

Multiagent Simulation on StarBED

Deploying Agent-based Traffic Simulation on StarBED

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Summary

1. Motivations
2. Architecture
3. The “agent” paradigm
4. MAS on StarBED stack
5. Traffic simulation

Motivations

- Agent-based, Large-scale, Distributed Simulation of Complex Systems
- Case: traffic simulation
- Simulation of complex behaviors using an agent-based model. These behaviors include:
 - Mobility
 - Driving
 - Traffic synchronization
 - Sensor networks

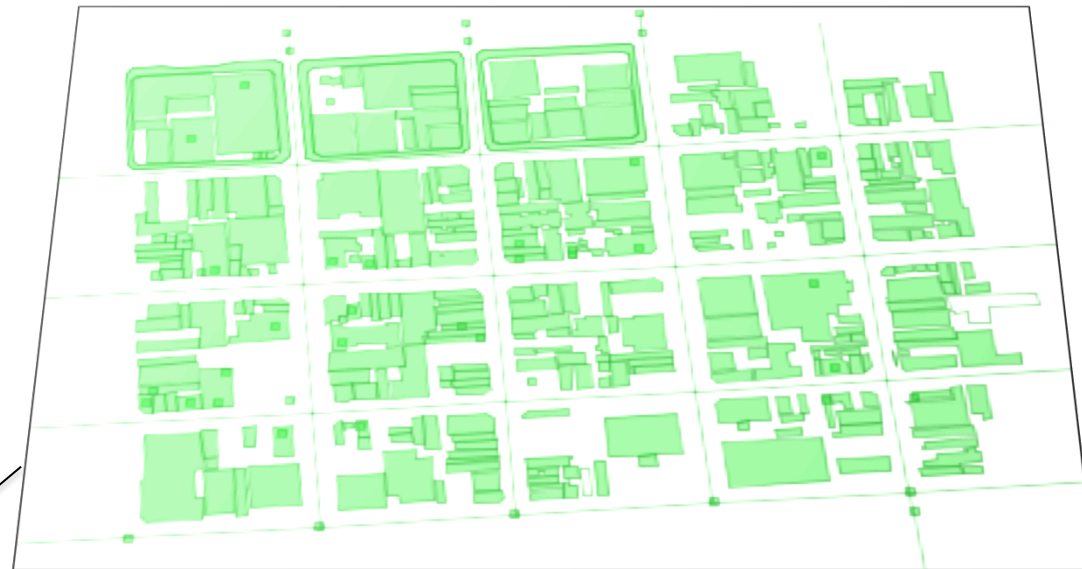
Motivations

- A **generic framework** for programmable agent-based components
 - Multilayered, with different levels of abstractions referring to different simulation layers
 - Reusable API for both distributed and non-distributed simulations
 - Generation of realistic simulation data
- A **testbed for general purpose Computational Intelligence**
 - coordination
 - collaboration
 - automated negotiation
 - etc.

Architecture

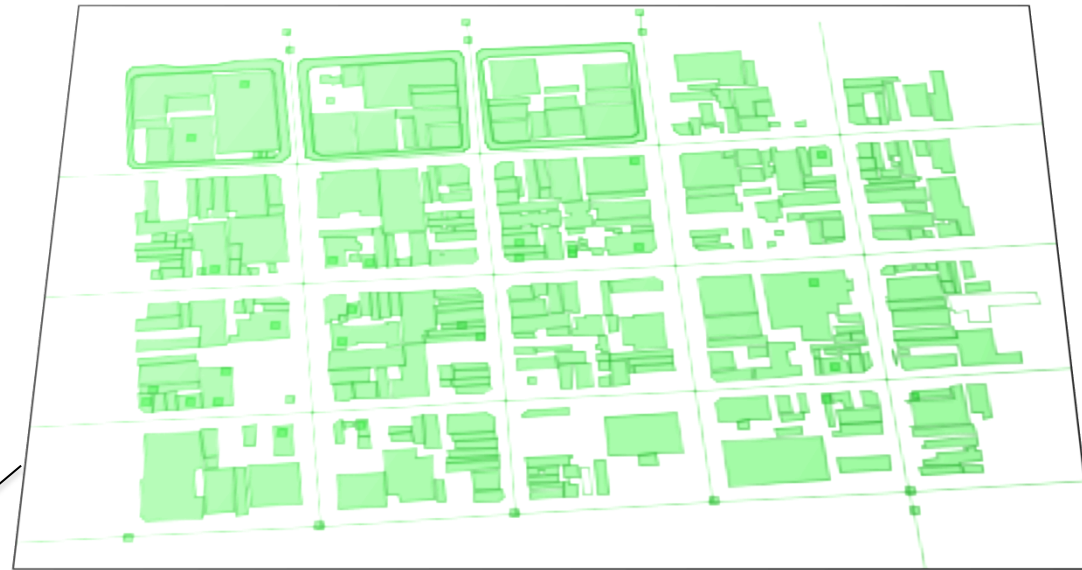
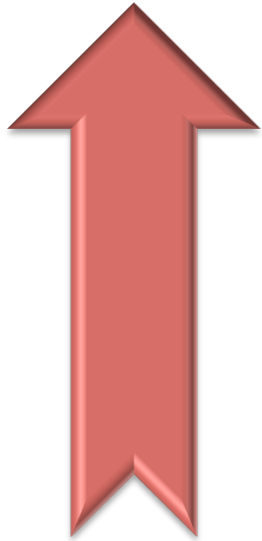
- Multilayered architecture built on a map

