Traffic Simulation with SARL

EuSarlCon 2019 - May 2nd 2019

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OUTLINE

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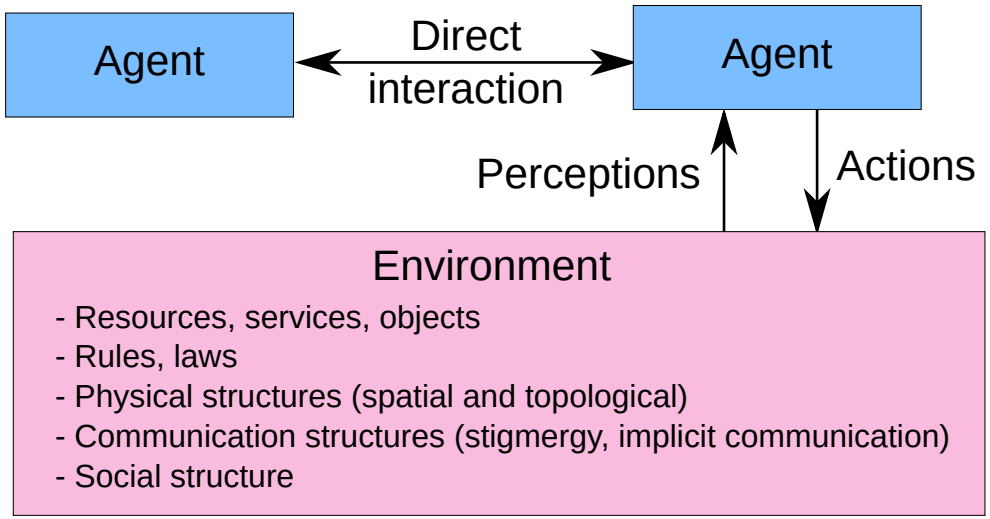
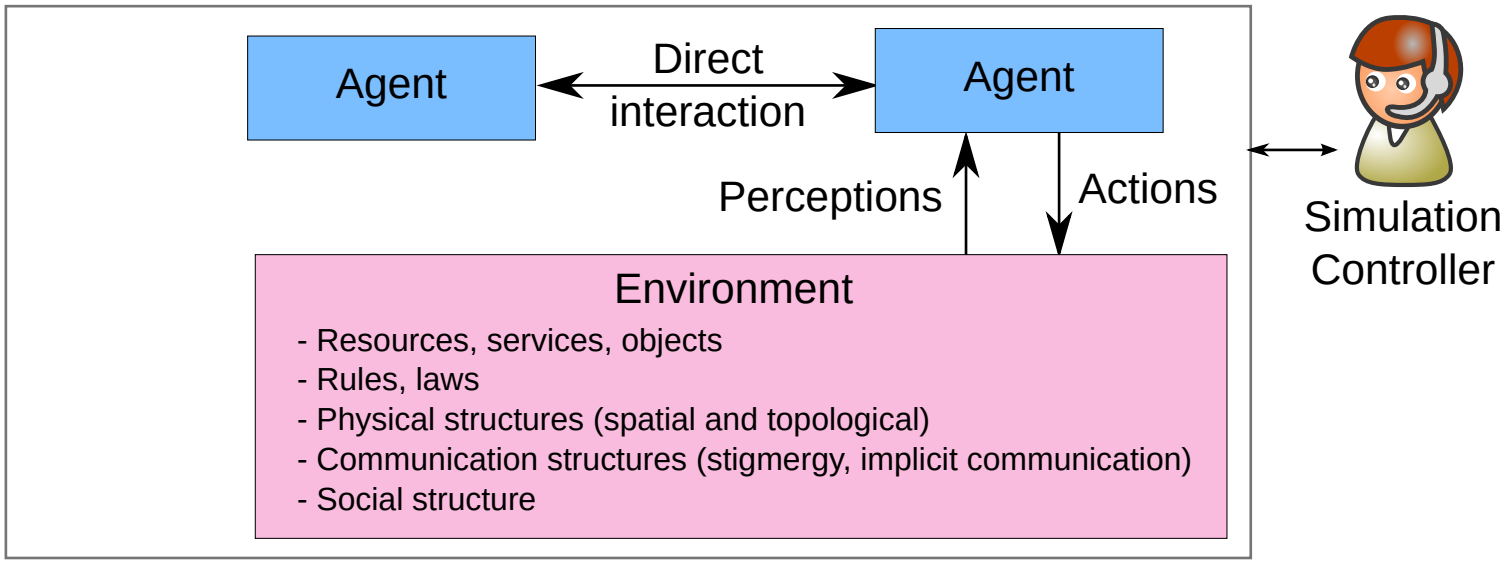

