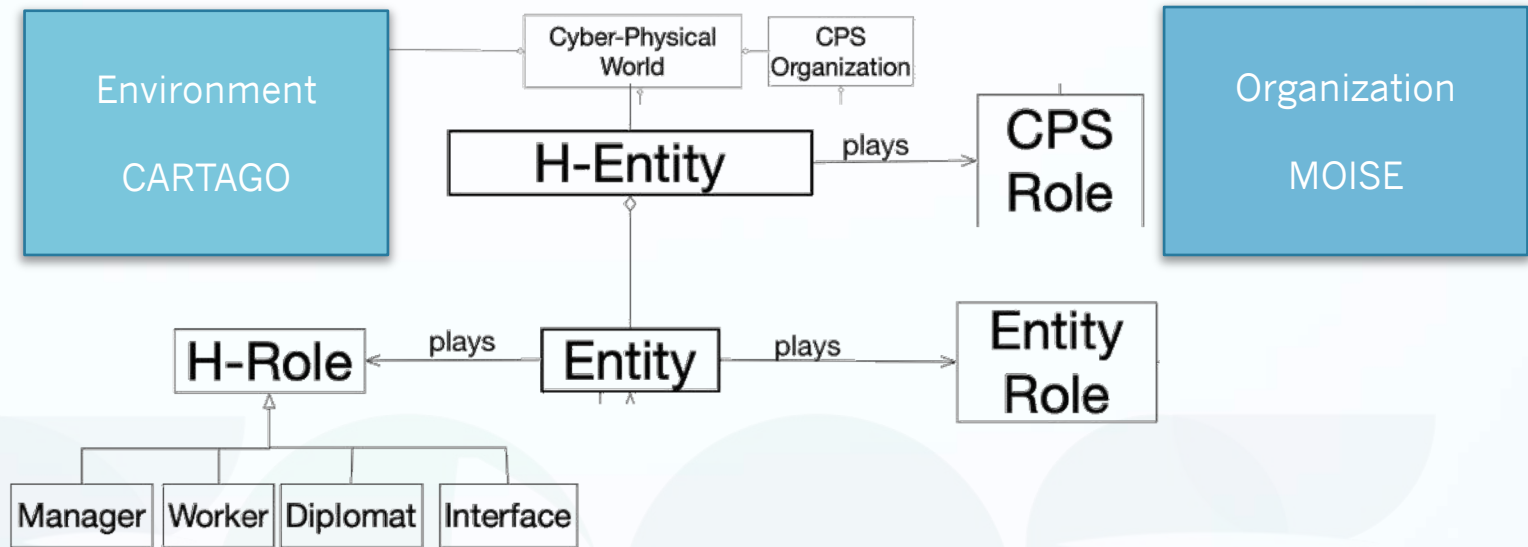
The Proposed Framework

The Meta-model: top-down perspective



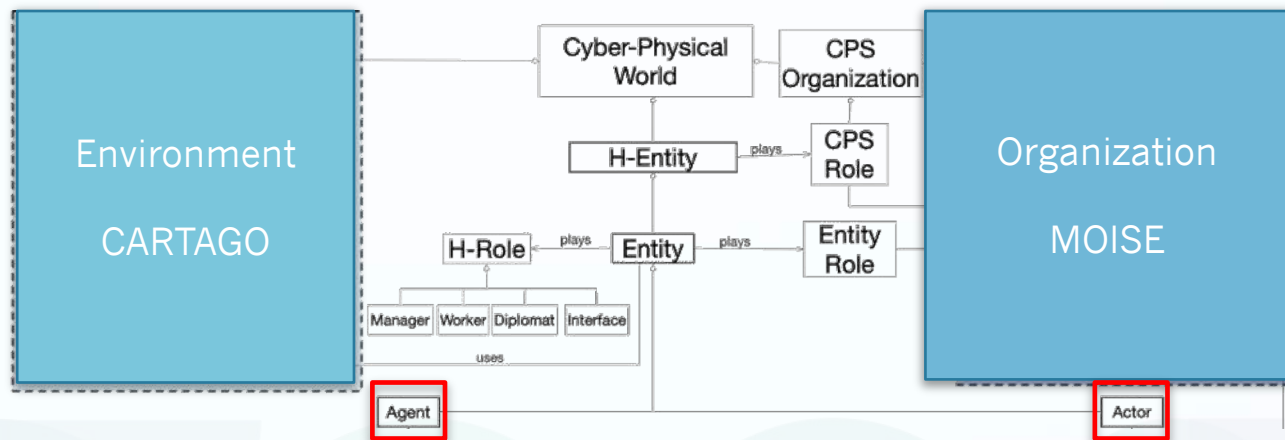
The Proposed Framework

The Meta-model: top-down perspective



The Proposed Framework

The Meta-model: top-down perspective





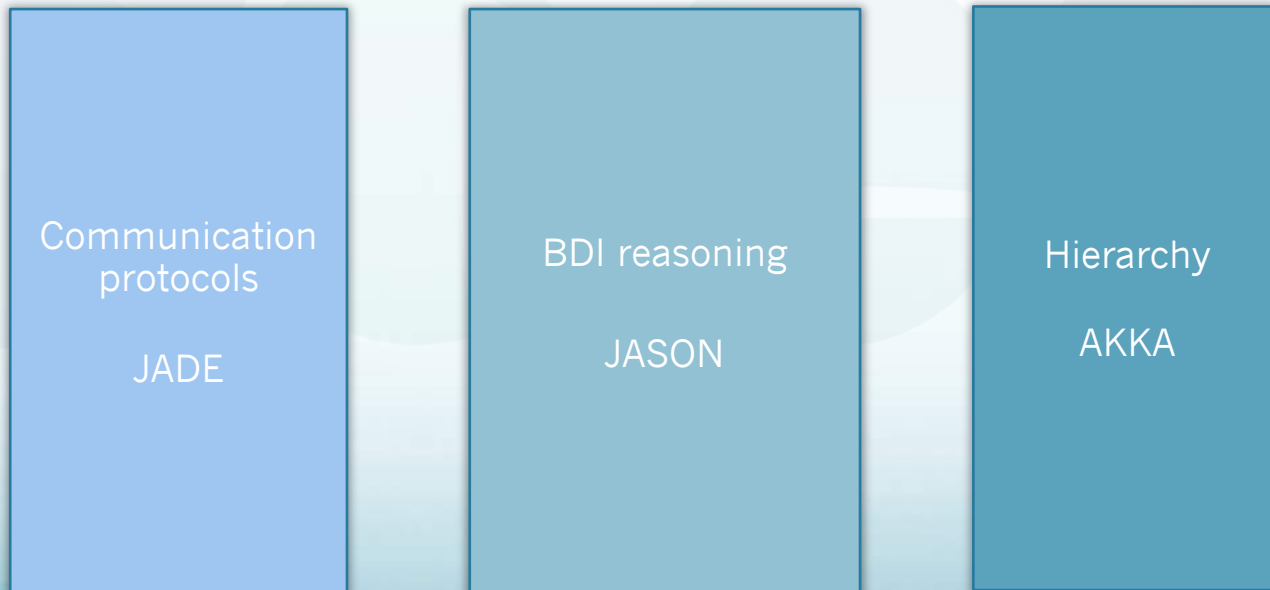
The Proposed Framework

The Meta-model: bottom-up perspective



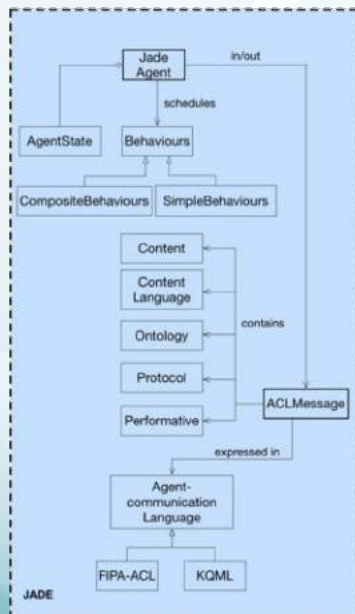
The Proposed Framework

The Meta-model: bottom-up perspective



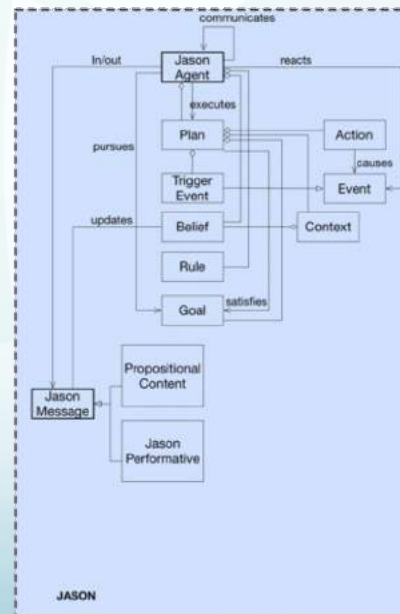
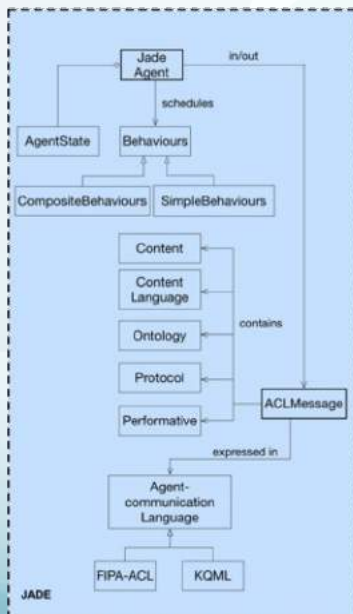
The Proposed Framework