Architecture



Geographical Layer
OSM

Architecture

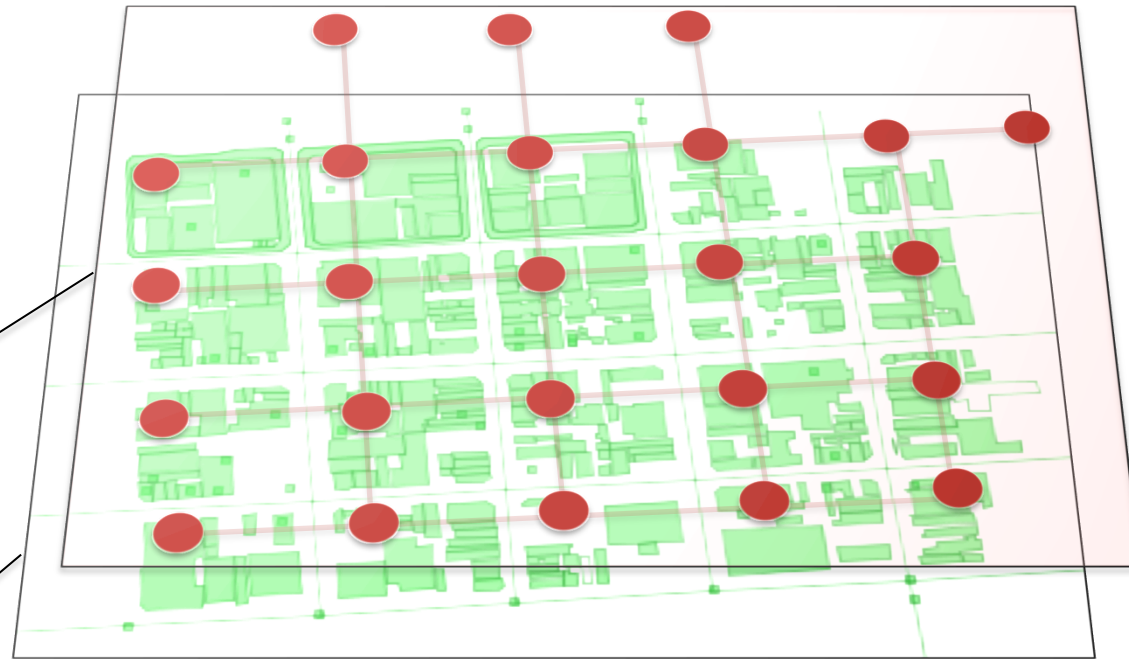


Geographical Layer
OSM

Architecture

Traffic Synch Layer
Traffic light

Geographical Layer
OSM

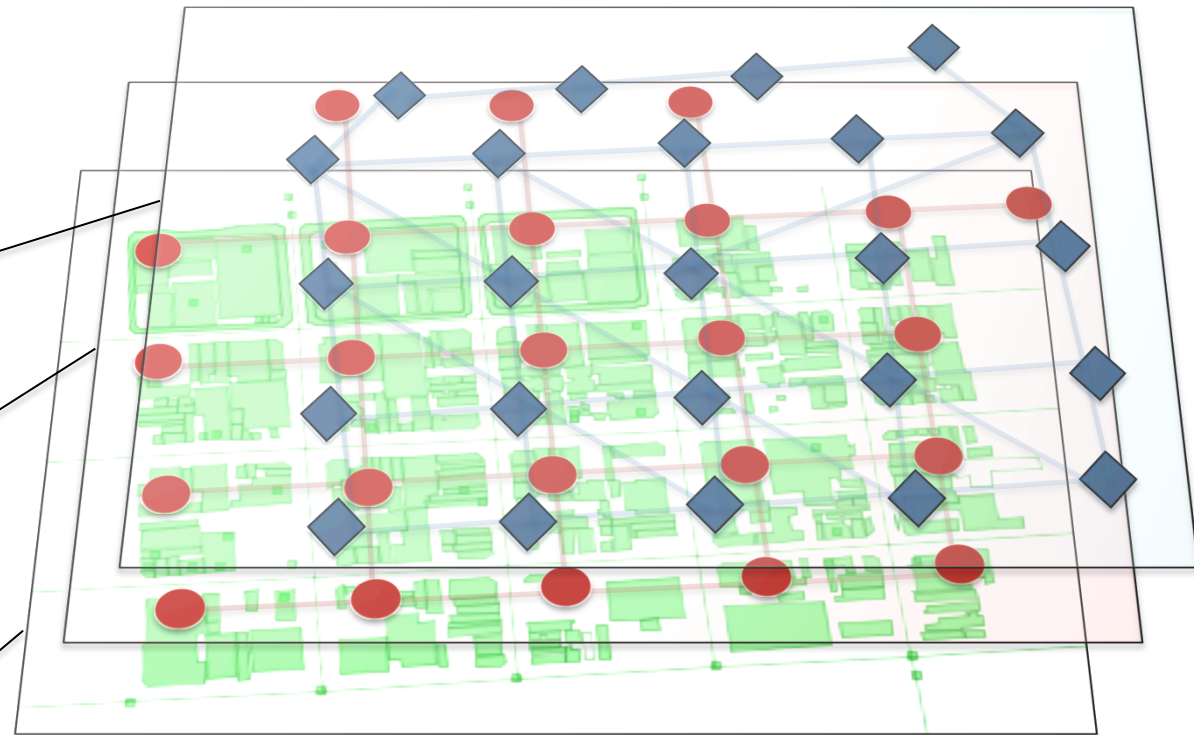