Agent
Direct interaction
Agent
Perceptions
Actions
Environment
- Resources, services, objects
- Rules, laws
- Physical structures (spatial and topological)
- Communication structures (stigmergy, implicit communication)
- Social structure

GENERAL AGENT-BASED SIMULATION ARCHITECTURE



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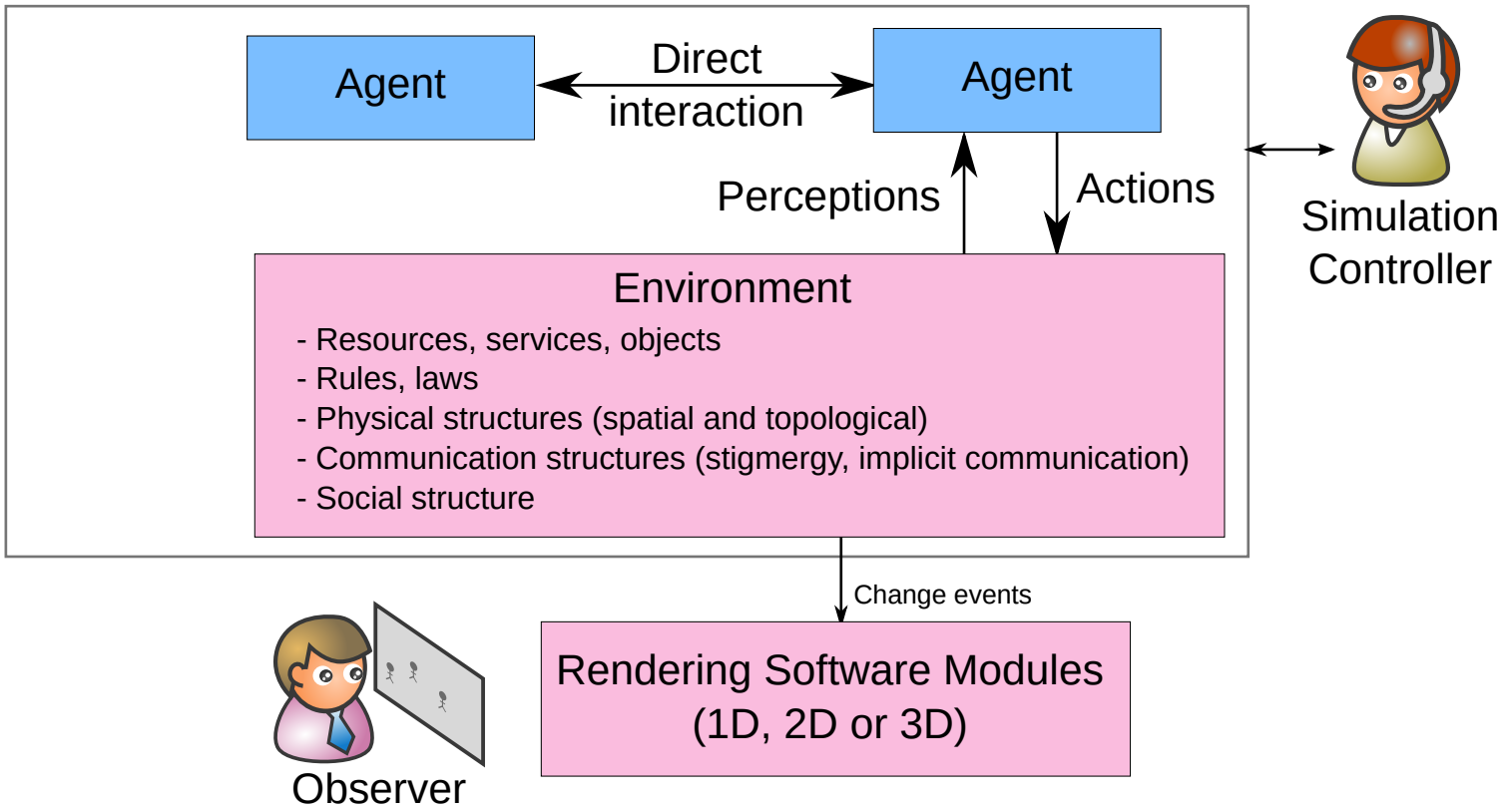