The Meta-model: bottom-up perspective



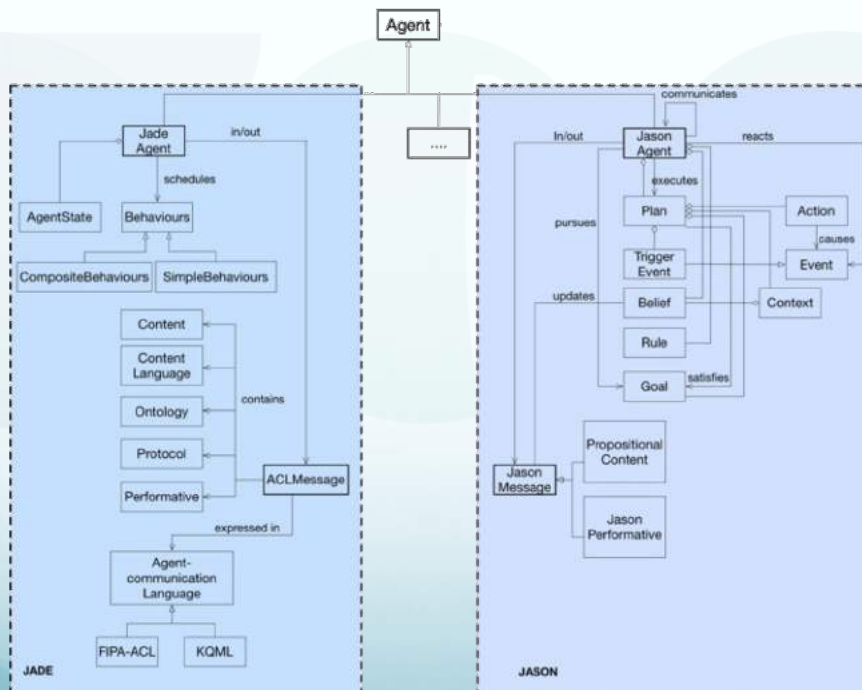
The Proposed Framework

The Meta-model: bottom-up perspective



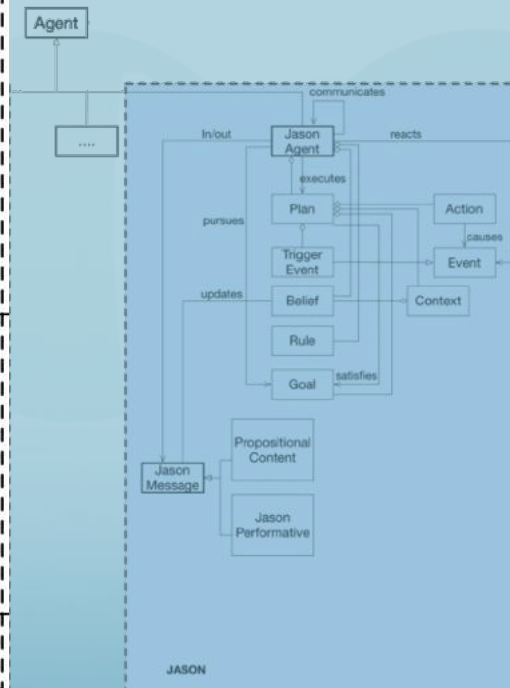
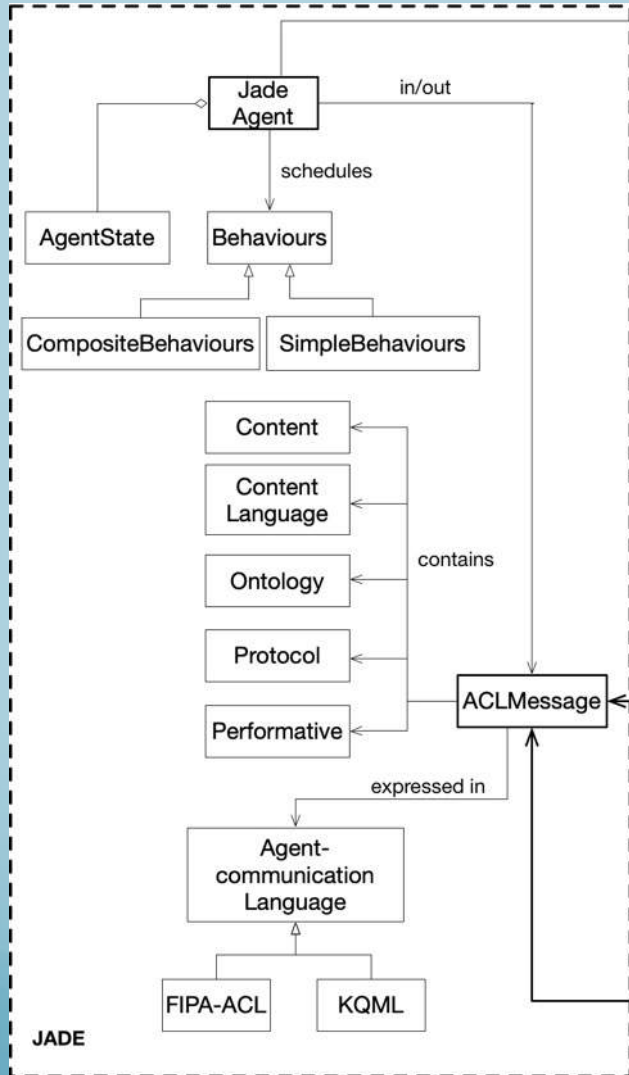
The Proposed Framework

