Gemini Project

ASCETISM project

Simone Silvetti
Numerical Methods Group

© 2022 ESTECO SpA

Reference

This presentation refers to Gemini GitHub repository TAG:

220902_final_presentation

© 2022 ESTECO SpA

Simone Silvetti
Numerical Methods Group

modeFRONTIER

VOLTA

cardanit

esteco.com

© 2022 ESTECO SpA

Simone Silvetti
Numerical Methods Group

Nebula

Inverse Reinforcement Learning
Edge case identification

viscando™

TNO innovation for life

© 2022 ESTECO SpA

Gemini Project

What we did

IRL integration in ESMINI

Build a Python Framework

Results / Problems / Improvements

© 2022 ESTECO SpA

Gemini Project

Original Intention

IRL integration in ESMINI

Build a Python **Framework**

- Modular / Extensible
- Understandable

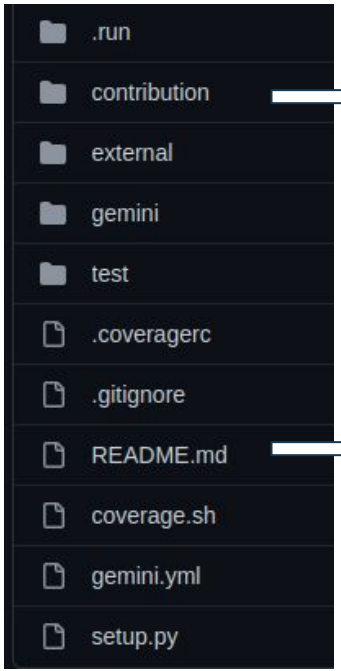
Results / Problems / Improvements

© 2022 ESTECO SpA

Gemini Project

How to start

Gemini Project



CONTRIBUTION.md
(documentation)

Installation instructions (works on Linux)

© 2022 ESTECO SpA

Gemini Project

Legend

This is a class (you can search it in the code)

Dashed means not created in Gemini

This is a concept

Dashed means not created in Gemini

© 2022 ESTECO SpA

IRL Facts

Trained on timestamp dataset

	Standard	Standard	Standard	Standard	Standard
1	member	Timestamps_UNIX	X	Y	current_lane
2	0	1639299600.15	36.725052961732594	51.098050679850225	1
3	0	1639299600.1999998	36.01768369789217	49.97326869053703	1
4	0	1639299600.2499998	35.31051863223118	48.85082955701142	1
5	0	1639299600.2999995	34.60357786733129	47.73069858059758	1
6	0	1639299600.3499994	33.896881505774175	46.612841062619715	1
7	0	1639299600.3999994	33.19044965014154	45.49722230440197	1
8	0	1639299600.4499993	32.48430240301504	44.38380760726862	1

- Can predict position of the next time_step
- Velocity and acceleration are related to timestep

© 2022 ESTECO SpA

IRL Facts

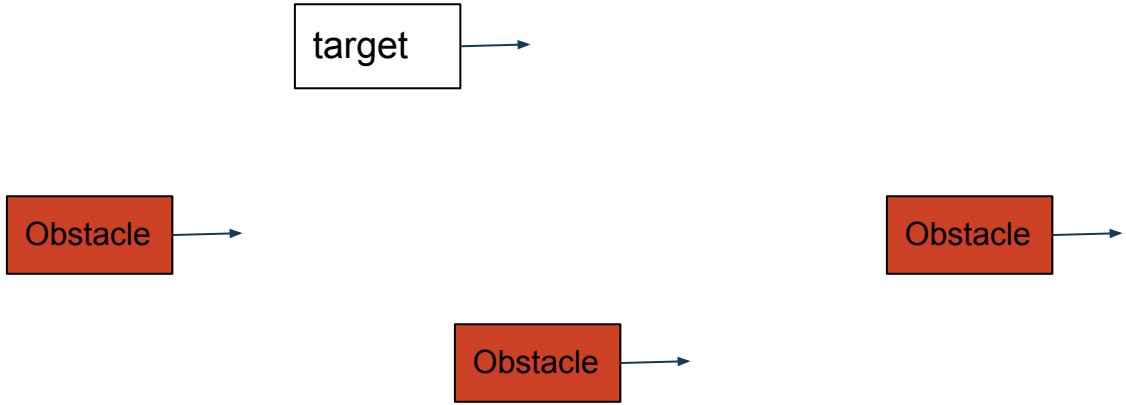
Trained on timestamp dataset

	Standard	Standard	Standard	Standard	Standard
1	member	Timestamps_UNIX	X	Y	current_lane
2	0	1639299600.15	36.725052961732594	51.098050679850225	1
3	0	1639299600.1999998	36.01768369789217	49.97326869053703	1
4	0	1639299600.2499998	35.31051863223118	48.85082955701142	1
5	0	1639299600.2999995	34.60357786733129	47.73069858059758	1
6	0	1639299600.3499994	33.896881505774175	46.612841062619715	1
7	0	1639299600.3999994	33.19044965014154	45.49722230440197	1
8	0	1639299600.4499993	32.48430240301504	44.38380760726862	1

- Can predict position of the next time_step
- Velocity and acceleration are related to timestep

© 2022 ESTECO SpA

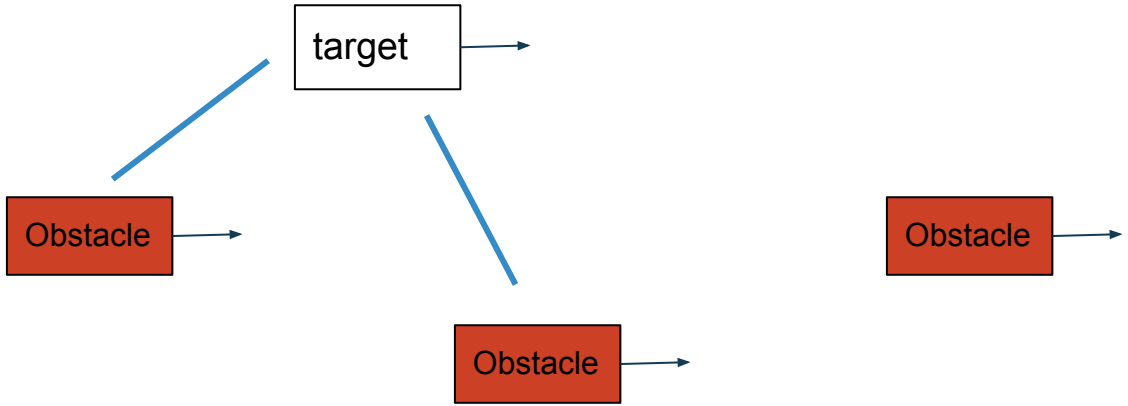
IRL Facts



© 2022 ESTECO SpA

IRL Facts

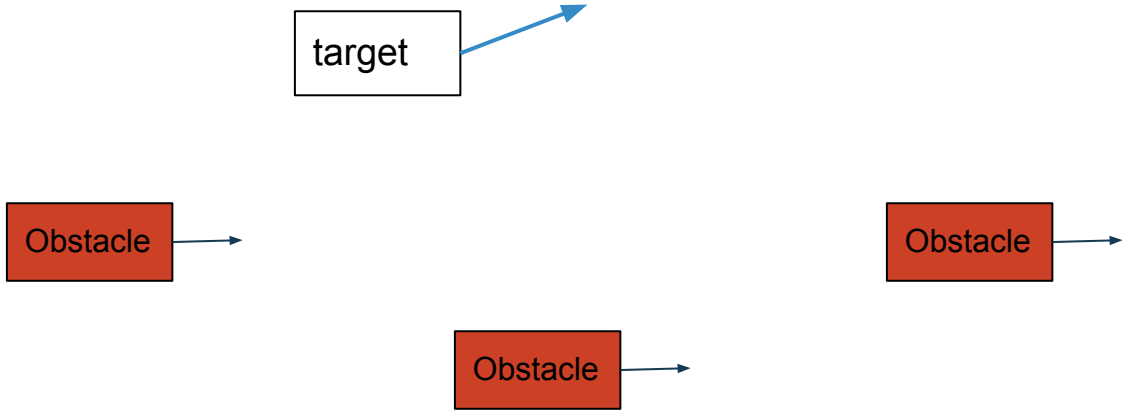
Perception



© 2022 ESTECO SpA

IRL Facts

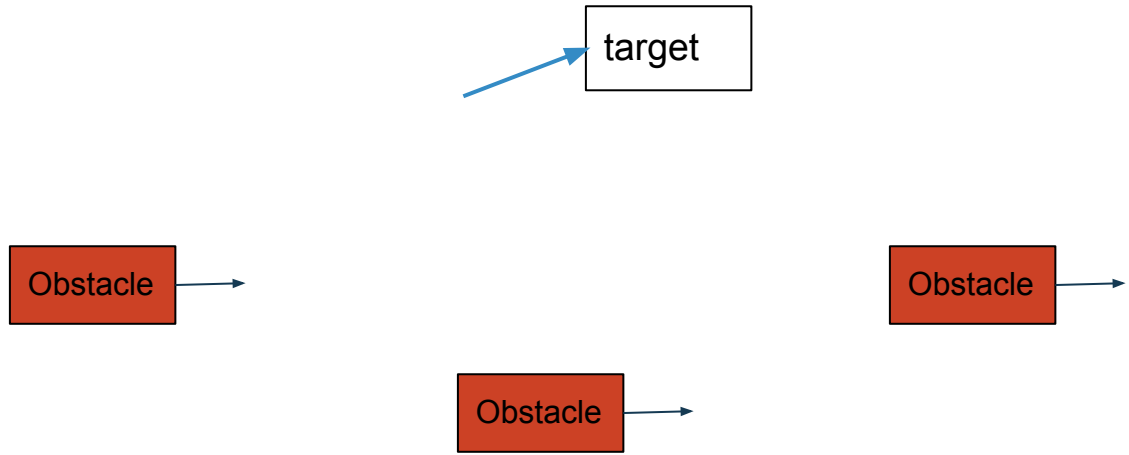
Action



© 2022 ESTECO SpA

IRL Facts

Teleporting

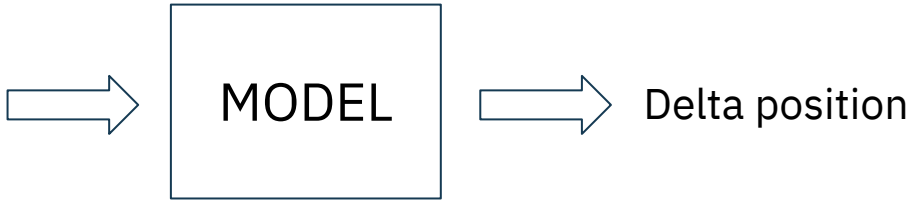


© 2022 ESTECO SpA

How IRL takes actions?