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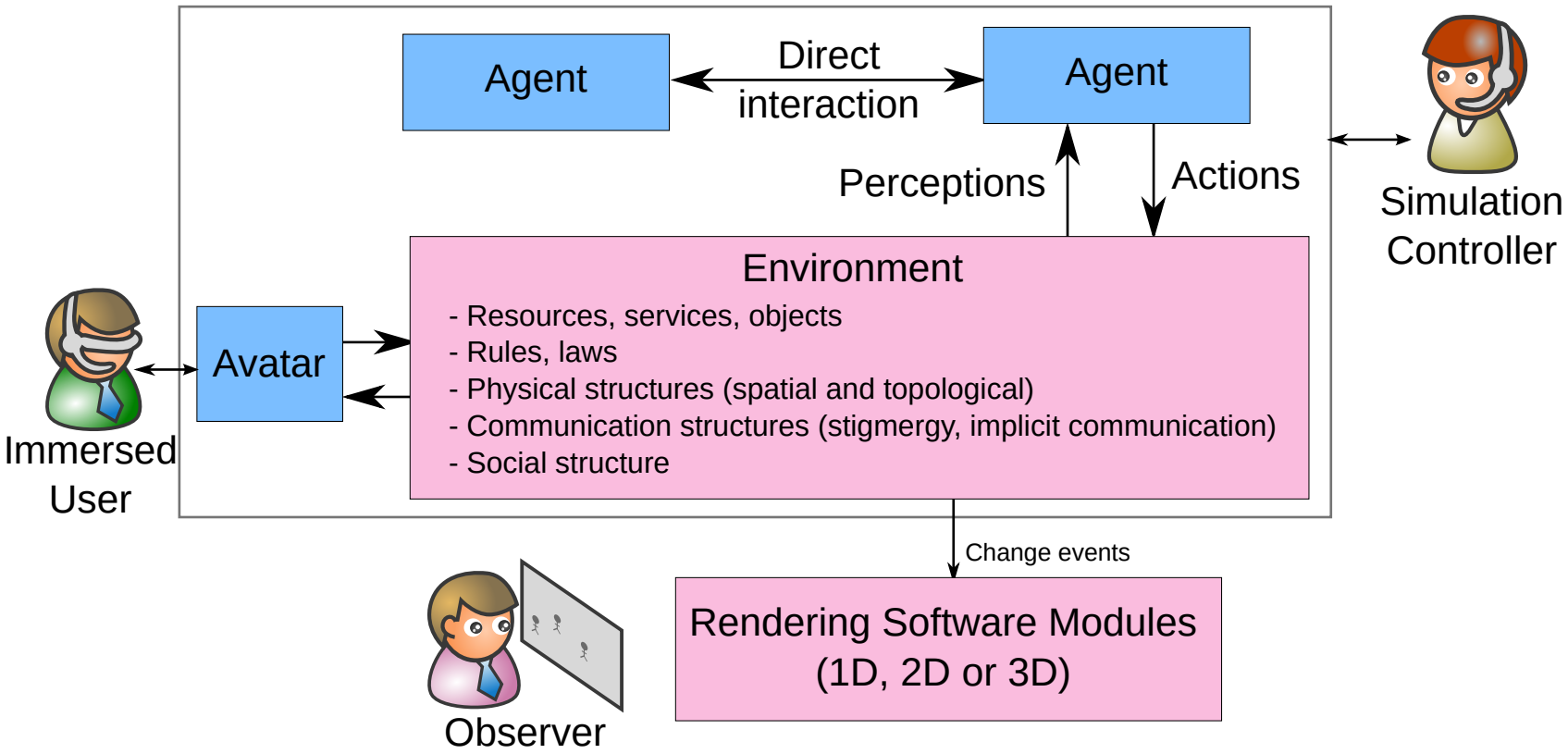