The Meta-model: bottom-up perspective



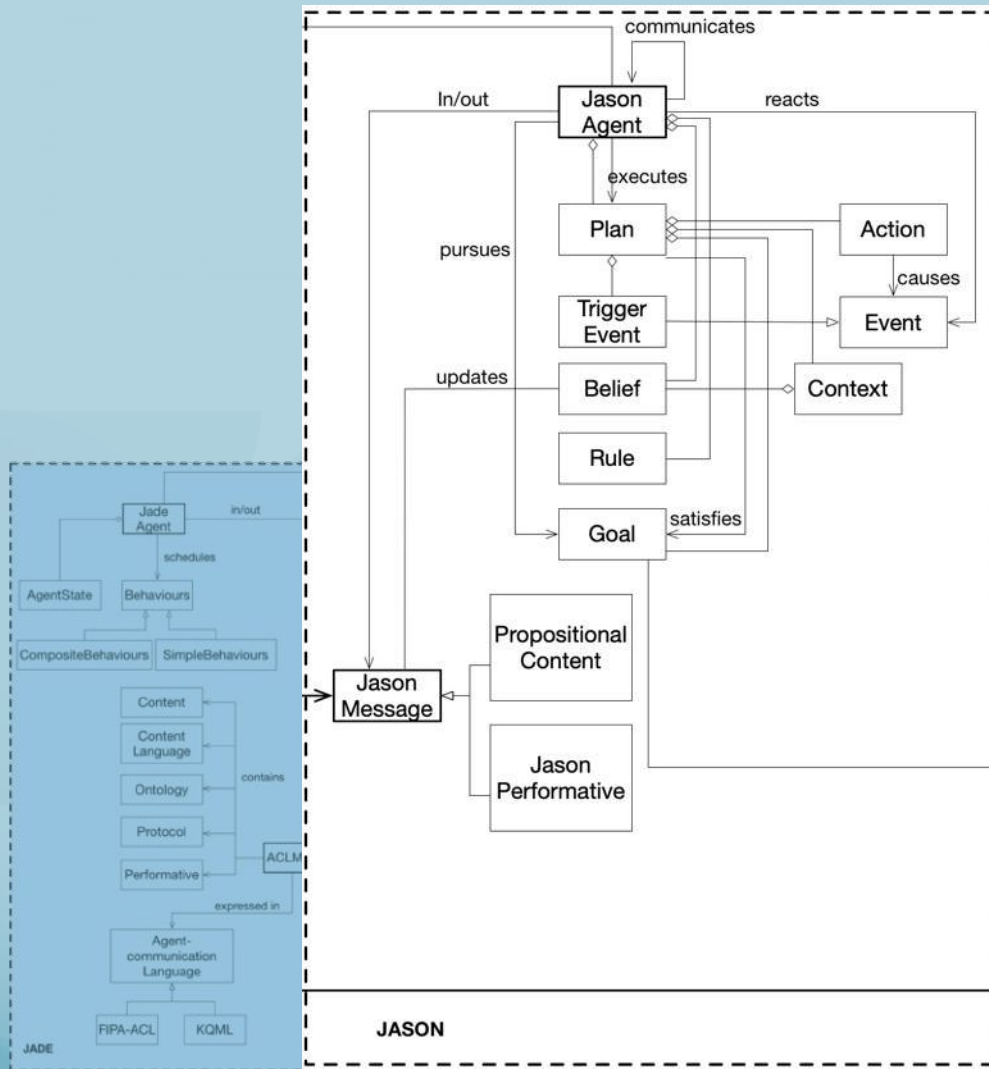
The Proposed Framework

The Meta-model: bottom-up perspective



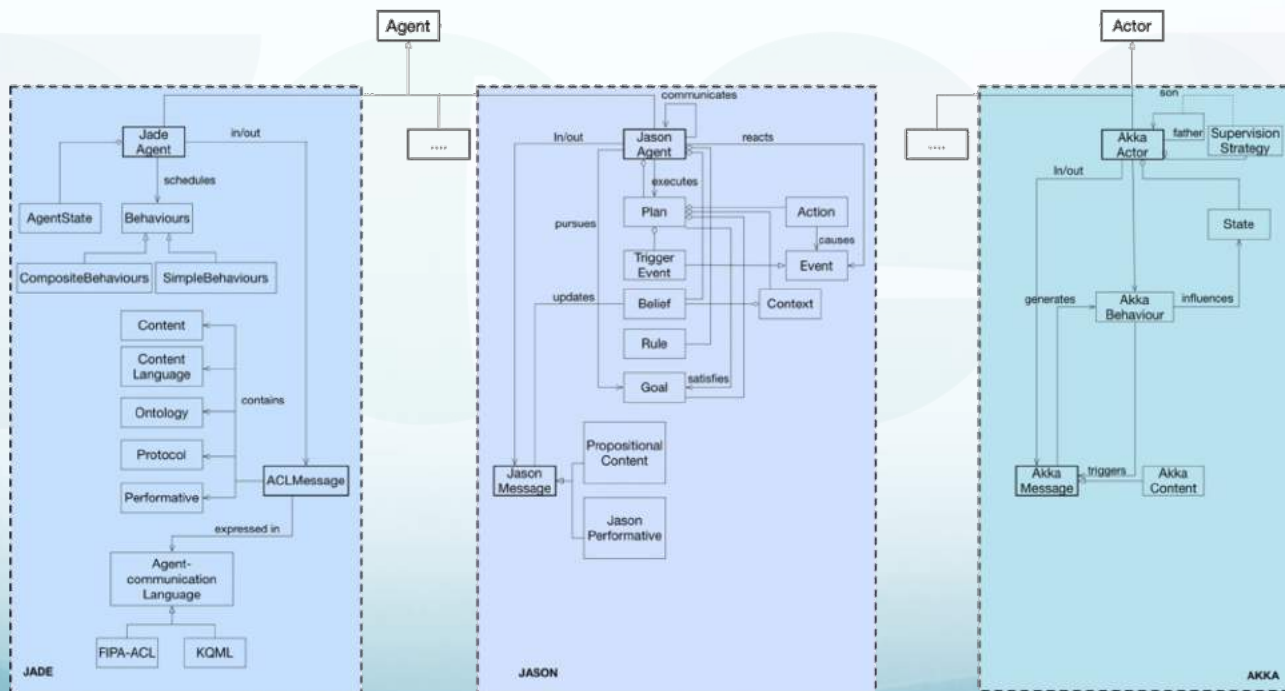
The Proposed Framework

The Meta-model: bottom-up perspective