Policy

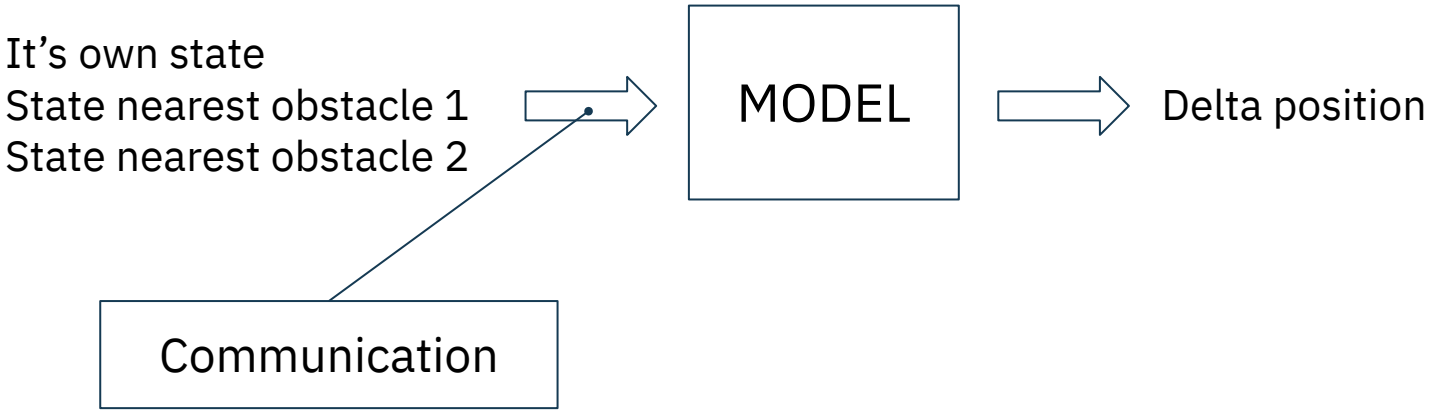
It’s own state
State nearest obstacle 1
State nearest obstacle 2



© 2022 ESTECO SpA

How IRL takes actions?

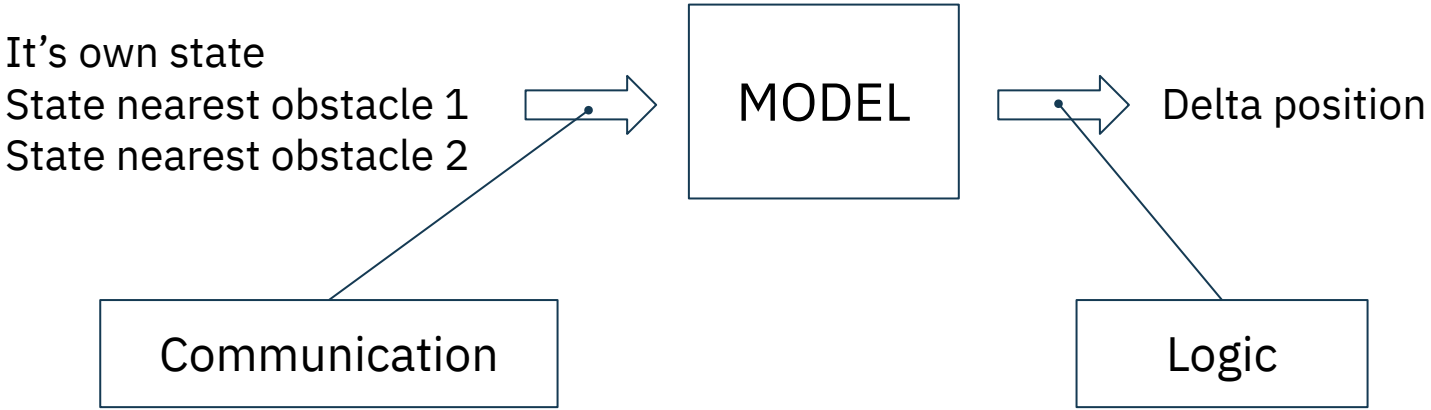
Policy



© 2022 ESTECO SpA

How IRL takes actions?

Policy



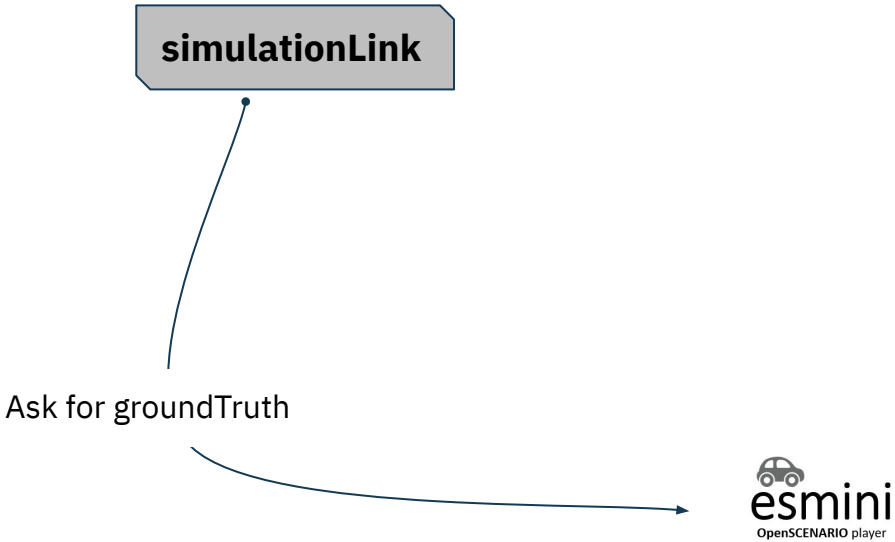
© 2022 ESTECO SpA

Communication (with ESMINI)

esmini
OpenSCENARIO player

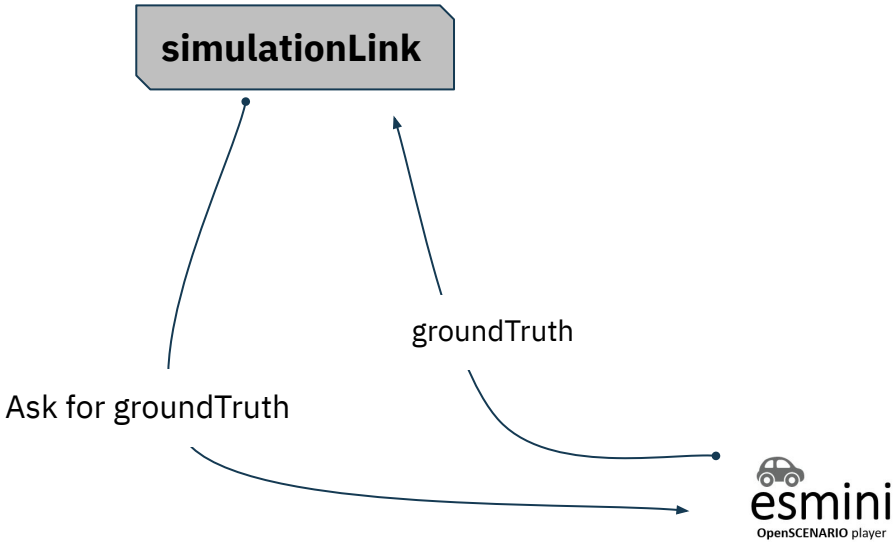
© 2022 ESTECO SpA

Communication (with ESMINI)



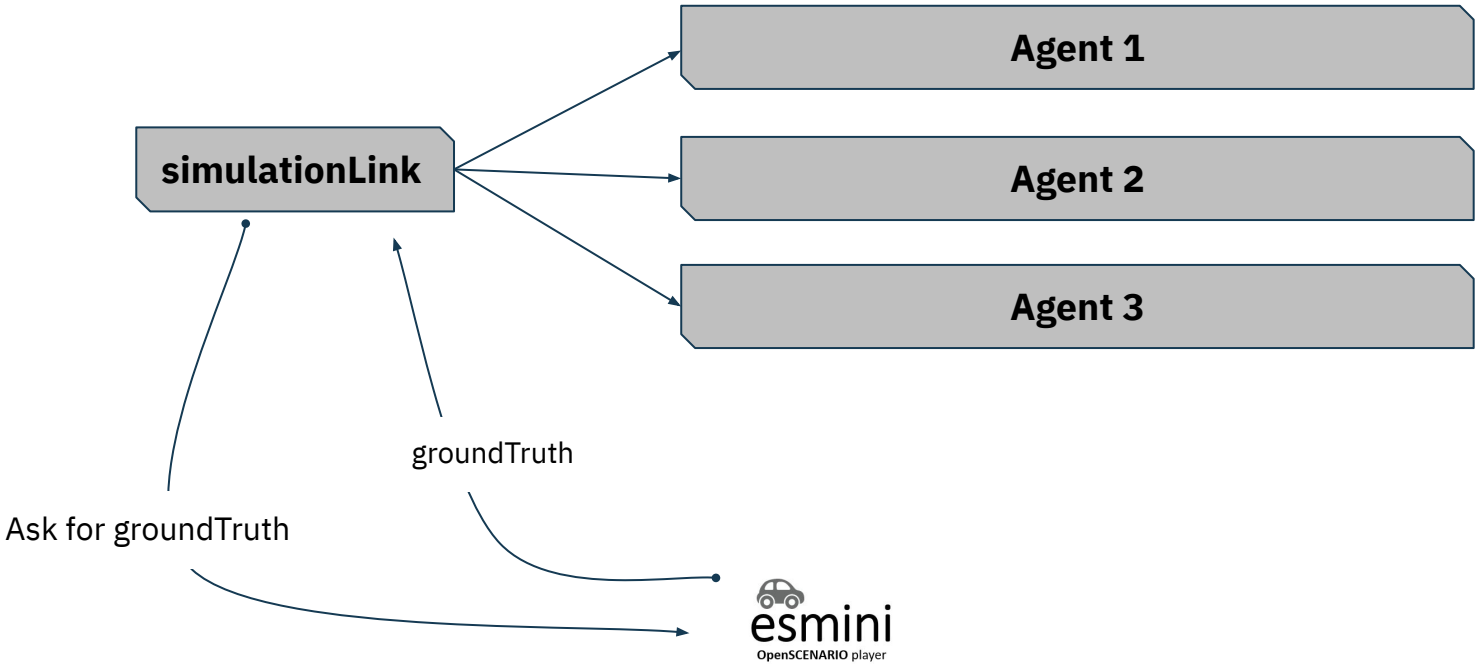
© 2022 ESTECO SpA

Communication (with ESMINI)



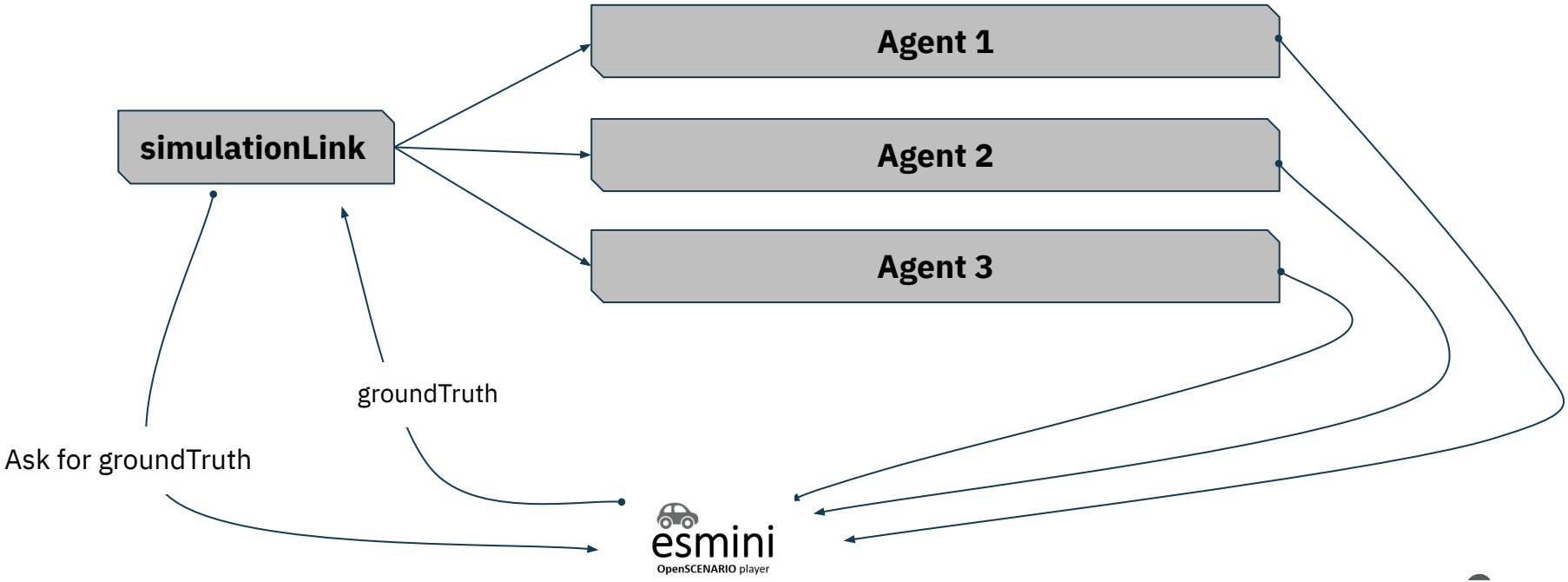
© 2022 ESTECO SpA

Communication (with ESMINI)