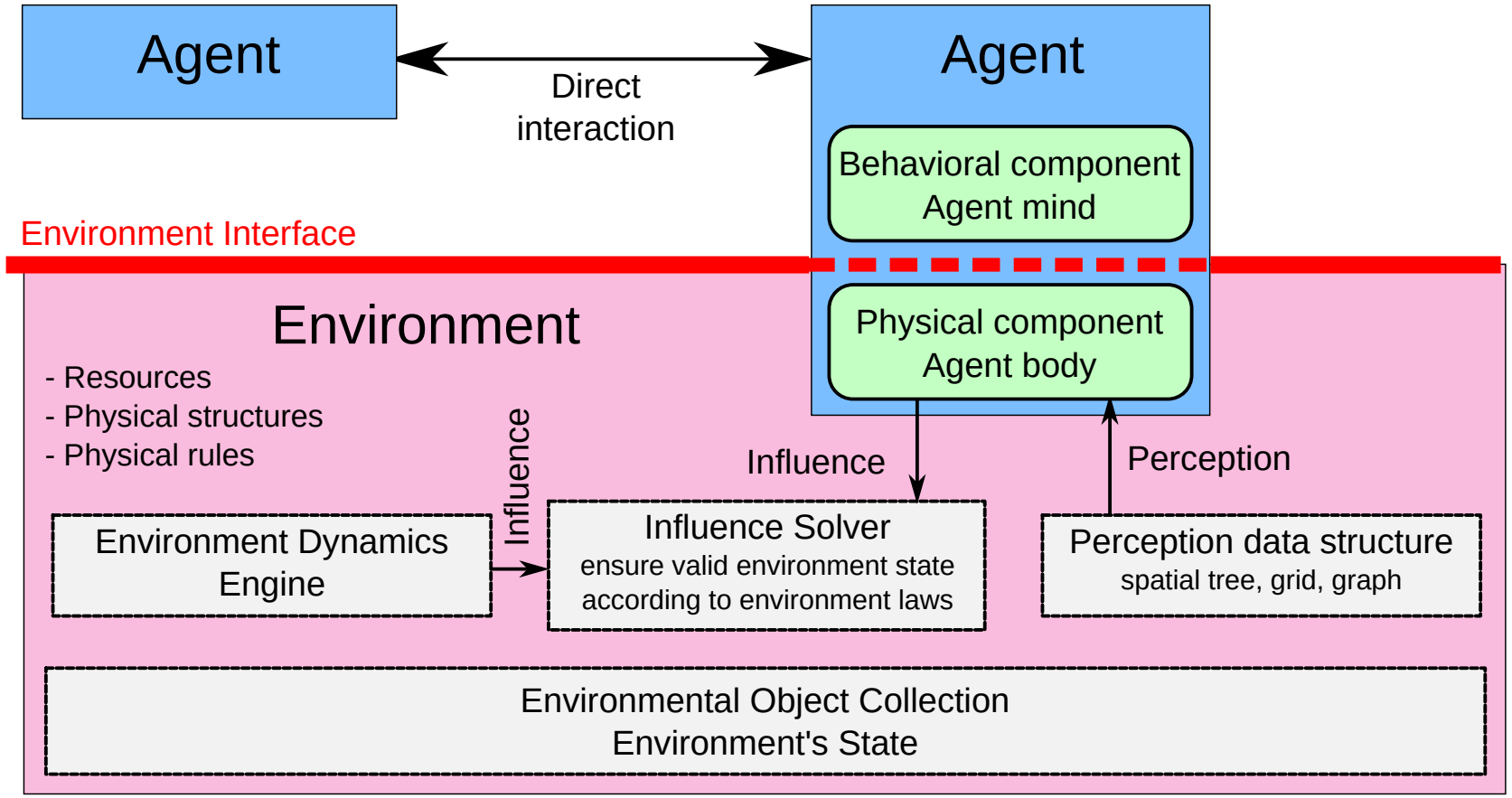
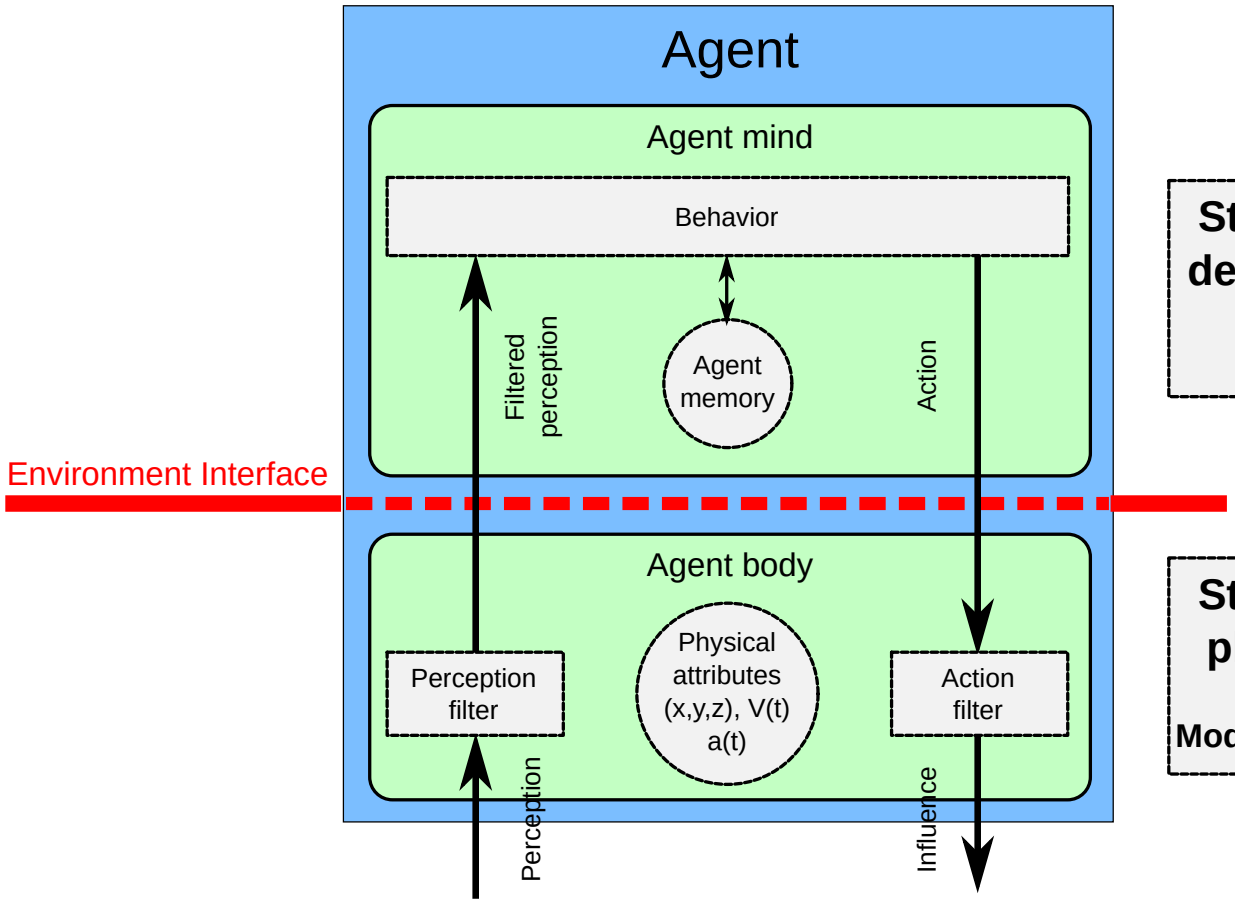