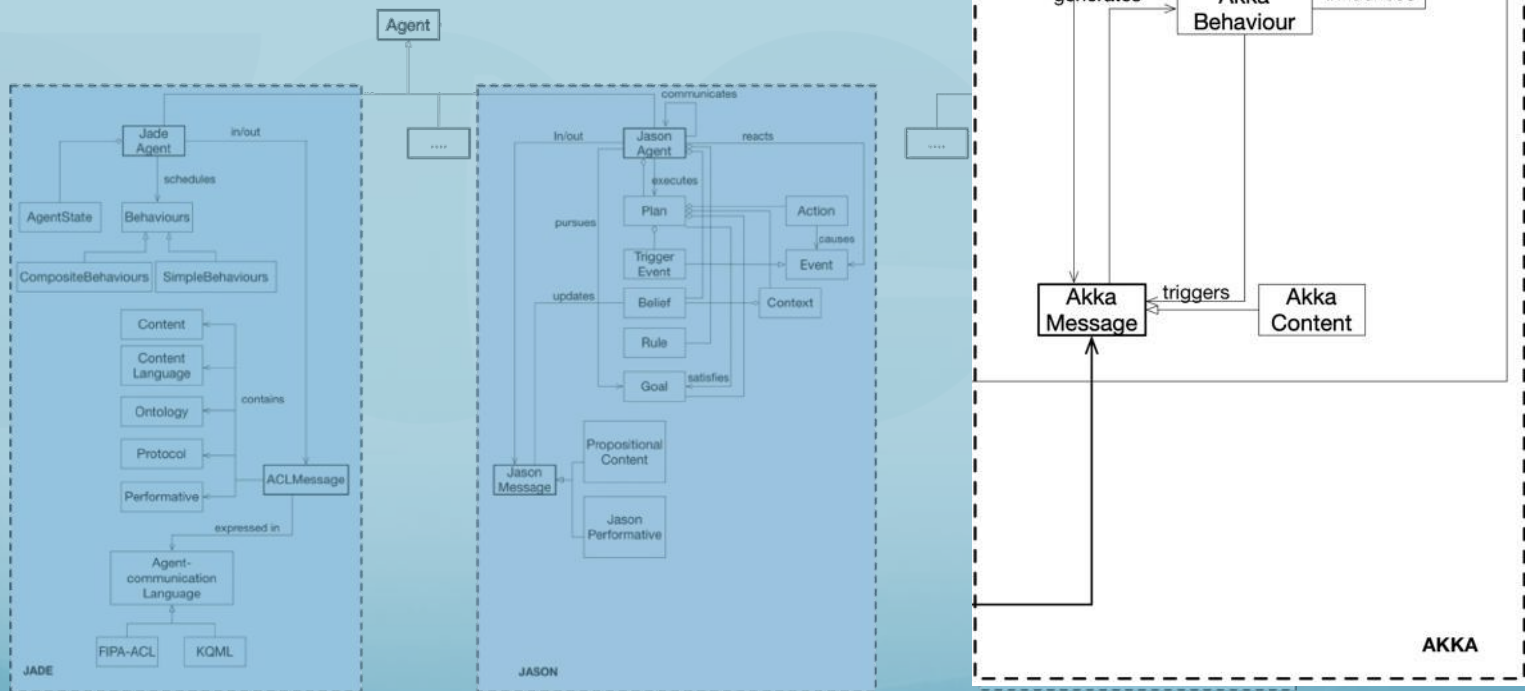
The Proposed Framework

The Meta-model: bottom-up perspective



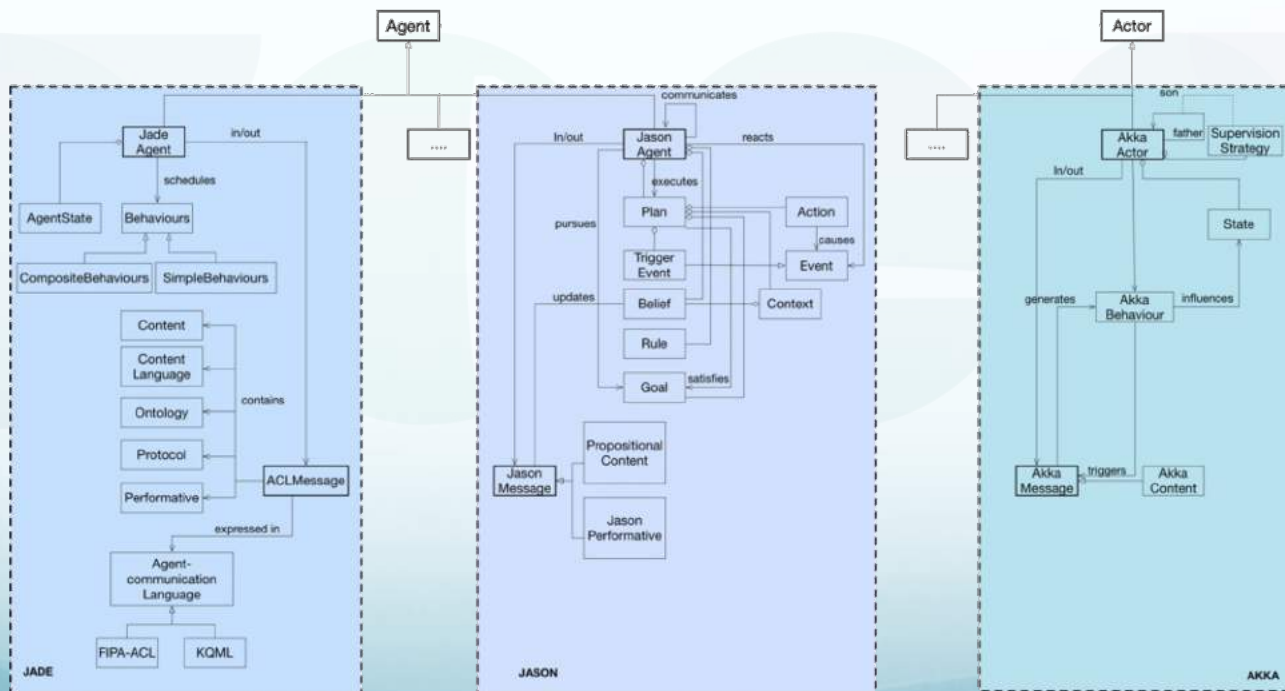
The Proposed Framework

The Meta-model: bottom-up perspective



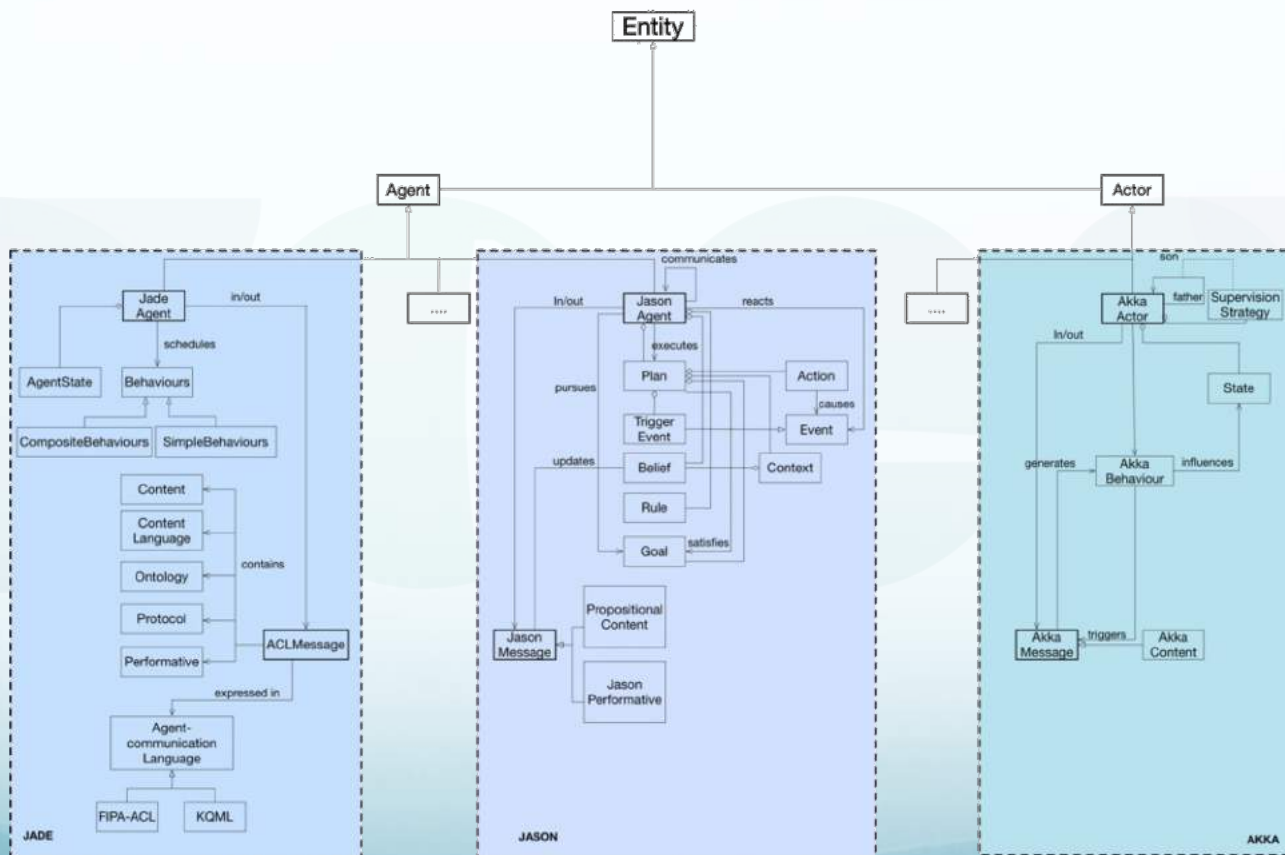
The Proposed Framework