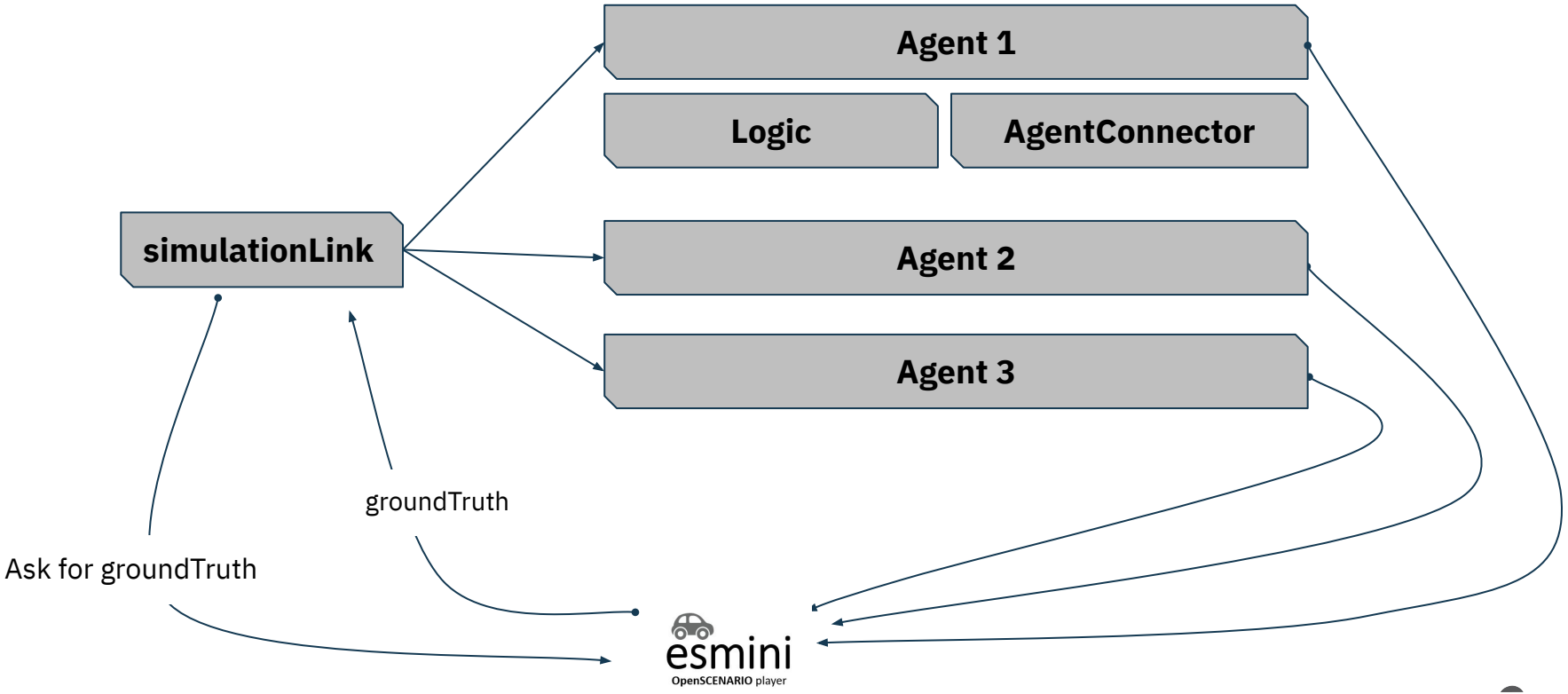
© 2022 ESTECO SpA

Communication (with ESMINI)



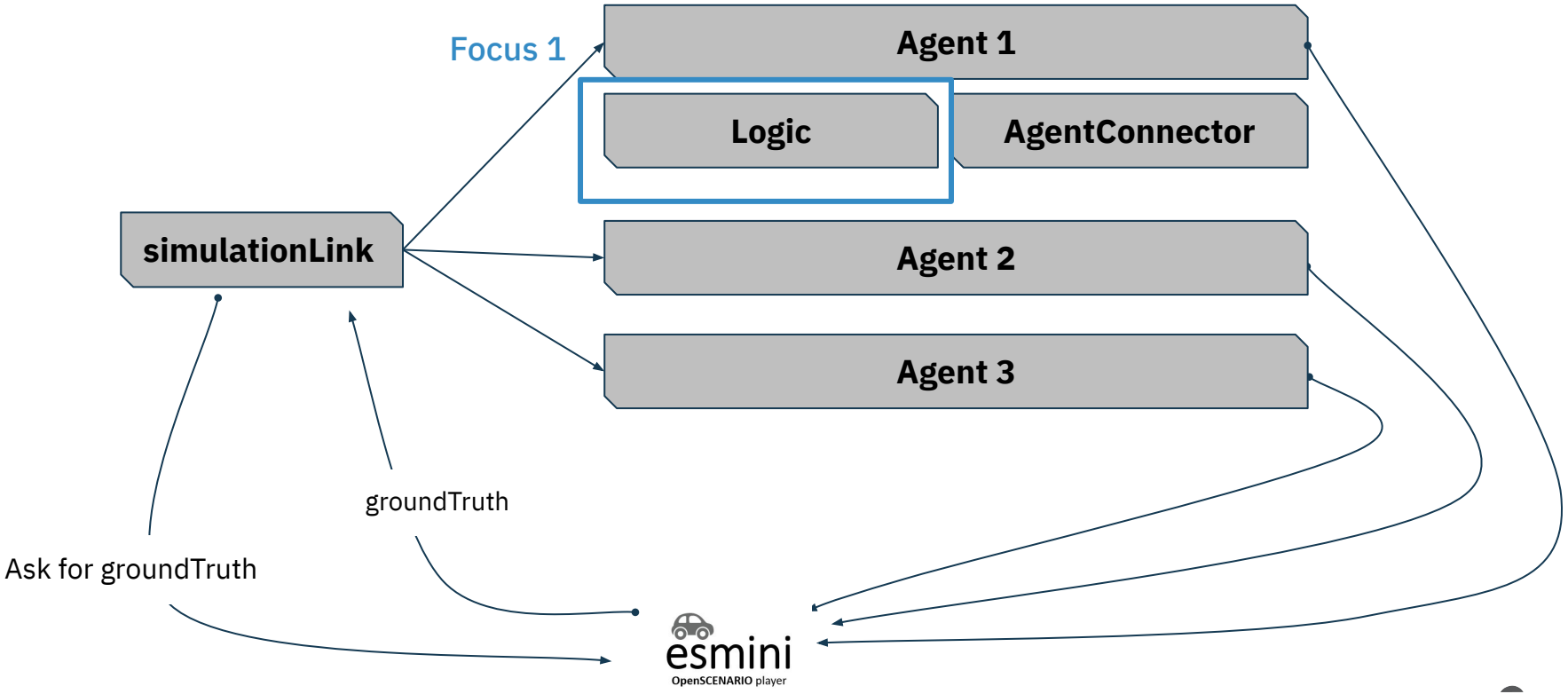
© 2022 ESTECO SpA

Communication (with ESMINI)



© 2022 ESTECO SpA

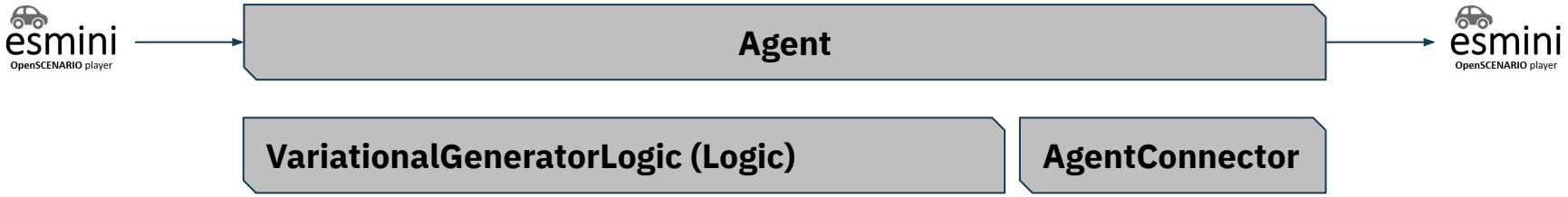
Communication (with ESMINI)



© 2022 ESTECO SpA

Communication (with ESMINI)

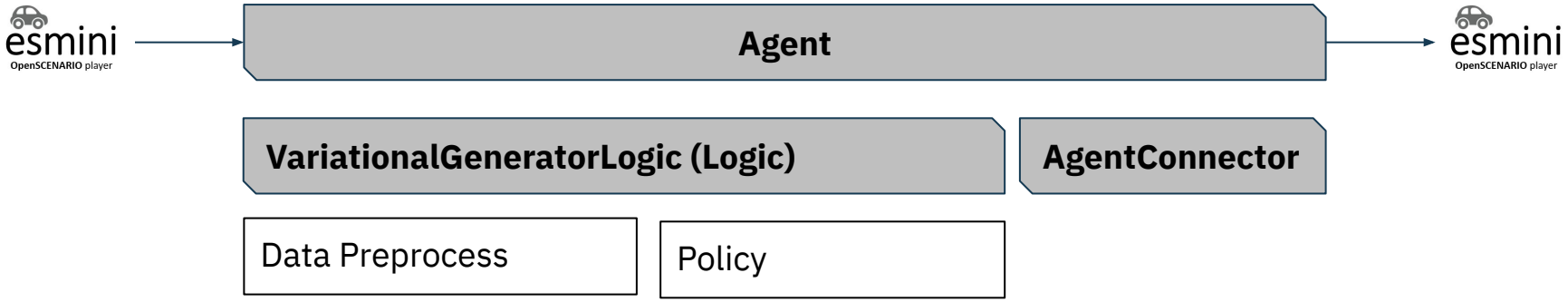
Focus 1



© 2022 ESTECO SpA

Communication (with ESMINI)