Galland (2009)



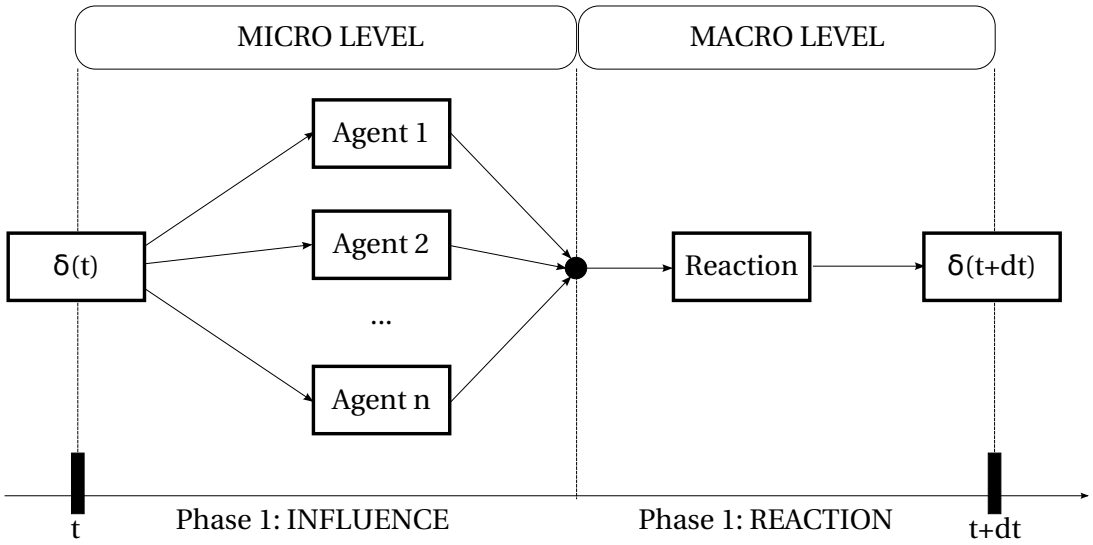
State variables of the decisional component
Readable/modifiable only by the agent

State variables of the physical component
Readable by the agent
Modifiable by the environment

Galland (2009)

How to support simultaneous actions from agents?

1. An agent does not change the state of the environment directly.
2. Agent gives a state-change expectation to the environment: the influence.
3. Environment gathers influences, and solves conflicts among them for obtaining its reaction.
4. Environment applies reaction for changing its state.