Architecture

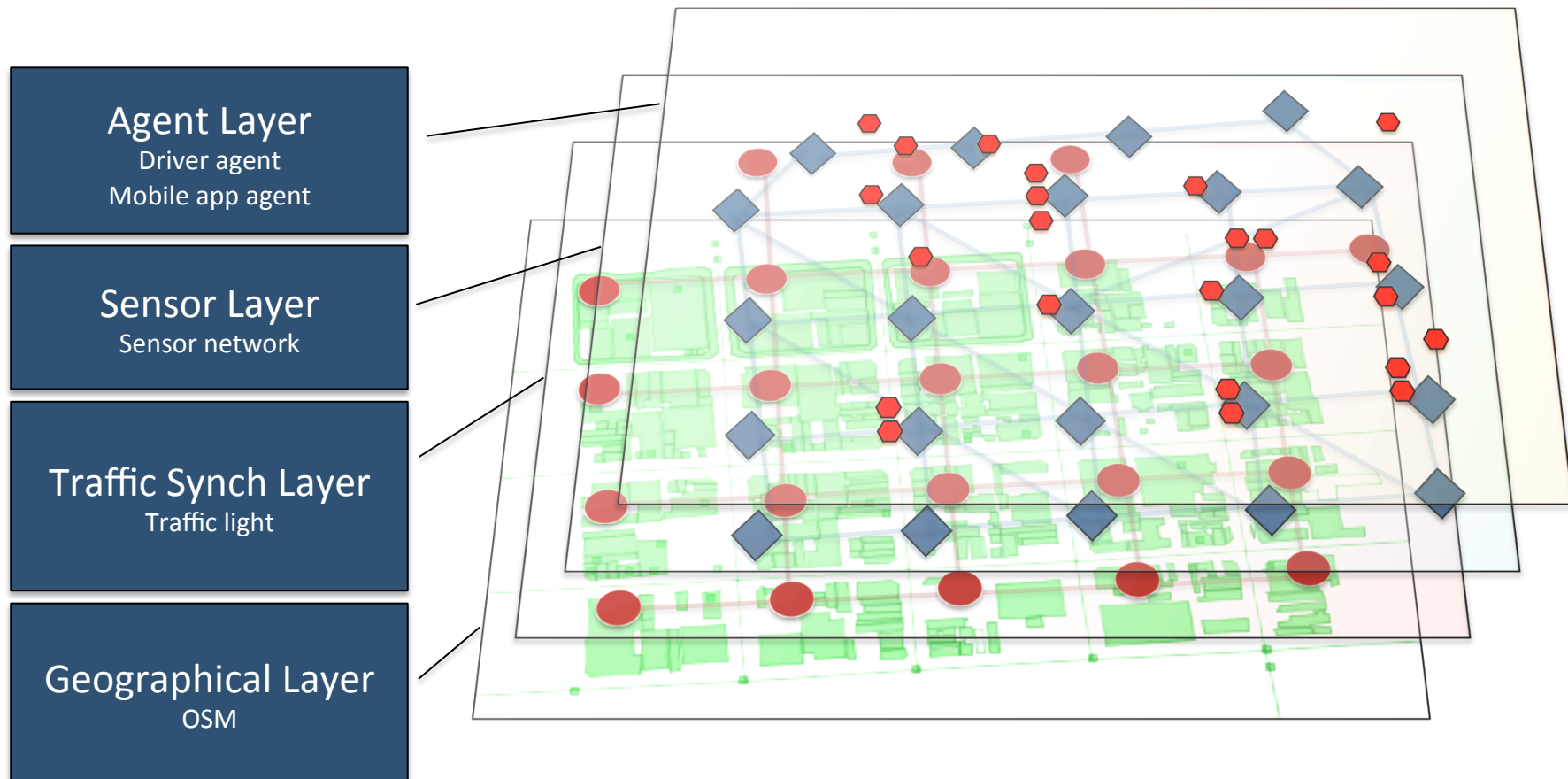
Sensor Layer
Sensor network

Traffic Synch Layer
Traffic light

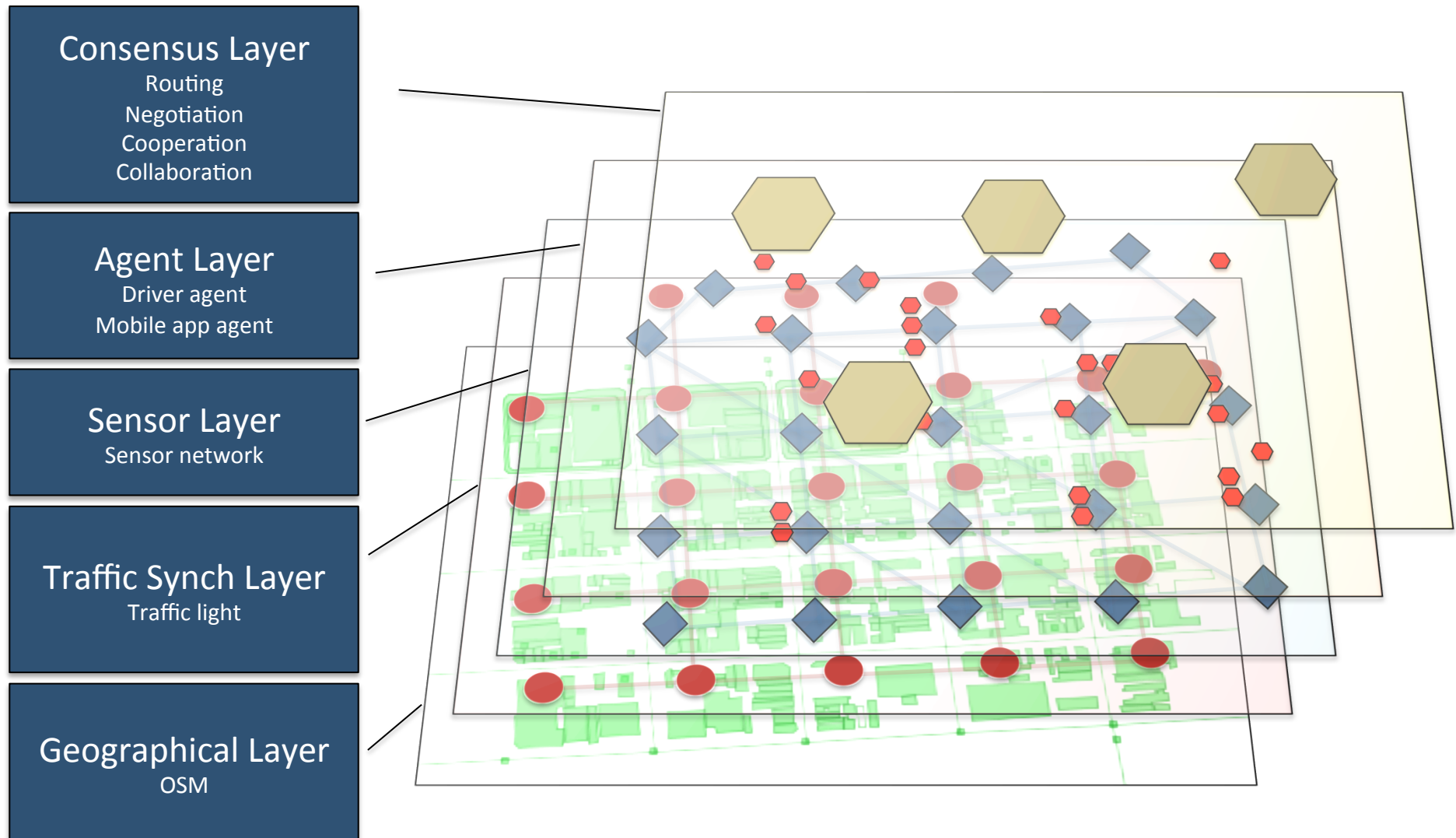
Geographical Layer
OSM



Architecture