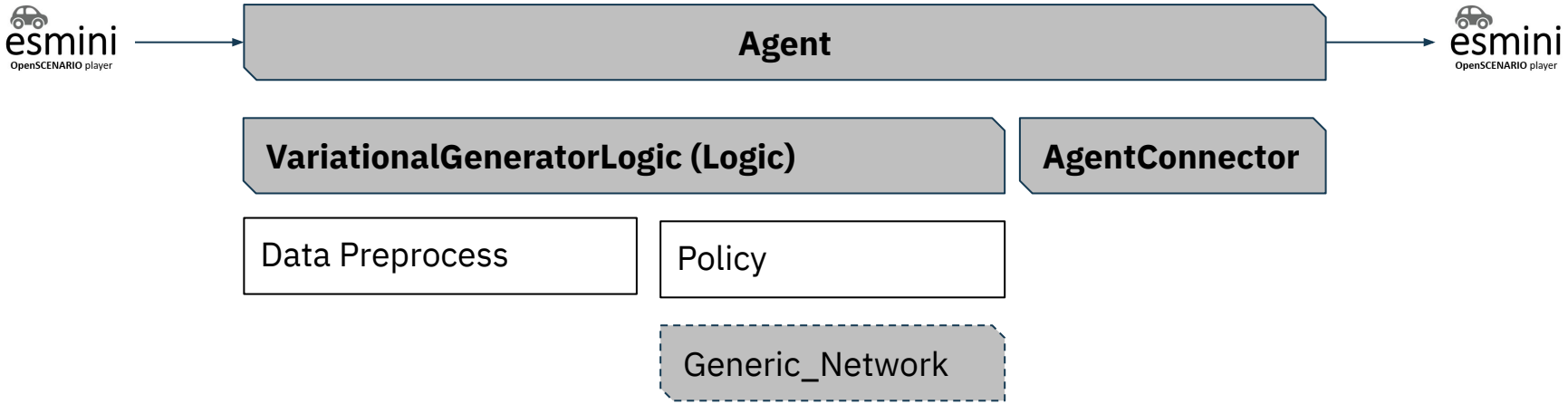
Focus 1



© 2022 ESTECO SpA

Communication (with ESMINI)

Focus 1



It’s own state
State nearest obstacle 1
State nearest obstacle 2

movement

© 2022 ESTECO SpA

Communication (with ESMINI)

Focus 1

esmini OpenSCENARIO player → **Agent** → esmini OpenSCENARIO player

VariationalGeneratorLogic (Logic)

AgentConnector

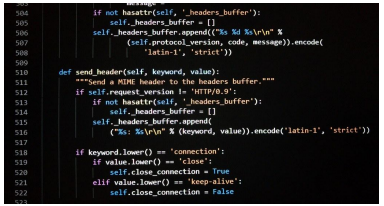
Data Preprocess

Policy

Generic_Network

It’s own state
State nearest obstacle 1
State nearest obstacle 2

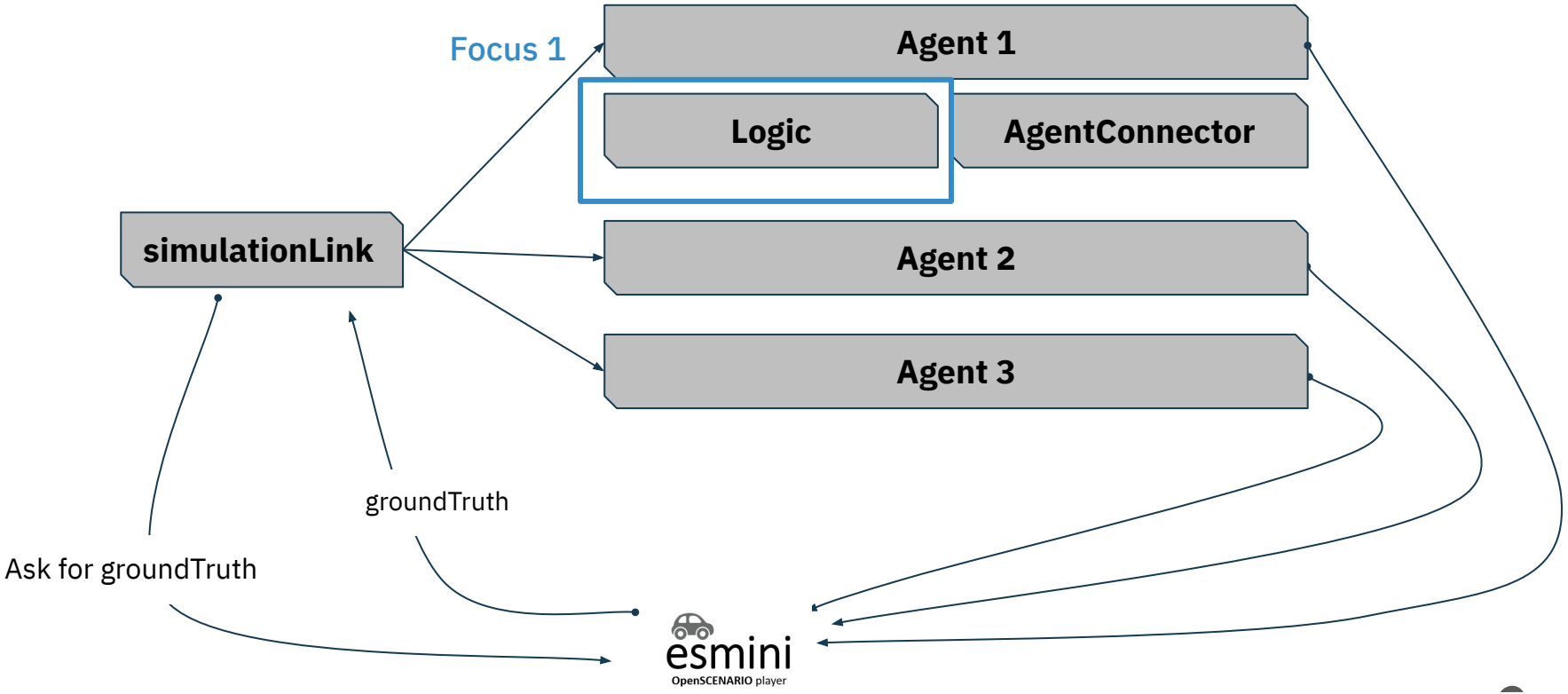
movement



Code Overview

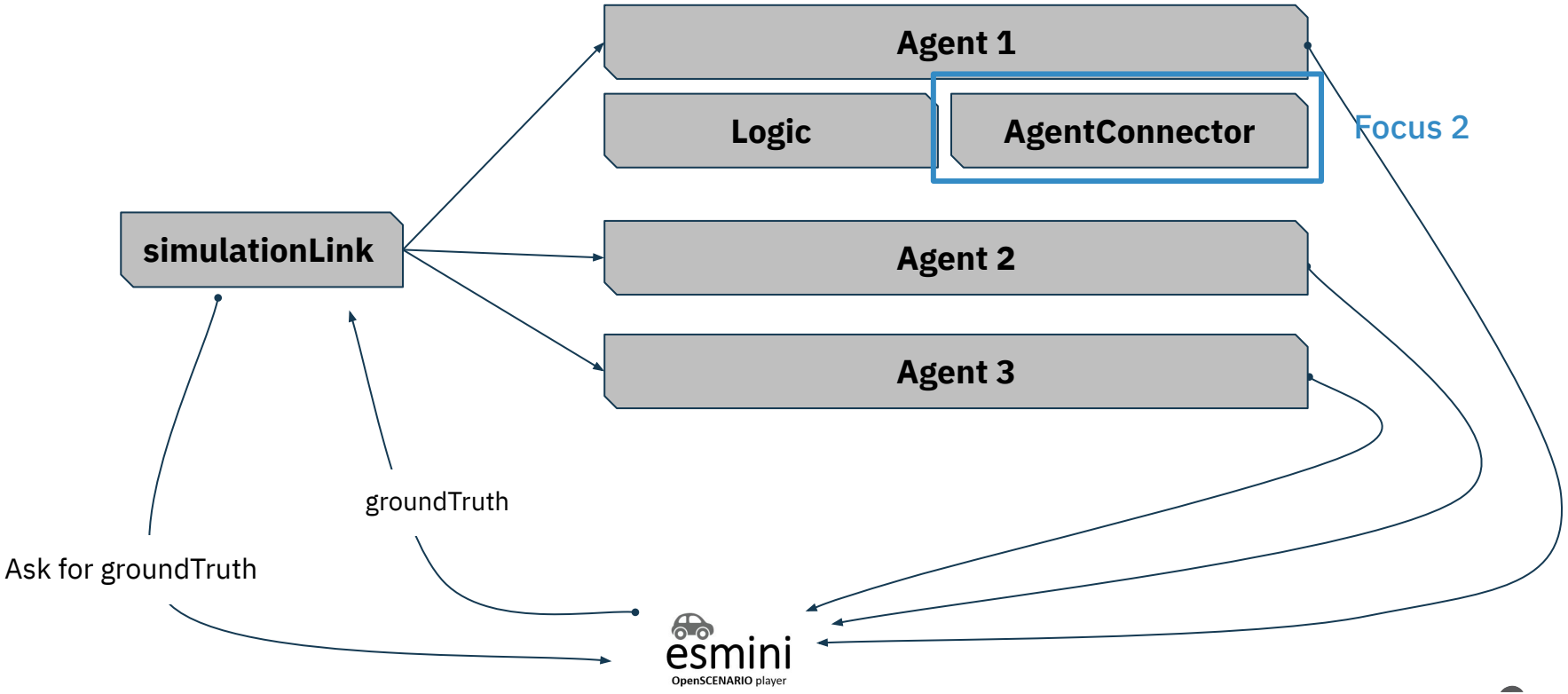
© 2022 ESTECO SpA

Communication (with ESMINI)



© 2022 ESTECO SpA

Communication (with ESMINI)



© 2022 ESTECO SpA

Communication (with ESMINI)

Focus 2

© 2022 ESTECO SpA

Communication (with ESMINI)

Focus 2

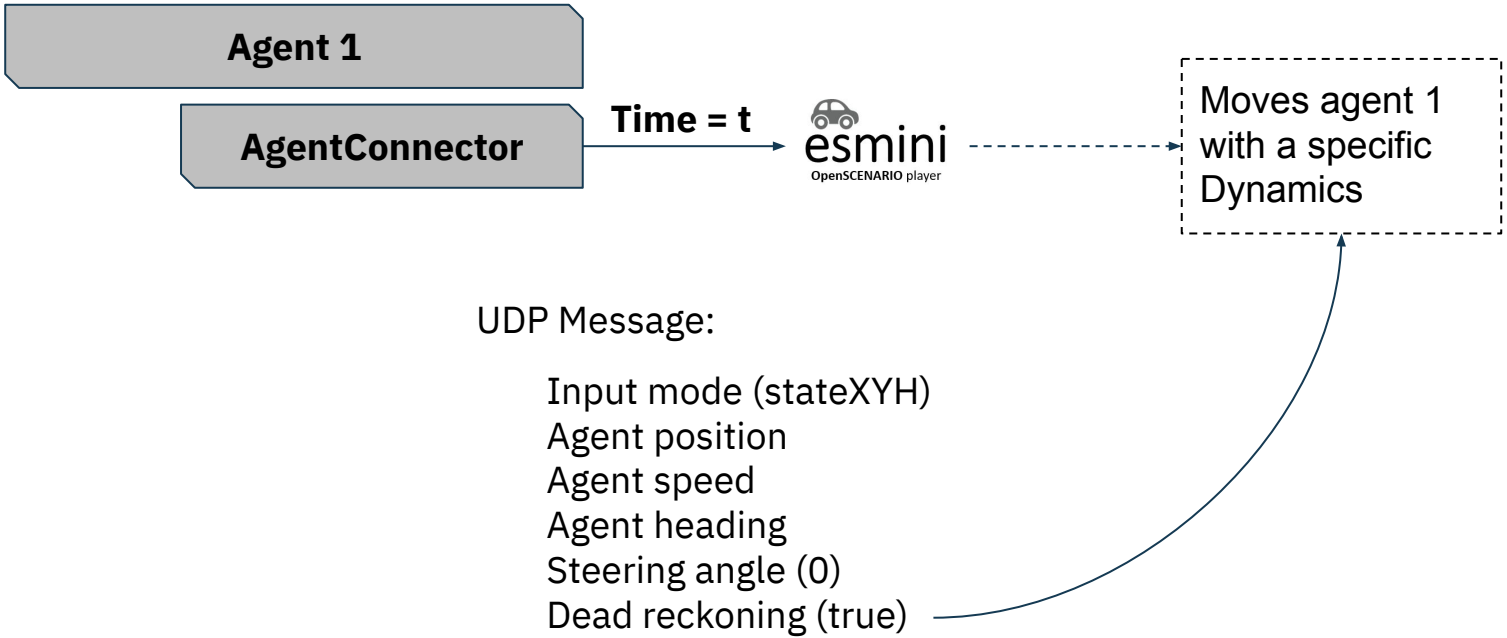
UDP Message:

Input mode (stateXYH)
Agent position
Agent speed
Agent heading
Steering angle (0)
Dead reckoning (true)

© 2022 ESTECO SpA

Communication (with ESMINI)

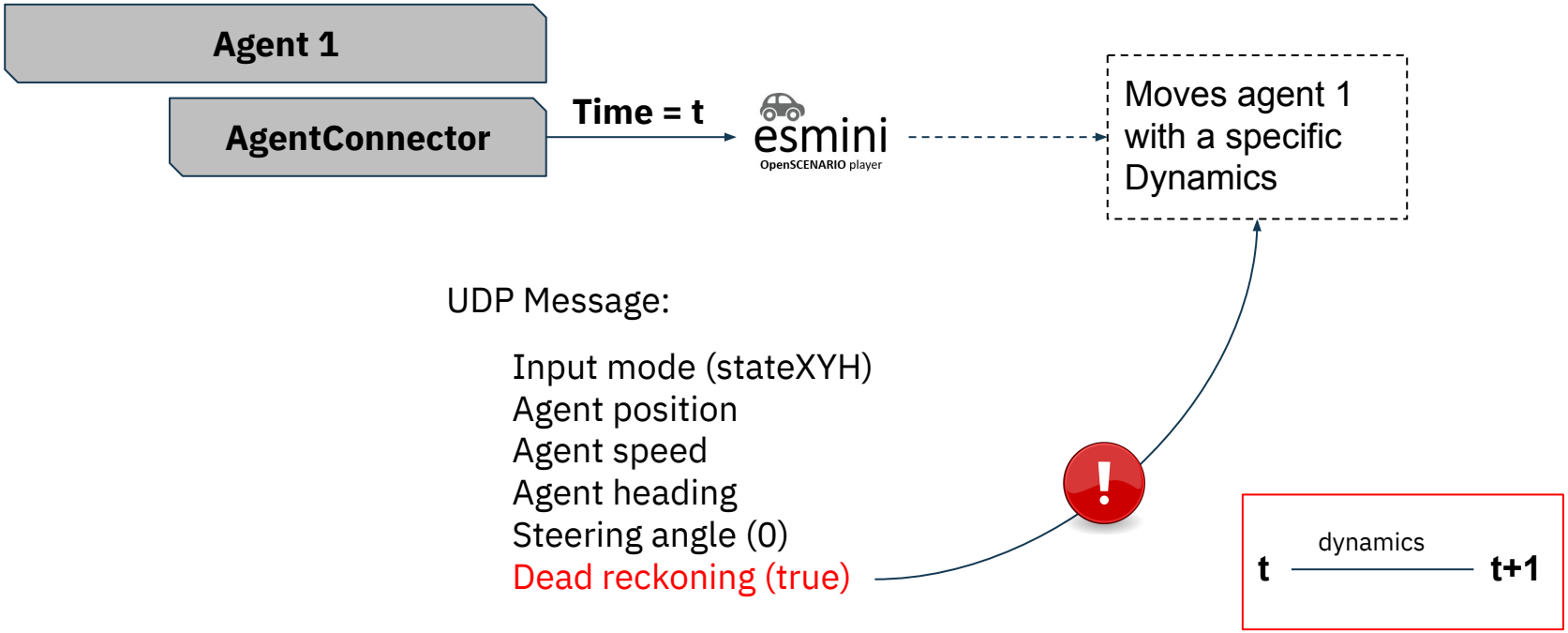
Focus 2



© 2022 ESTECO SpA

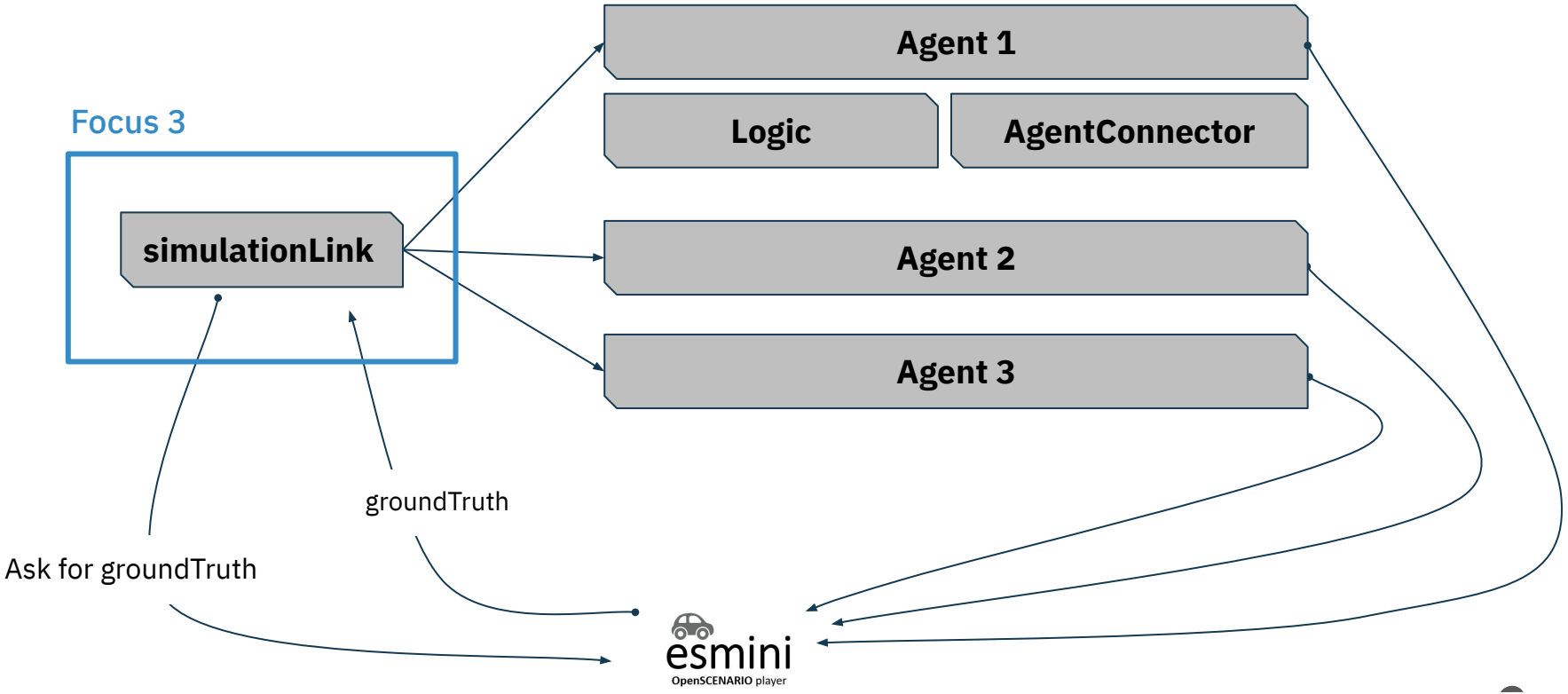
Communication (with ESMINI)

Focus 2



© 2022 ESTECO SpA

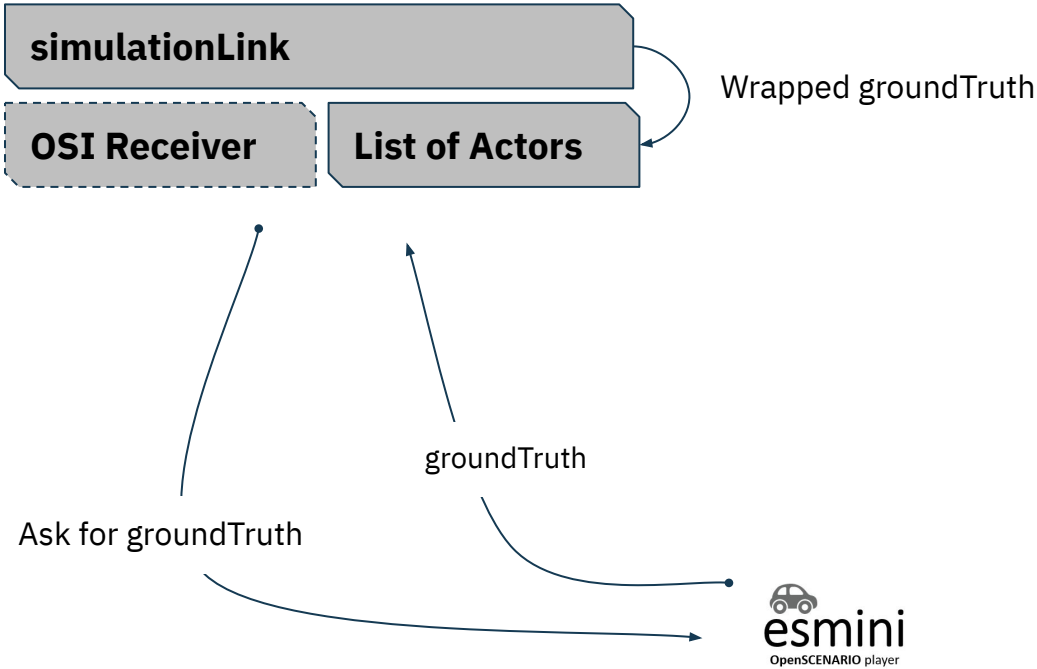
Communication (with ESMINI)



© 2022 ESTECO SpA

Communication (with ESMINI)