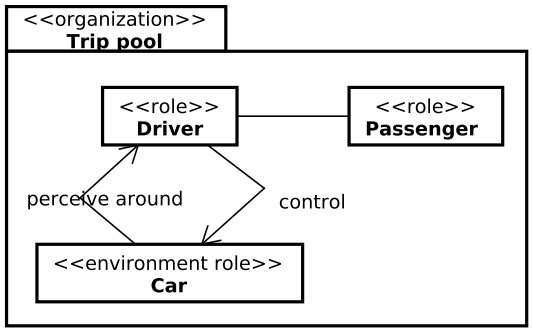


Michel (2007)

OUTLINE

- Each vehicle is simulated but road signs are skipped ⇒ mesoscopic simulation.
- The roads are extracted from a Geographical Information Database.

- The simulation model is composed of two parts (Galland, 2009):
  1. the environment: the model of the road network, and the vehicles.
  2. the driver model: the behavior of the driver linked to a single vehicle.



OUTLINE

Road Network

- Road polylines: $S = \left\{ \langle path, objects \rangle \middle| path = \langle (x_0, y_0) \cdots \rangle \right\}$
- Graph: $G = \{S, S \mapsto S, S \mapsto S\} = \{\text{segments}, \text{entering}, \text{exiting}\}$

Operations

- Compute the set of objects perceived by a driver (vehicles, roads...):

$$P = \left\{ o \middle| \begin{array}{c} distance(d, o) \leq \Delta \wedge \\ o \in O \wedge \\ \forall (s_1, s_2), path = s_1.\langle p, O \rangle.s_2 \end{array} \right\}$$

  where *path* is the roads followed by a driver d.

- Move the vehicles, and avoid physical collisions.

Galland (2009)

BODY MANAGEMENT CAPACITY

- The agent has the capacity to use the car.
- The body supports the interactions with the environment.

```
event Perception {
  val objects : List<
     SituatedObject>
}

capacity EnvironmentInteraction {
  def getBody : AgentBody
  def move(a : float,
    path : List<RoadSegment>)
}

event CarInfluence {
  val acceleration : float
  val path : List<RoadSegment>

  new (a : float, p : List<
     RoadSegment>) {
    this.acceleration = a
    this.path = p.unmodifiableList
  }
}
```

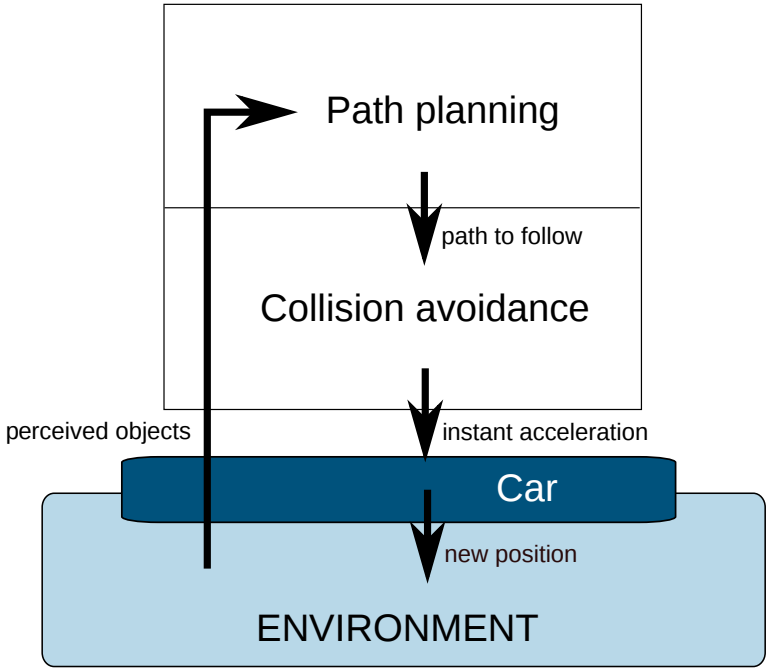
```
skill PhysicBody implements
    EnvironmentInteraction {

  val env : UUID
  val body : AgentBody

  def getBody : AgentBody {
    this.body
  }
  def move(a : float,
    path : List<RoadSegment>) {
    emit(new CarInfluence(float,
     path))
      [UUID == this.env]
  }
}
```

Galland (2015)

OUTLINE



Jasim model (Galland, 2009)

- Based on the A* algorithm (Dechter, 1985; Delling, 2009):
  - extension of the Dijkstra's algorithm: search shortest paths between the nodes of a graph.
  - introduce the heuristic function h to explore first the nodes that permits to converge to the target node.