The Meta-model: bottom-up perspective

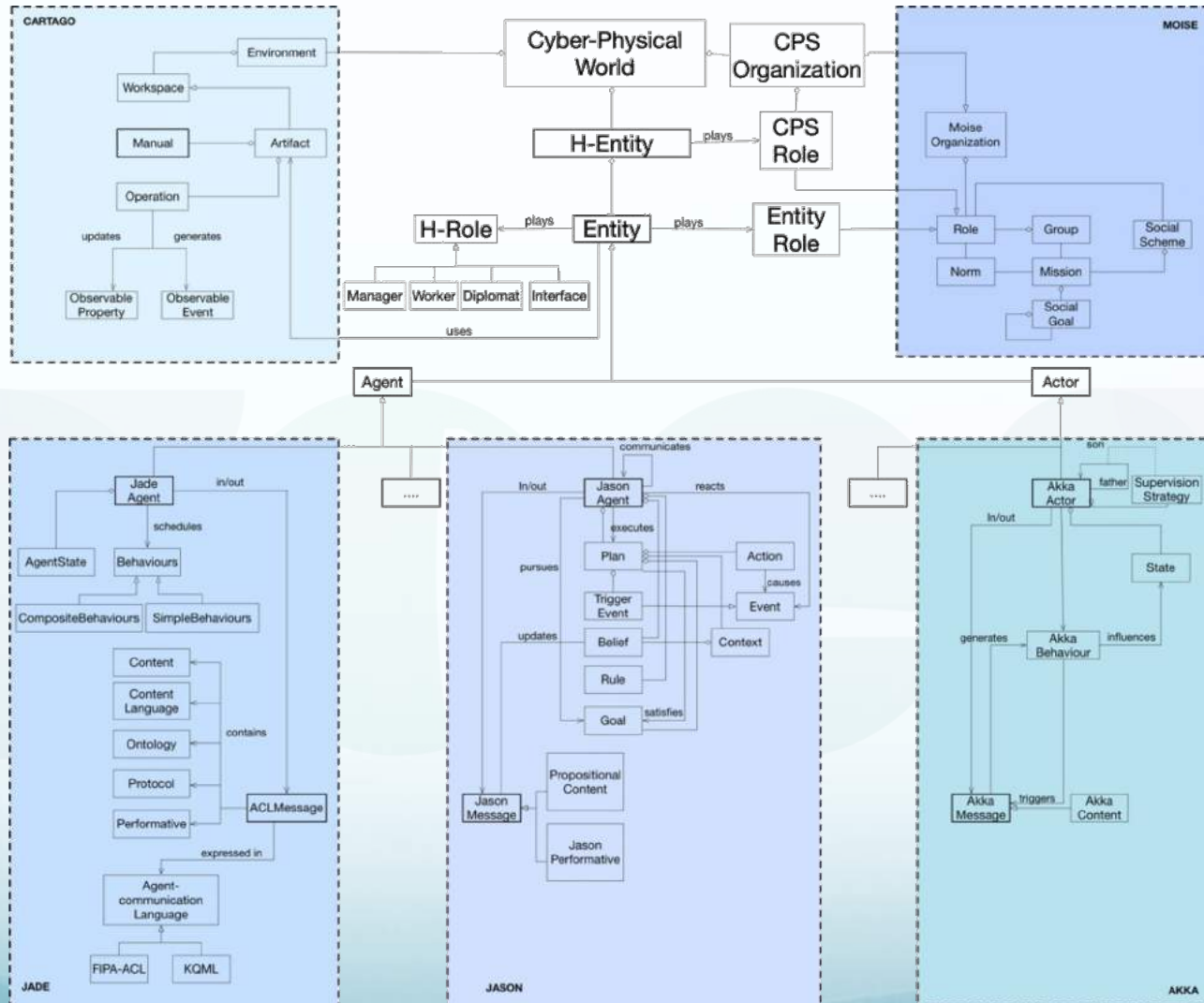


The Proposed Framework

The Meta-model: bottom-up perspective

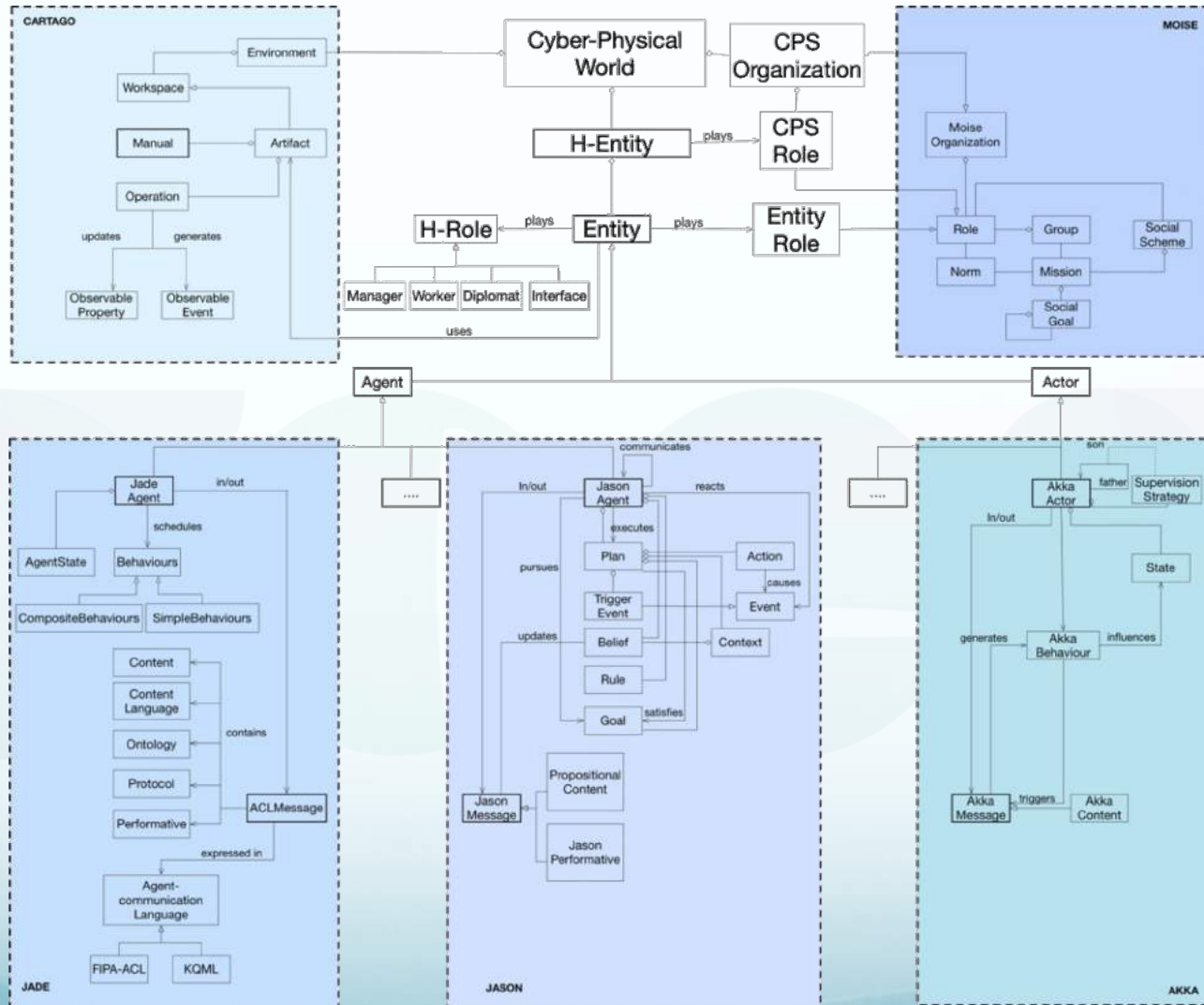


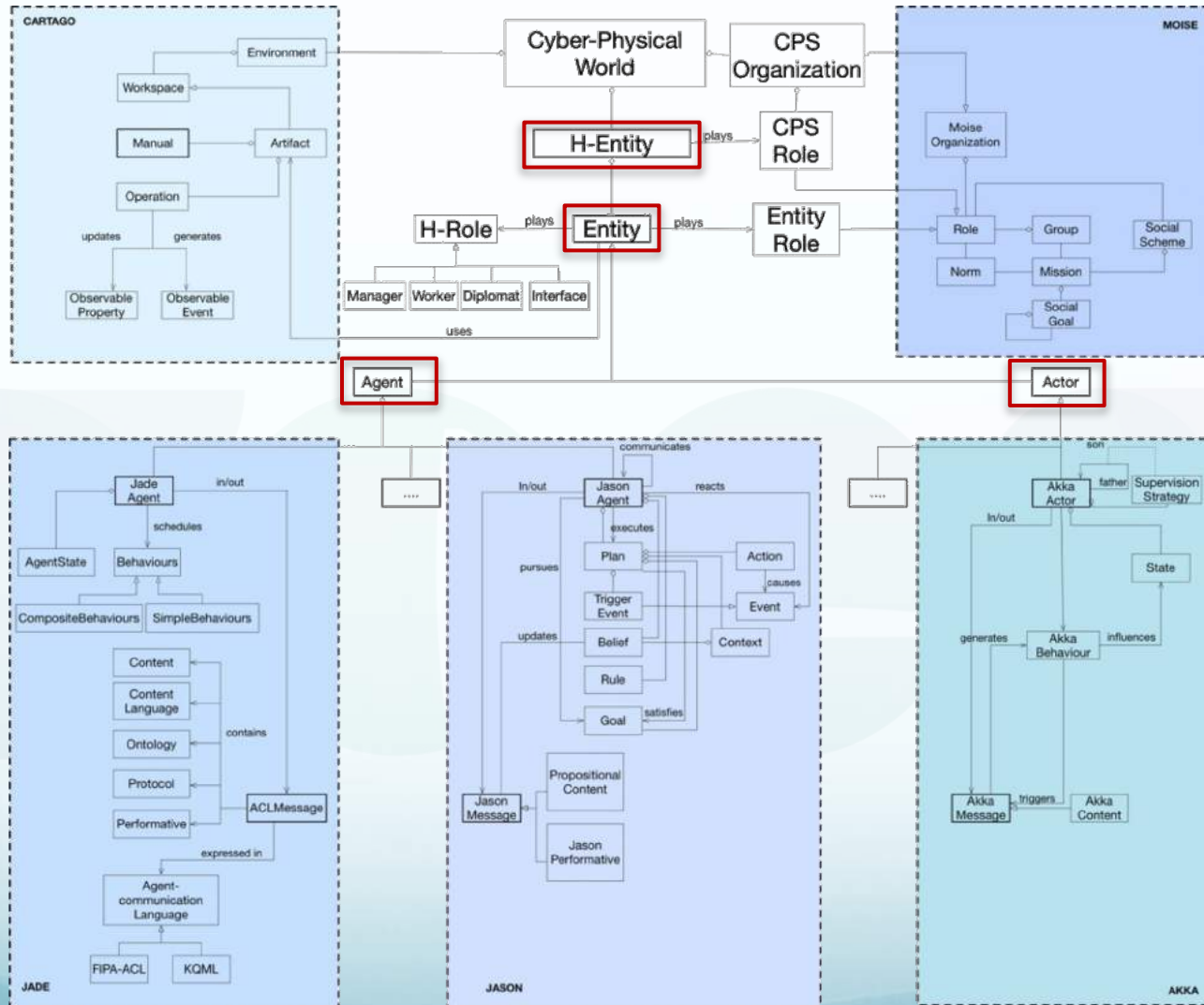
The Meta-model: bottom-up perspective