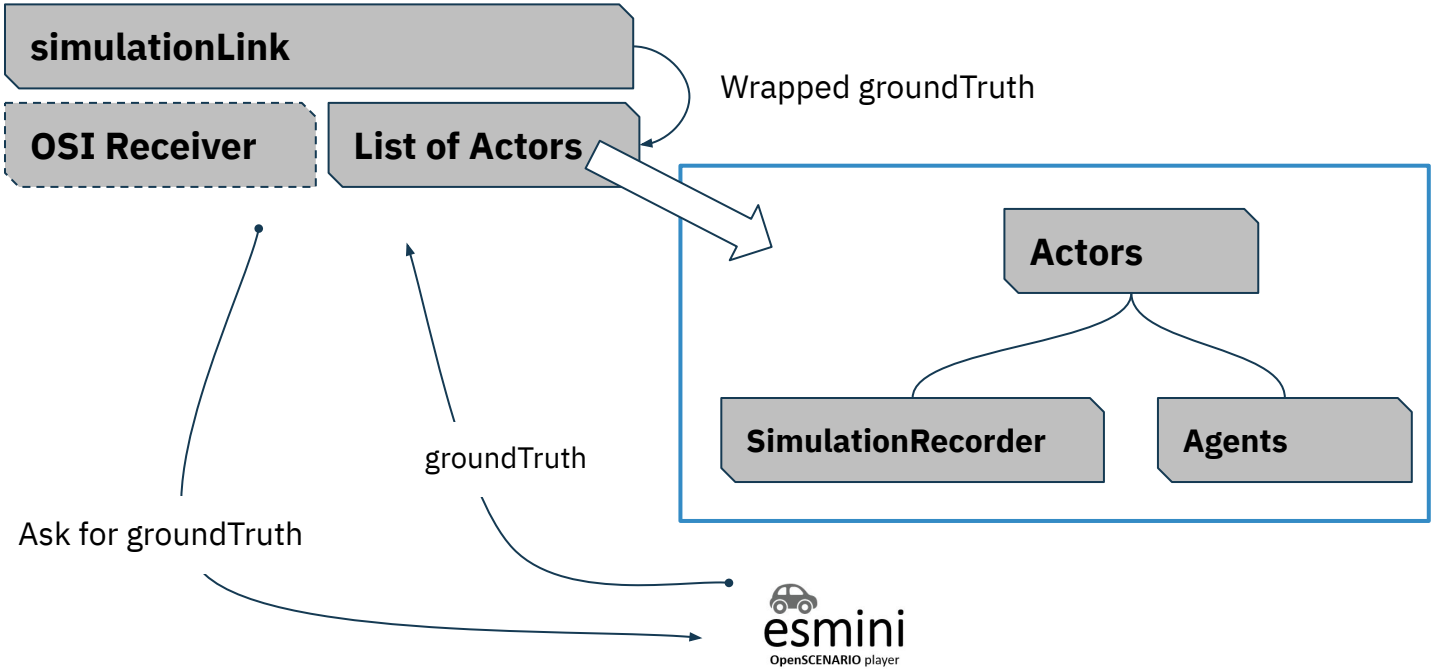
Focus 3



© 2022 ESTECO SpA

Communication (with ESMINI)

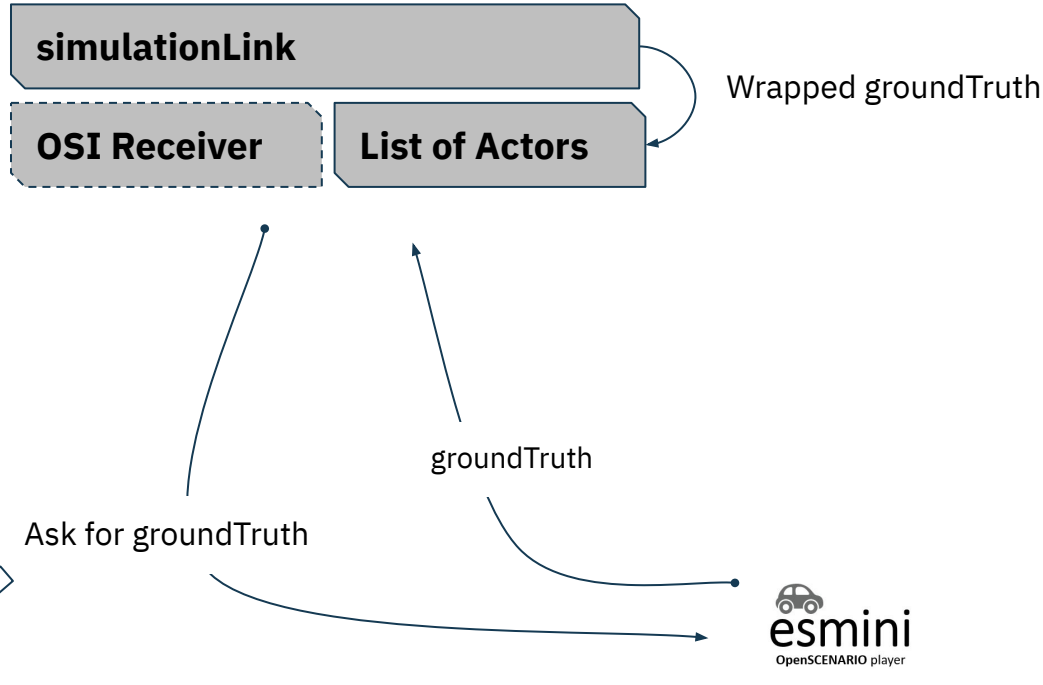
Focus 3



© 2022 ESTECO SpA

Communication (with ESMINI)

Focus 3

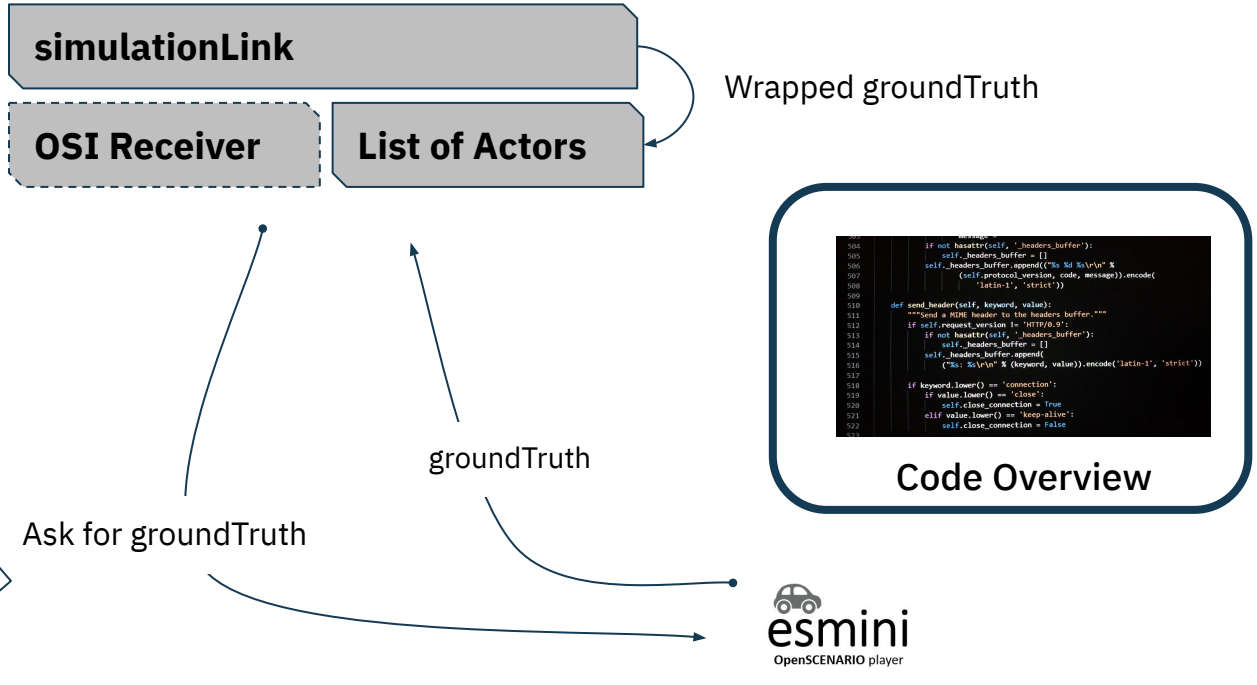


Polling each time_step (0.05 sec) seconds

© 2022 ESTECO SpA

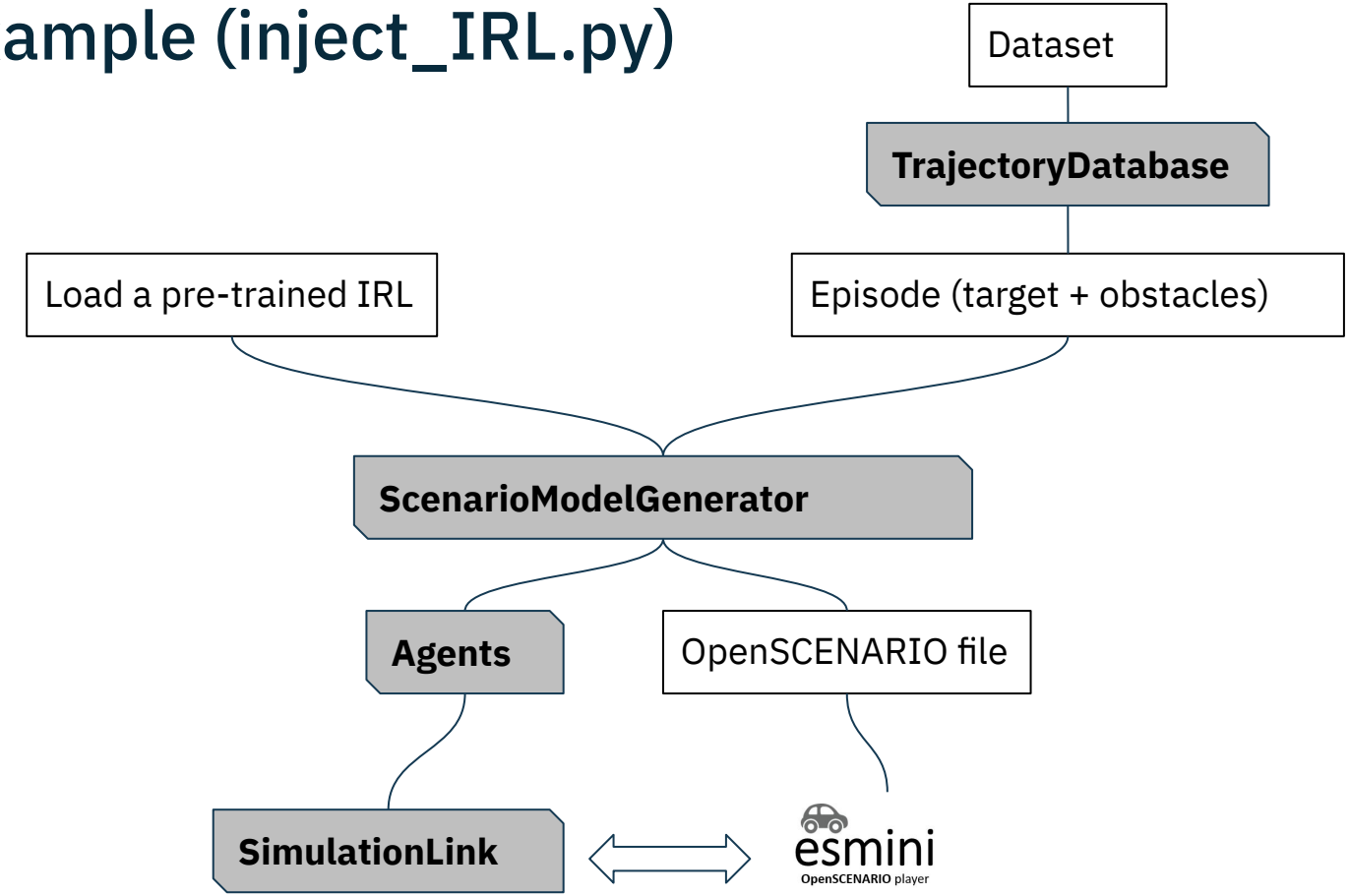
Communication (with ESMINI)