- Inspired by the D*-Lite algorithm (Koenig, 2005):
  - A* family.
  - supports dynamic changes in the graph topology and the values of the edges.

- Principle: compute the acceleration of the vehicle to avoid collisions with the other vehicles.
- Intelligent Driver Model (Treiber, 2000)

$$\texttt{followerDriving} = \begin{cases} -\dfrac{(v\Delta v)^2}{4b\Delta p^2} & \text{if the object ahead is far} \\ -a\dfrac{(s+vw)^2}{\Delta p^2} & \text{if the object ahead is near} \end{cases}$$

- Free driving:

$$\texttt{freeDriving} = a\left(1 - \left(\frac{v}{v_c}\right)^4\right)$$

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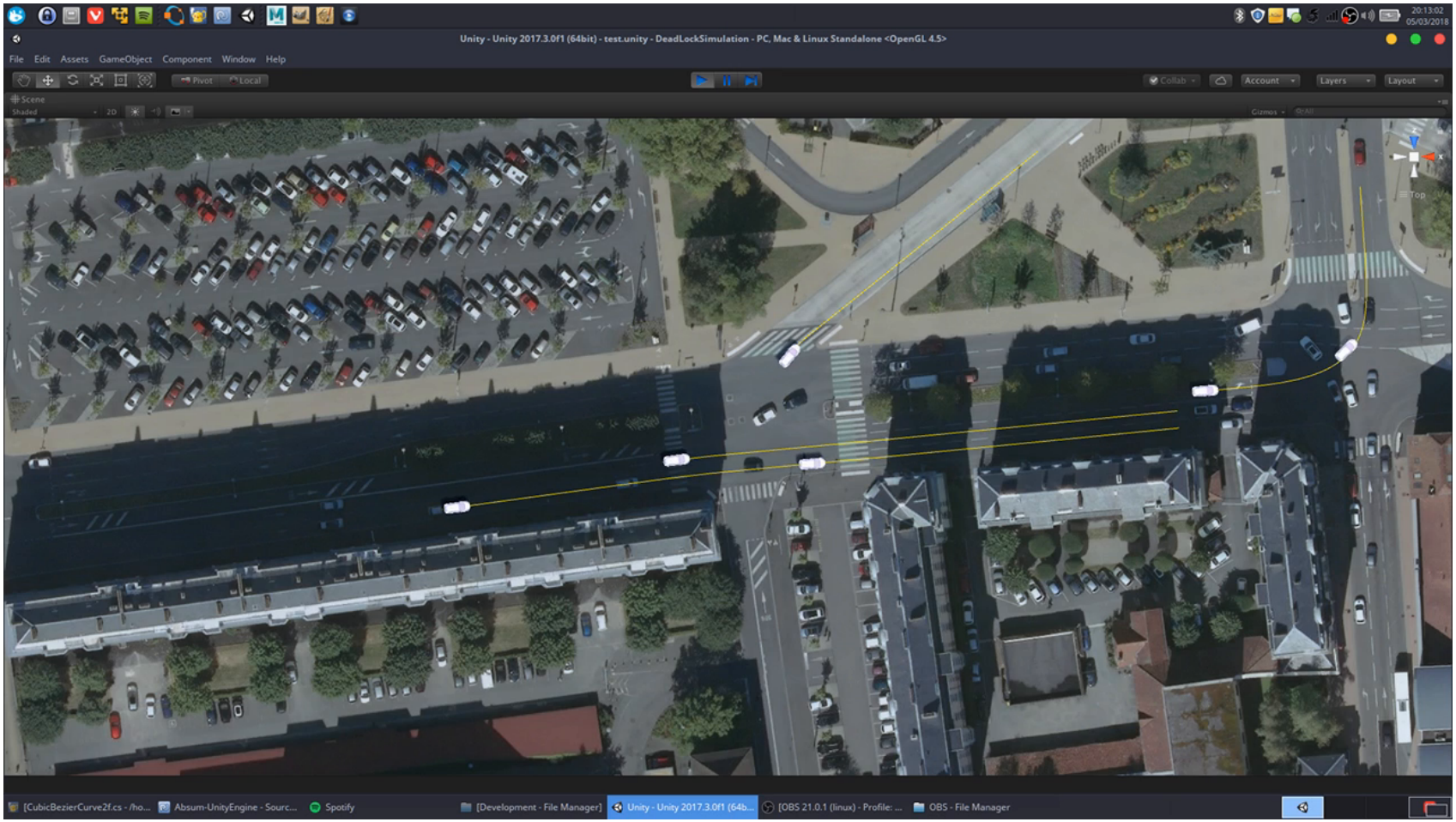
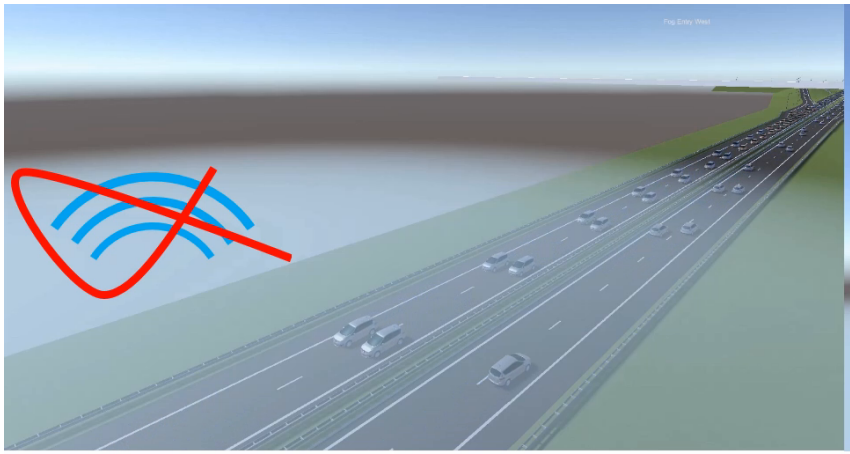
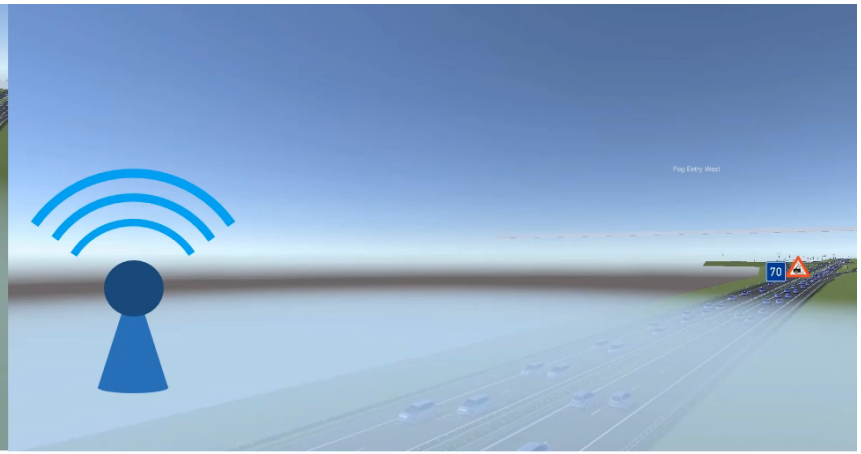
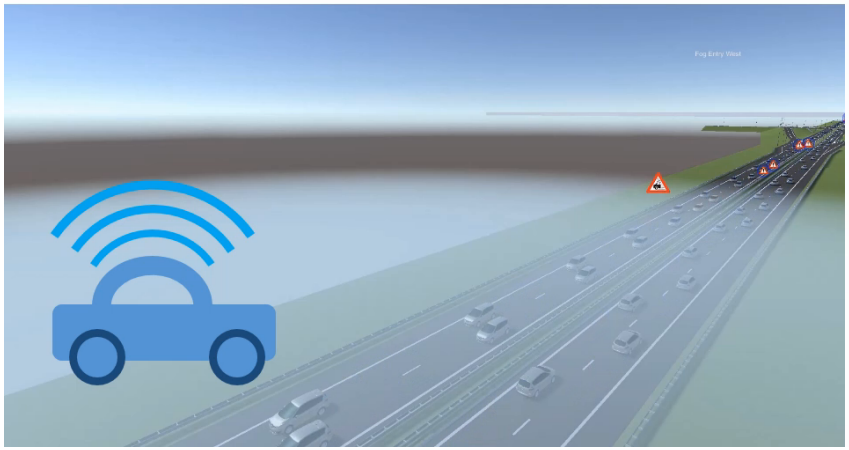


Simulation of Lane Changing Behavior (Lombard, 2017)

Simulation of emergency situation on a french highway (Buisson, 2014)







Traffic and V2X simulation

Comparison between scenarios in fog situation

Simulation of fog situation in Qatar (Abbas-Turki, 2017)

Thank you for your attention...

Appendix

OUTLINE

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