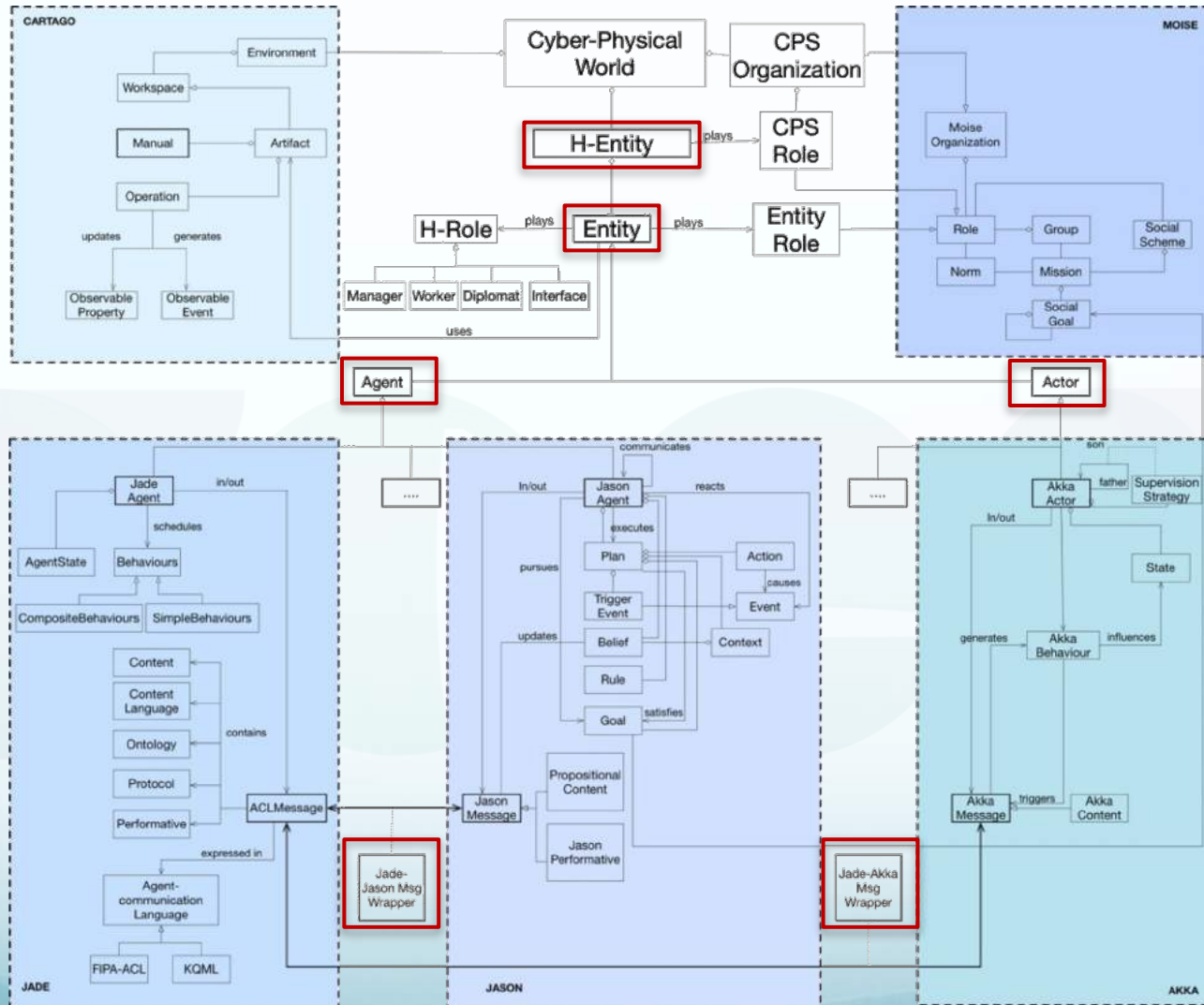


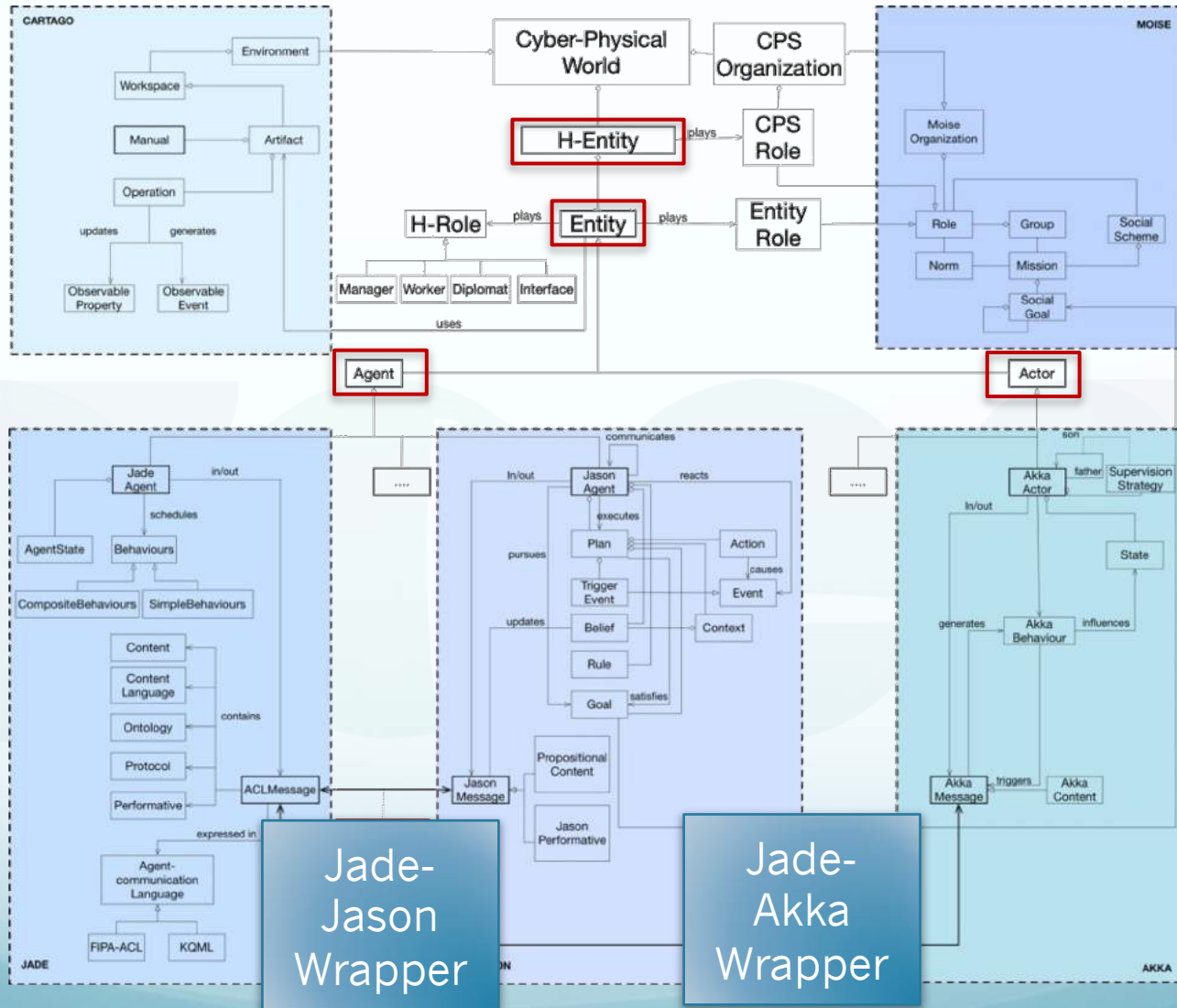
The linking Entities

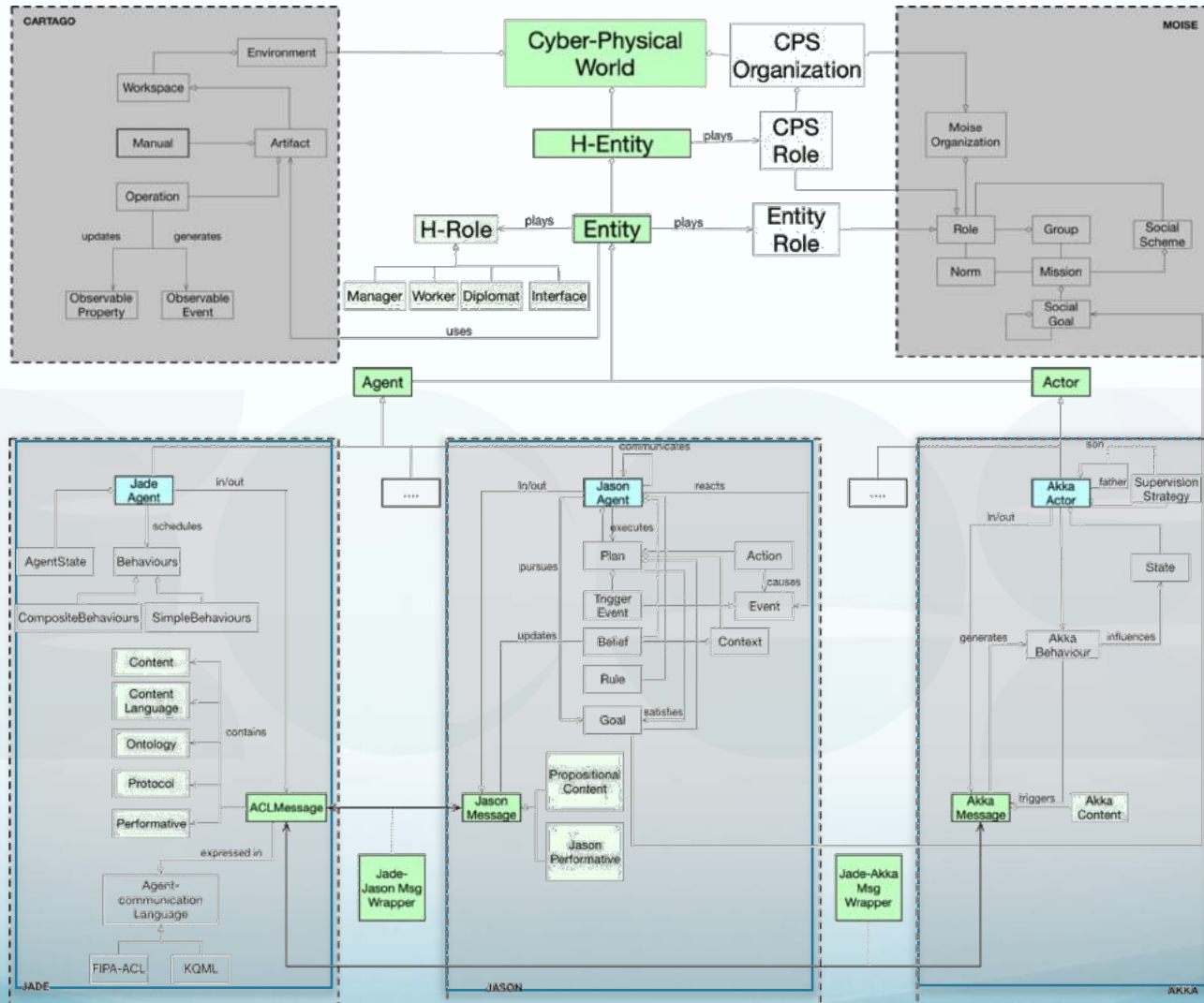


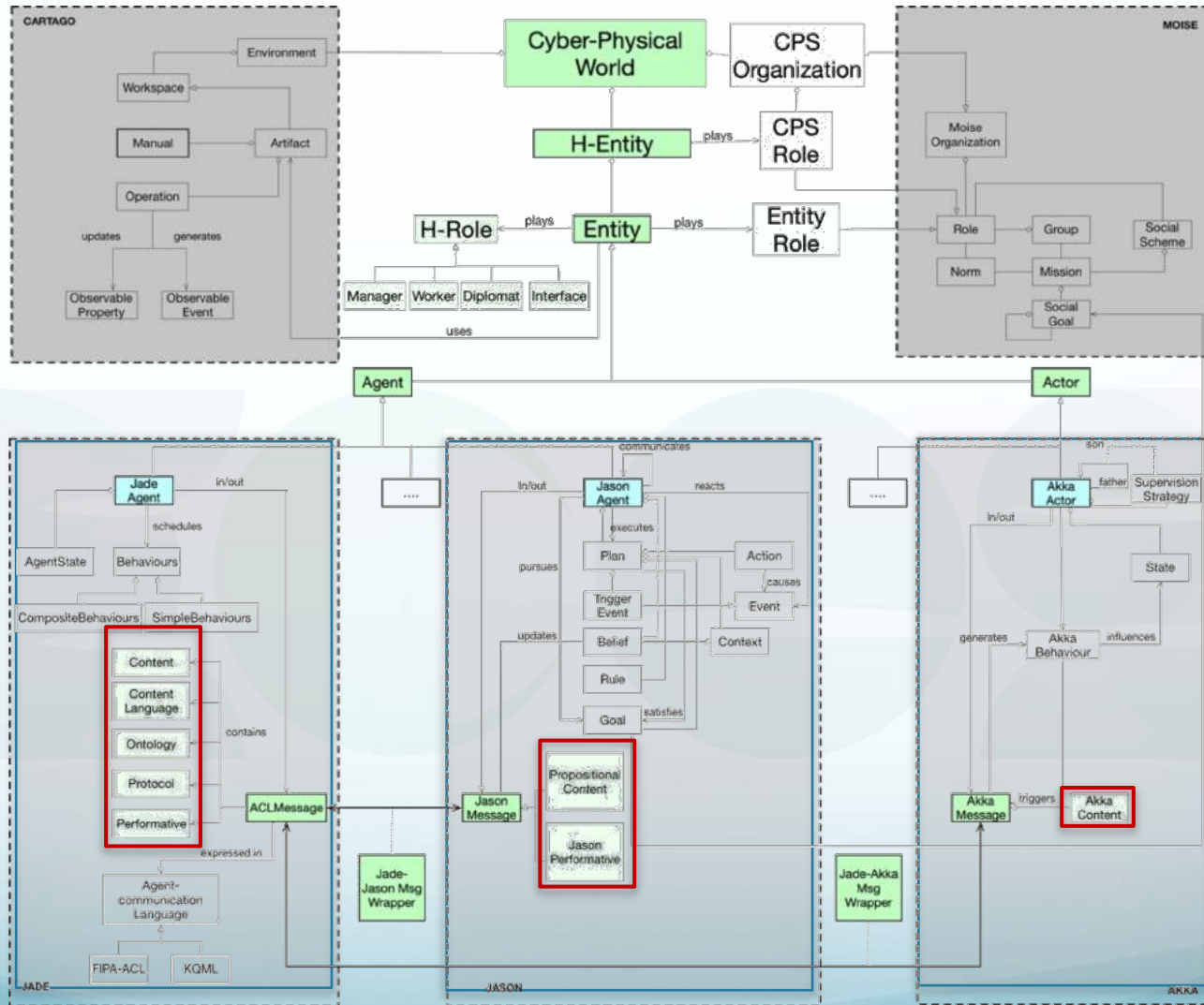


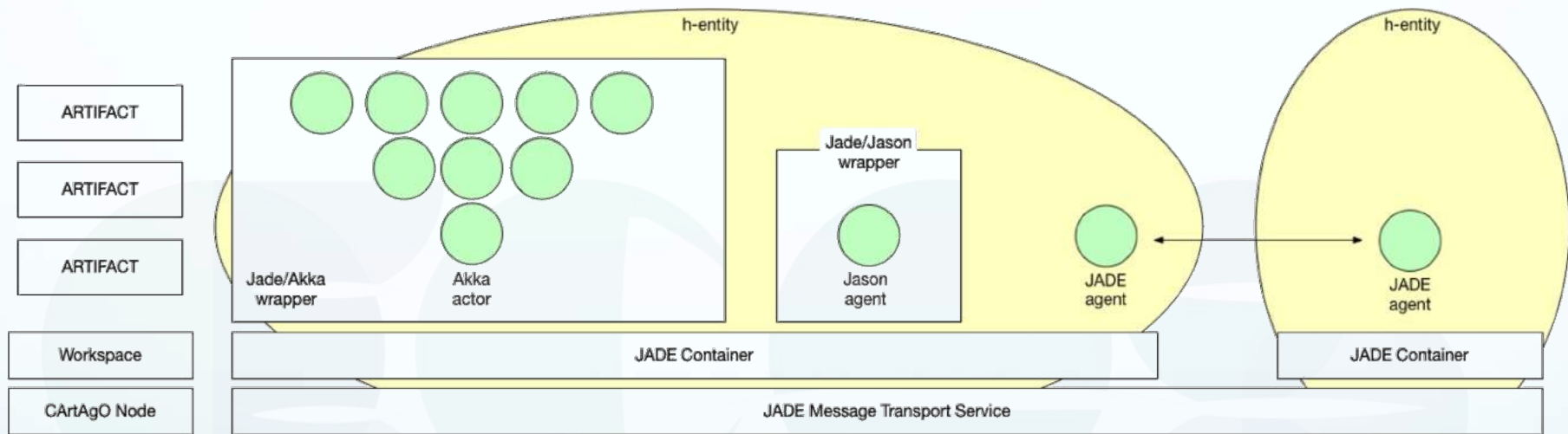


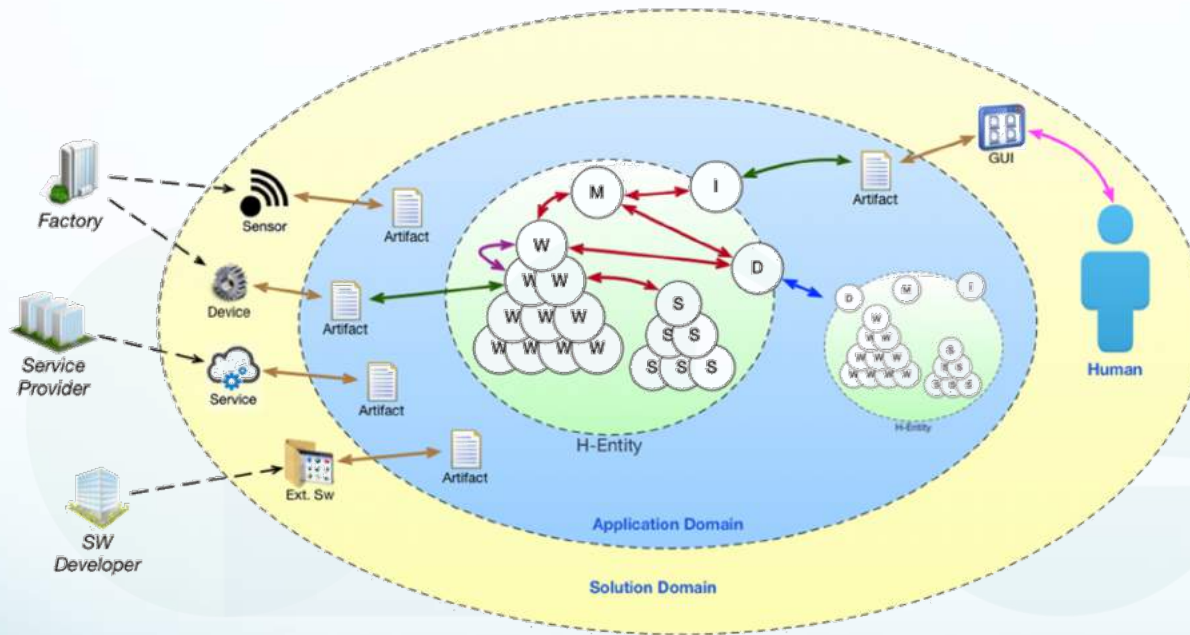