Focus 3



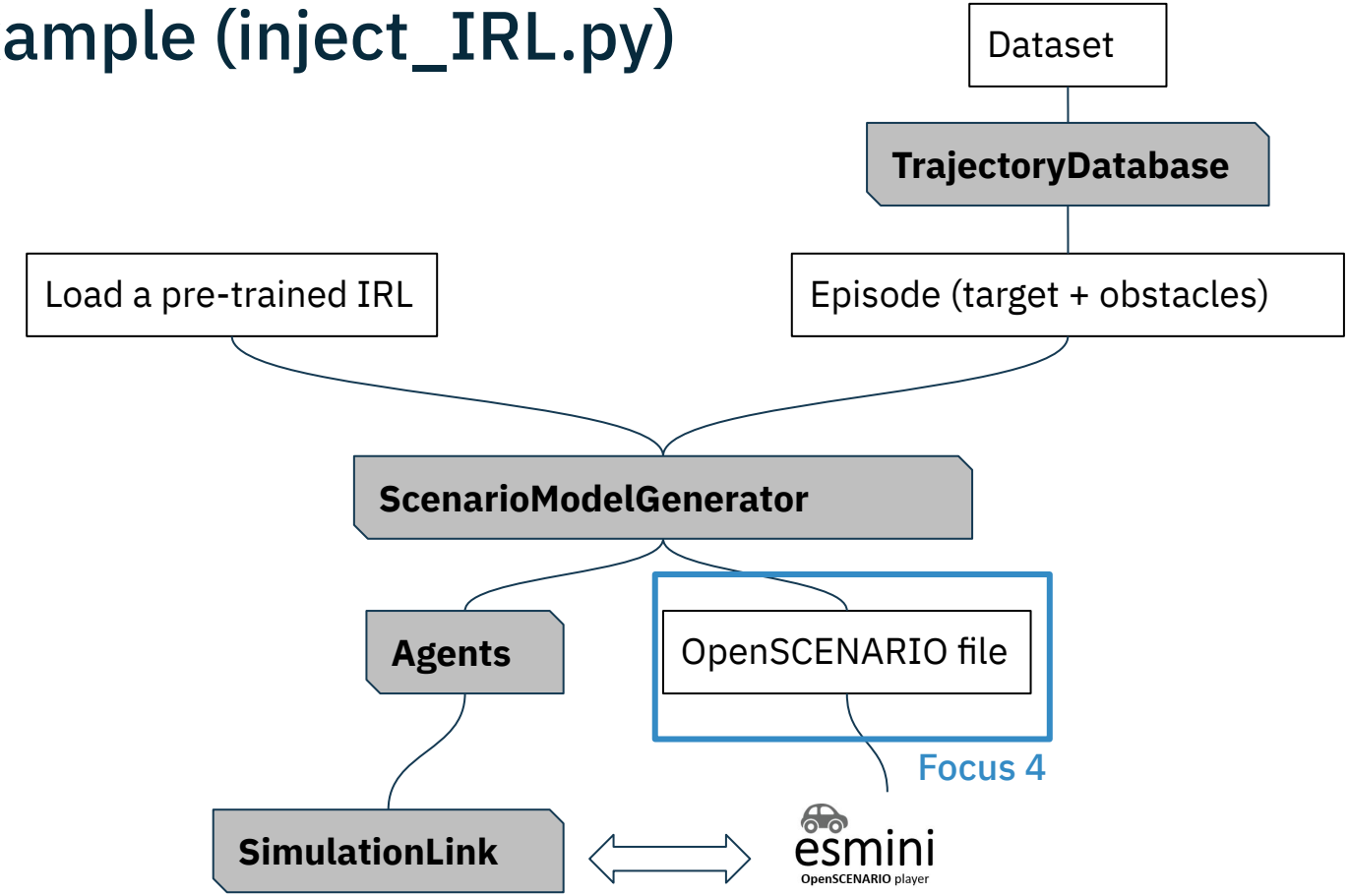
© 2022 ESTECO SpA

Example (inject_IRL.py)



© 2022 ESTECO SpA

Example (inject_IRL.py)



© 2022 ESTECO SpA

Example (inject_IRL.py)

Focus 4

```
<Entities>
    <ScenarioObject name="ego">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_white"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53901"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
    <ScenarioObject name="obstacle0">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_red"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53902"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
```

Target

Obstacle

© 2022 ESTECO SpA

Example (inject_IRL.py)

Focus 4

```
<Entities>
    <ScenarioObject name="ego">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_white"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53901"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
    <ScenarioObject name="obstacle0">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_red"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53902"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
```

© 2022 ESTECO SpA

Example (inject_IRL.py)

Focus 4

```
<Entities>
    <ScenarioObject name="ego">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_white"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53901"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
    <ScenarioObject name="obstacle0">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_red"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53902"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
```

© 2022 ESTECO SpA

Example (inject_IRL.py)

Focus 4

```
<Entities>
    <ScenarioObject name="ego">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_white"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53901"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
    <ScenarioObject name="obstacle0">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_red"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53902"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
```

© 2022 ESTECO SpA

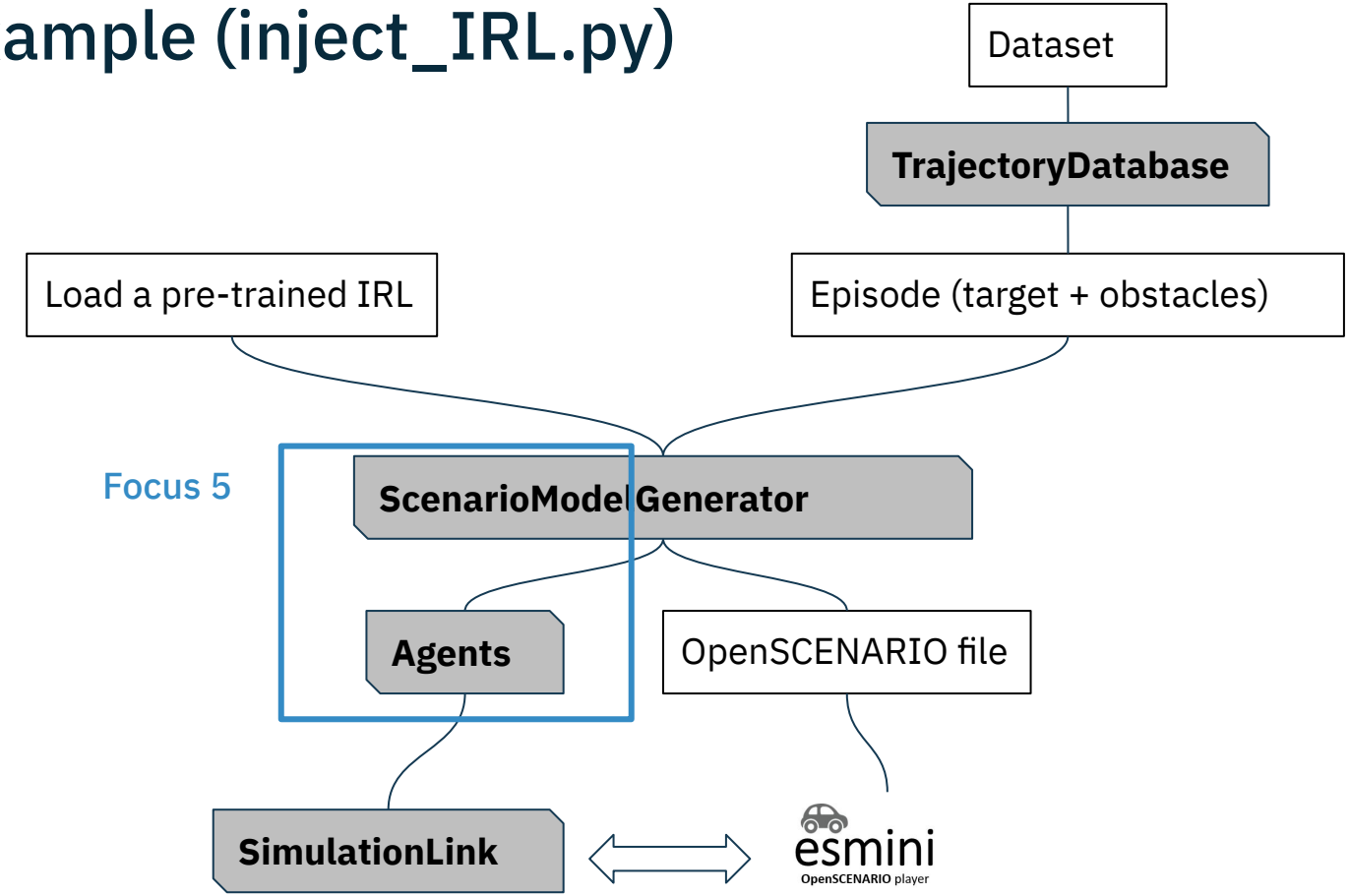
Example (inject_IRL.py)

Focus 4

```
<Entities>
    <ScenarioObject name="ego">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_white"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53901"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
    <ScenarioObject name="obstacle0">
        <CatalogReference catalogName="VehicleCatalog" entryName="car_red"/>
        <ObjectController>
            <CatalogReference catalogName="ControllerCatalog" entryName="UDPDriverController">
                <ParameterAssignments>
                    <ParameterAssignment parameterRef="Port" value="53902"/>
                    <ParameterAssignment parameterRef="ExecMode" value="synchronous"/>
                </ParameterAssignments>
            </CatalogReference>
        </ObjectController>
    </ScenarioObject>
```

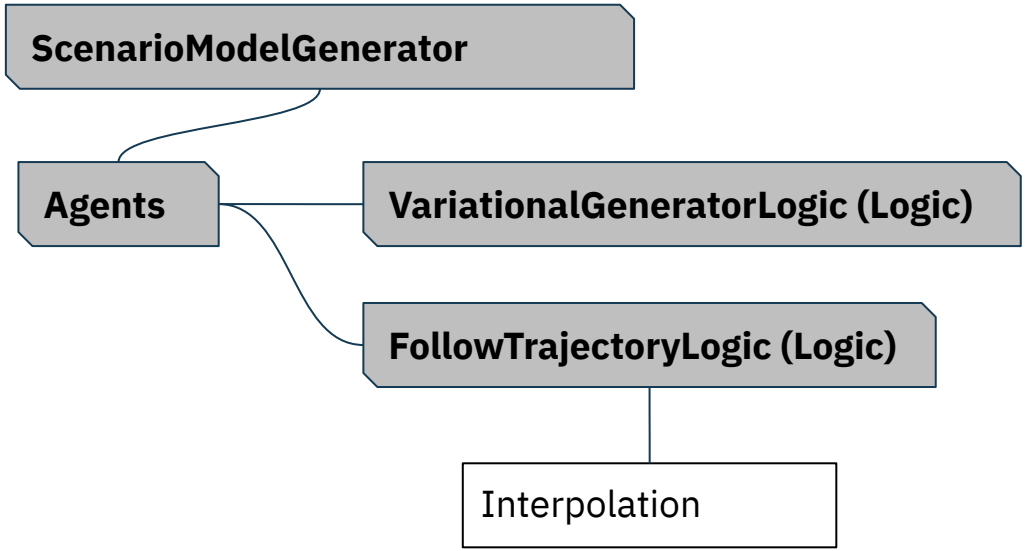
© 2022 ESTECO SpA

Example (inject_IRL.py)



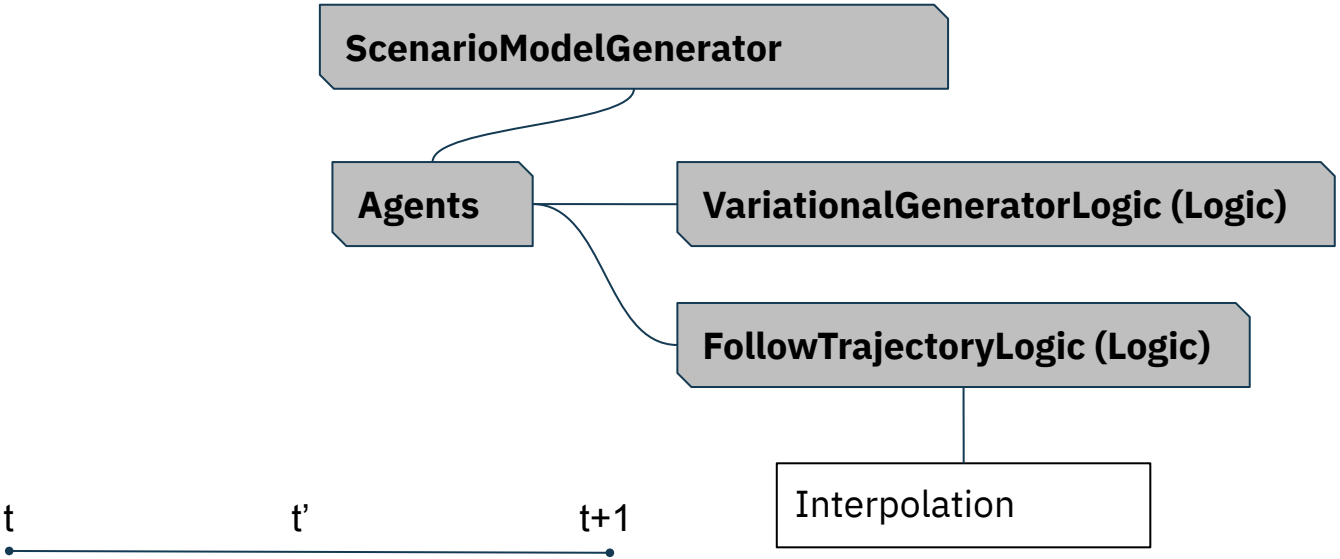
© 2022 ESTECO SpA

Example (inject_IRL.py)



© 2022 ESTECO SpA

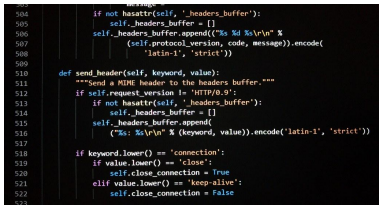
Example (inject_IRL.py)



$a(t') = a(t)$
$v(t') = v(t)$
$s(t') = s(t) + [t' - t] * [s(t+1) - s(t)]$

© 2022 ESTECO SpA

Results / Problems / Improvements



```
            if not hasattr(self, '_headers_buffer'):
                self._headers_buffer = []
            self._headers_buffer.append(("%s %d %s\r\n" %
                    (self.protocol_version, code, message)).encode(
                        'latin-1', 'strict'))

    def send_header(self, keyword, value):
        """Send a MIME header to the headers buffer."""
        if self.request_version != 'HTTP/0.9':
            if not hasattr(self, '_headers_buffer'):
                self._headers_buffer = []
            self._headers_buffer.append(
                ("%s: %s\r\n" % (keyword, value)).encode('latin-1', 'strict'))

        if keyword.lower() == 'connection':
            if value.lower() == 'close':
                self.close_connection = True
            elif value.lower() == 'keep-alive':
                self.close_connection = False
```

Code Overview

© 2022 ESTECO SpA

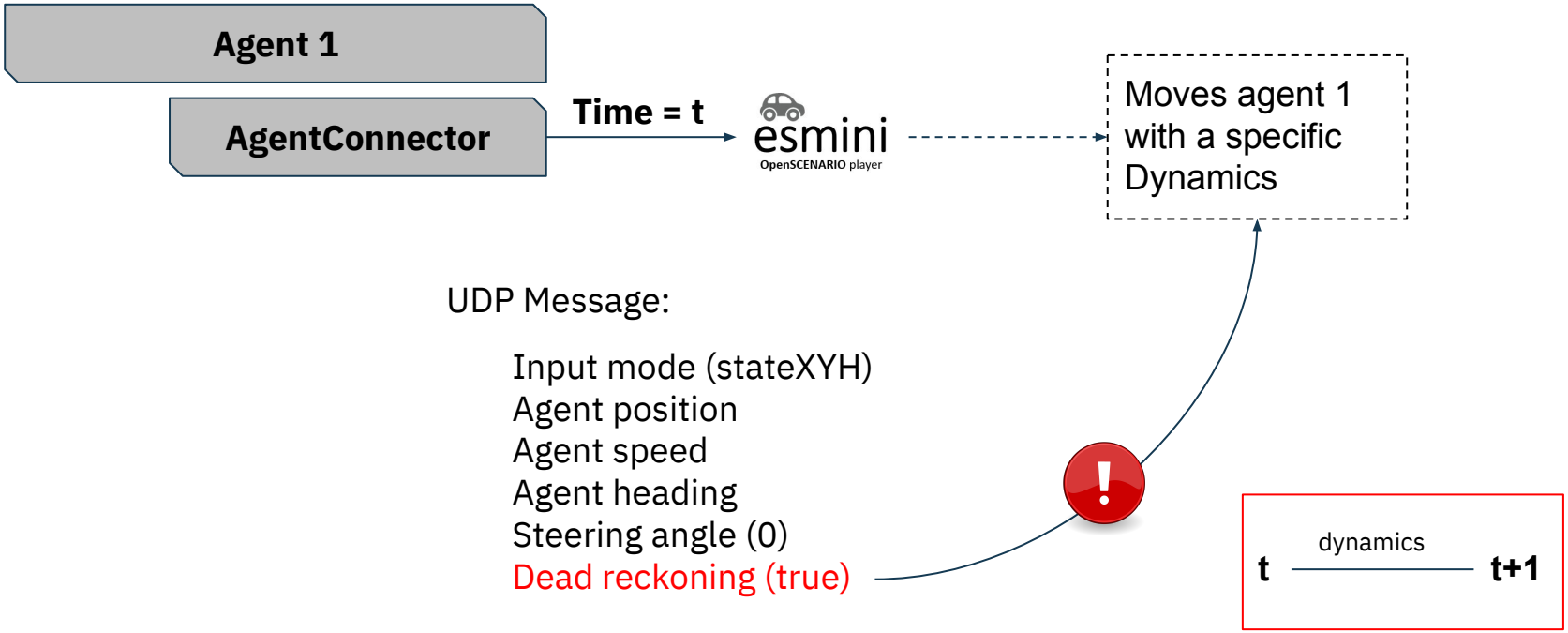
Results / Problems / Improvements

Spikes / Zig-Zag / Dead Reckoning / New Dynamics / ESMINI API

© 2022 ESTECO SpA

Results / Problems / Improvements

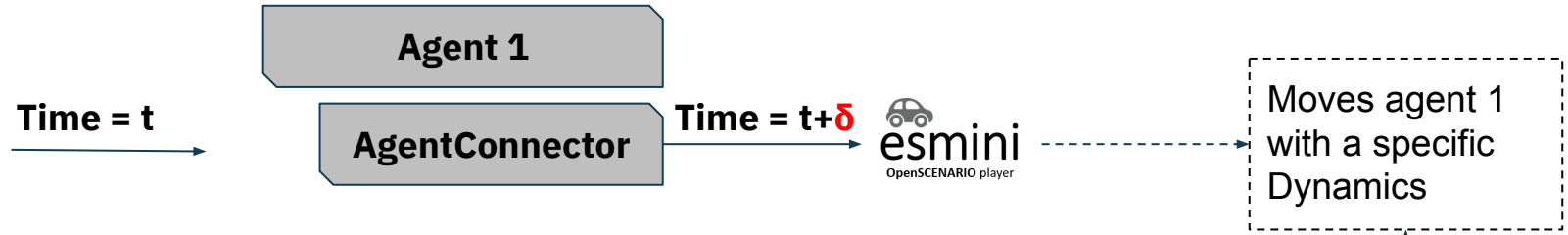
Dead reckoning dynamics



© 2022 ESTECO SpA

Results / Problems / Improvements

Dead reckoning dynamics



Agents states

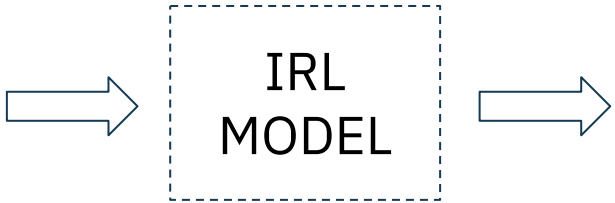
UDP Message:

Input mode (stateXYH)
Agent position (??)
Agent speed
Agent heading
Steering angle (0)
Dead reckoning (true)

© 2022 ESTECO SpA

Results / Problems / Improvements

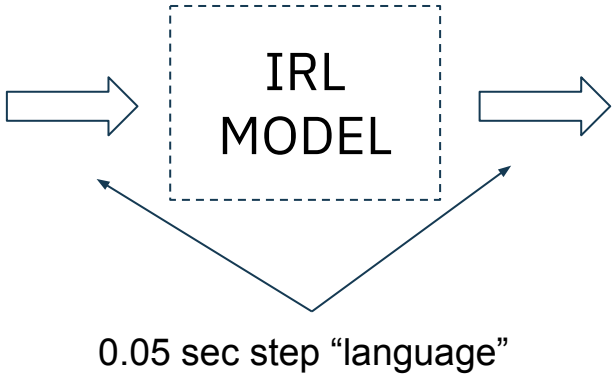
Speed / Adaptation / New IRL Model / Better Adaptation



© 2022 ESTECO SpA

Results / Problems / Improvements

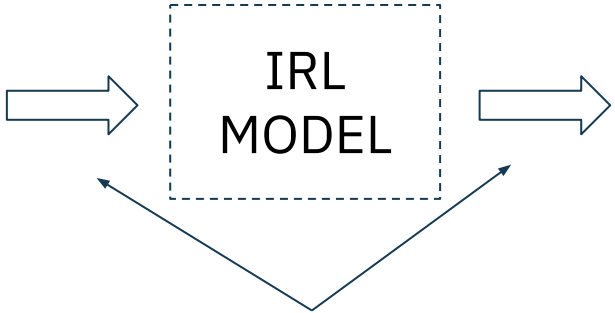
Speed / Adaptation / New IRL Model / Better Adaptation



© 2022 ESTECO SpA

Results / Problems / Improvements

Speed / Adaptation / New IRL Model / Better Adaptation



0.05 sec step “language”

Code Overview

© 2022 ESTECO SpA

Results / Problems / Improvements

Waiting Agents / OpenSCENARIO / Ghost agent / OpenSCENARIO Specification

© 2022 ESTECO SpA

Thank You!

© 2022 ESTECO S.p.A.

ESTECO Copyright Policy

All the ESTECO communication materials, including but not limited to presentations and slides, are under copyright of ESTECO.

We encourage you to use this documentation when you need to present our company, products and technologies, under the following conditions:

- You are not allowed to modify it in any way that may alter the content.
- You must always acknowledge the ESTECO property.
- You can add your logo but you must not delete or hide the ESTECO one.
- You cannot extract and use illustrations, graphics or any other images included in the ESTECO presentations out of context, unless you have requested permission to marketing@esteco.com.
- You must not use any ESTECO materials in a way that may compromise the reputation of ESTECO.
- You cannot distribute ESTECO materials without prior written approval from ESTECO.

Our permission to use ESTECO materials is conditioned upon your compliance with these terms of use. Any use contrary to these limitations is a violation of the intellectual property rights of ESTECO and/or its contributors and is prohibited.

By downloading and using any ESTECO material, you accept these terms. If you do not agree to these terms of use, do not use any ESTECO materials.

For any information or doubts, do not hesitate to contact us: marketing@esteco.com.