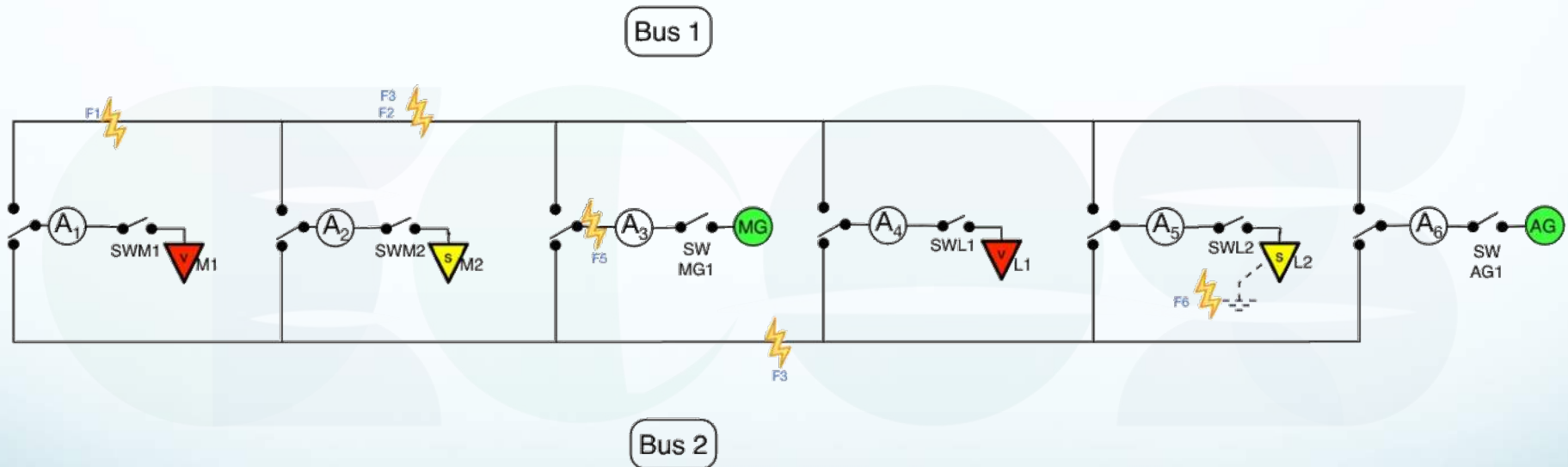
| | |
|--------------------|---------------|
| M=Manager | Jason Agent |
| I=Interface | Cartago/Jason |
| W=Worker | Akka Actor |
| S=Simulator | Akka Actor |
| D=Diplomat | Jade Agent |
| Artifact | Cartago |

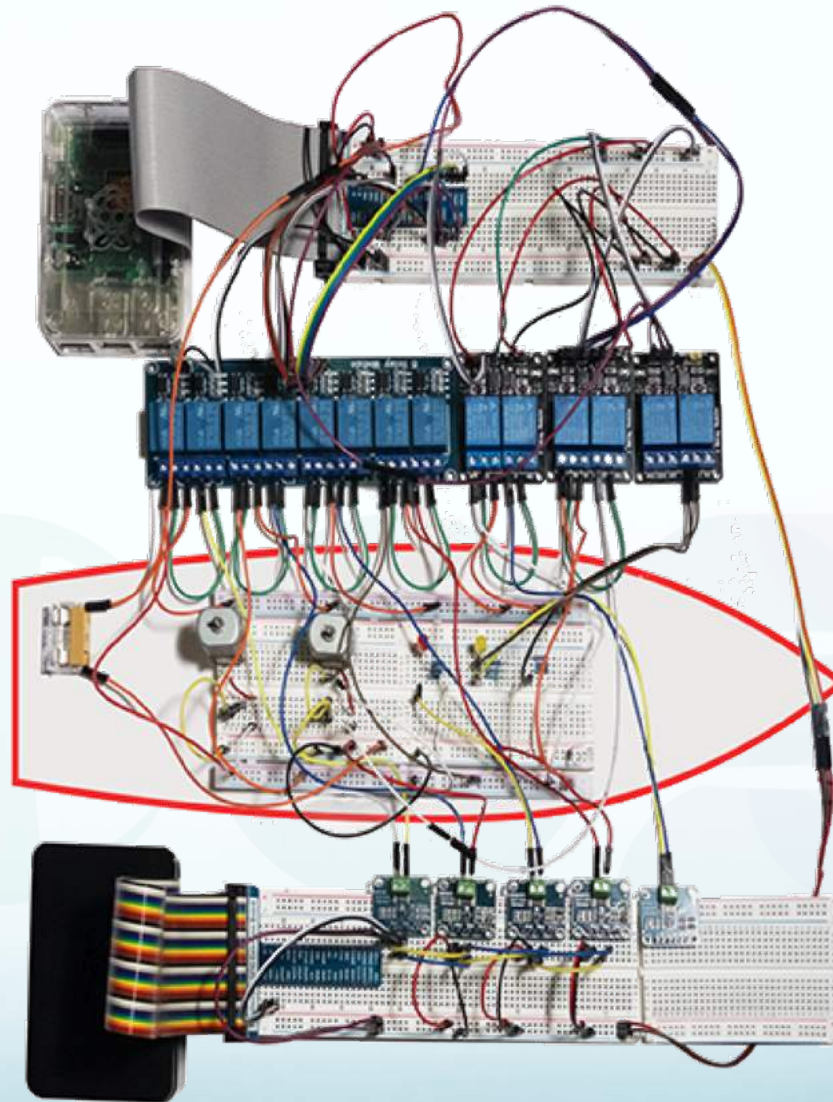
The Application



The Application

Proof of concepts



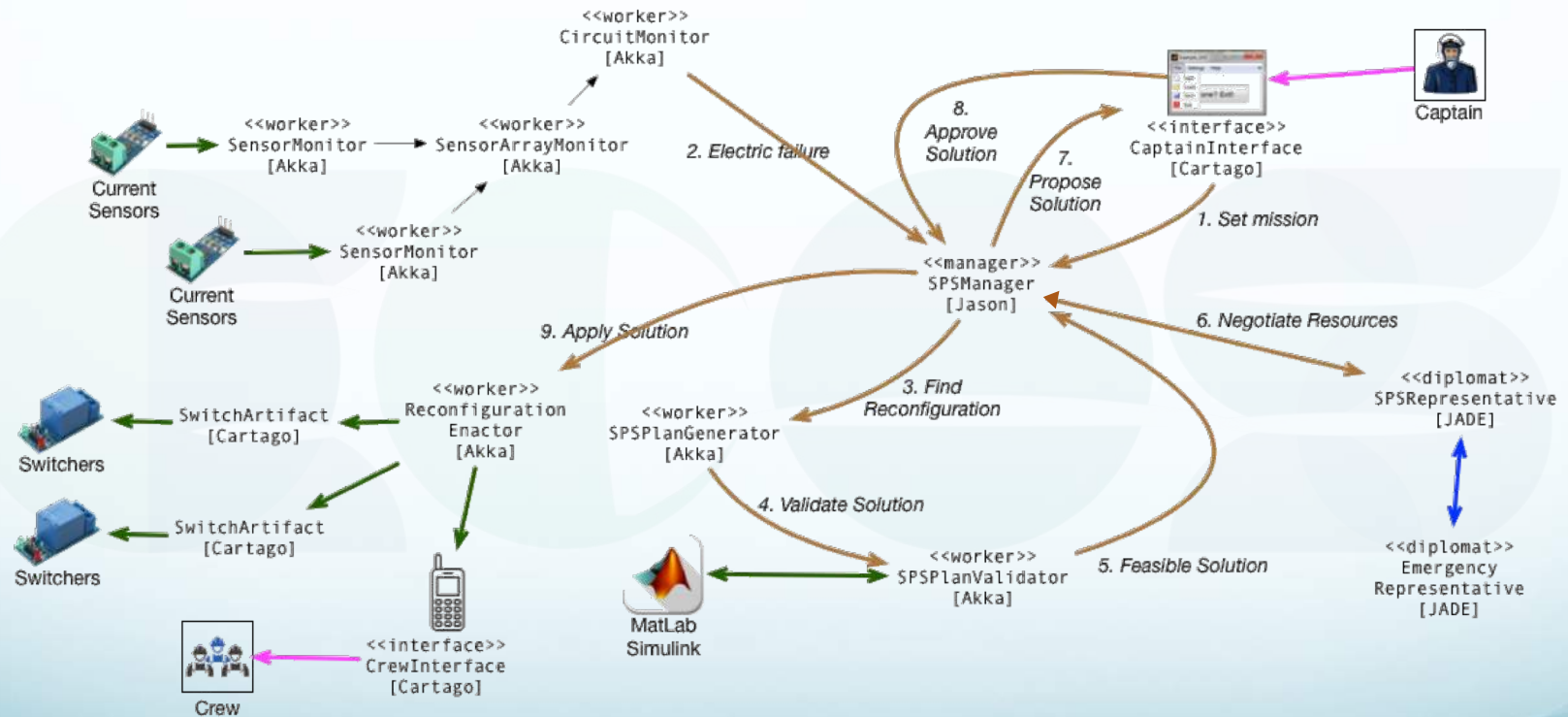


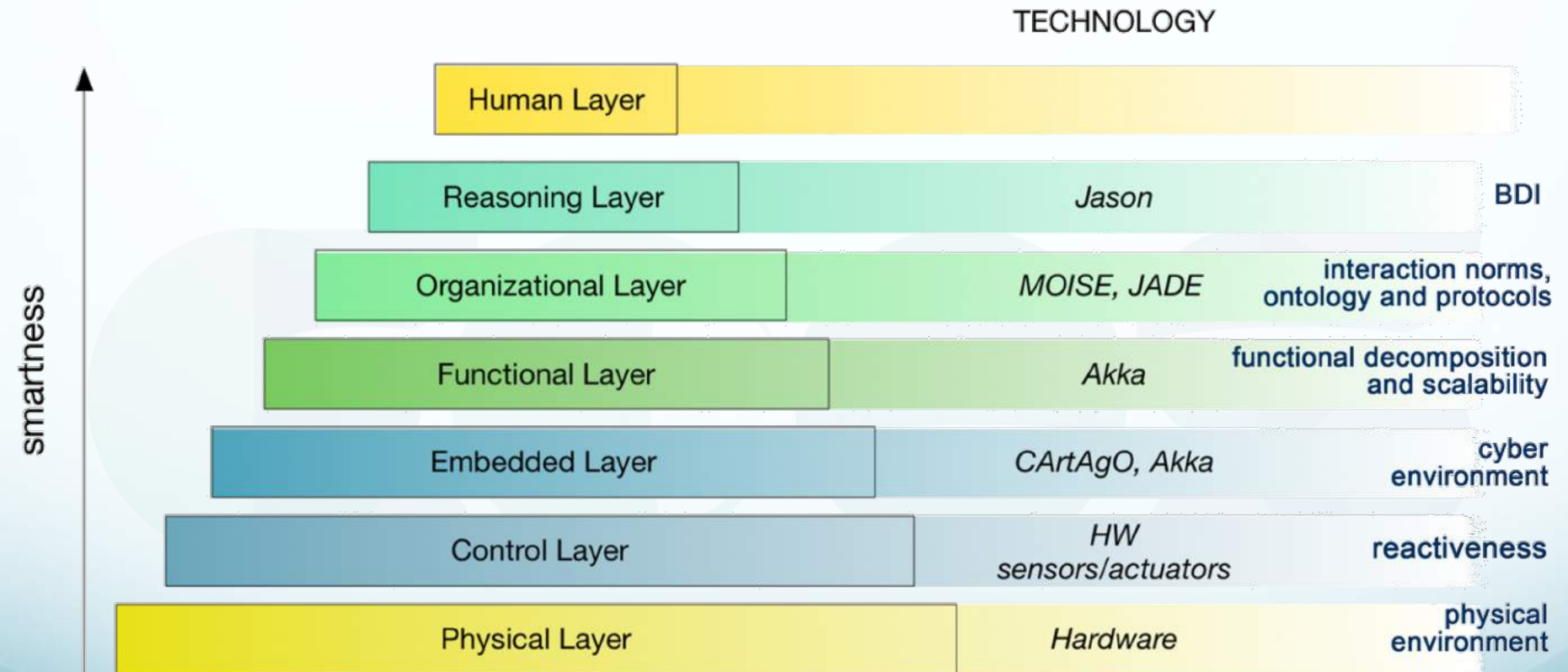
The Solution

The SPS reconfiguration Scenario



The Solution





Future Works

- Developing a methodology and a tool
- Extending to other development paradigms (e.g. Simulink)
- developing a **Smart Ship** solution (the SPS reconfiguration system prototype is now under test)

Thank you for your attention

Any questions?

Contacts:

flavia.zaffora@icar.cnr.it