Architecture

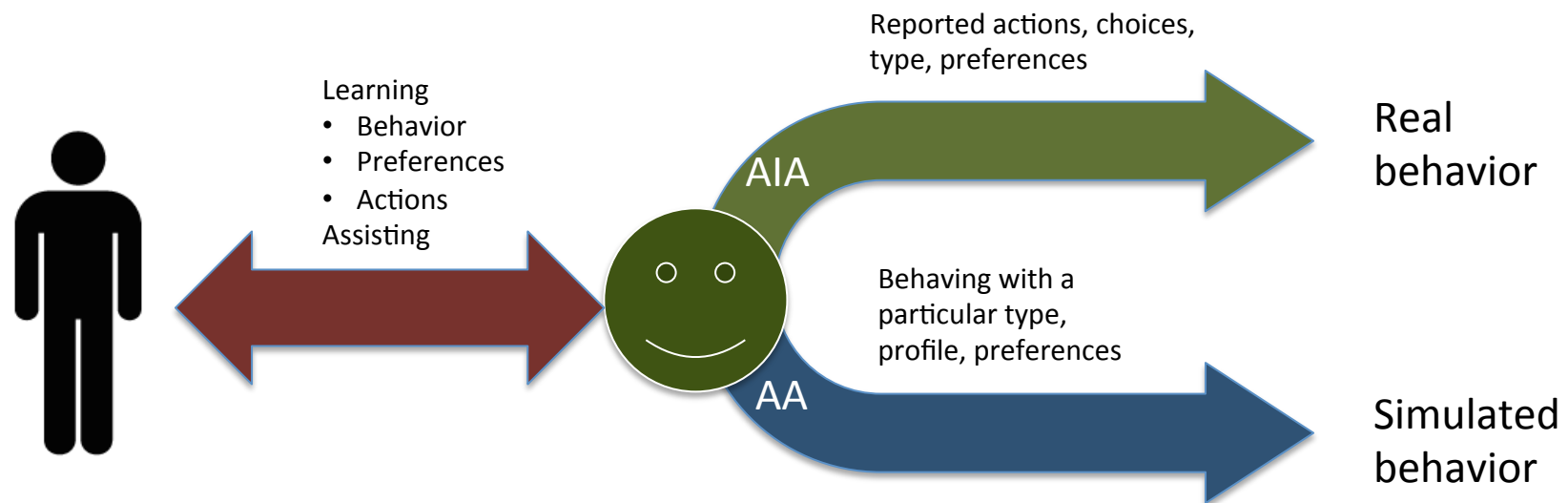


The “agent” paradigm

- Reactive, autonomous, collaborative, and goal-oriented agents
 - autonomous: parallel and distributed deployment (StarBED)
- **Microscopic** (autonomous) and **macroscopic** (collective) simulation
- An agent capable of
 - Reproducing realistic mobility
 - Learning of preferences, behaviors (peers modeling)
 - Elicitation
 - Optimization
 - etc.

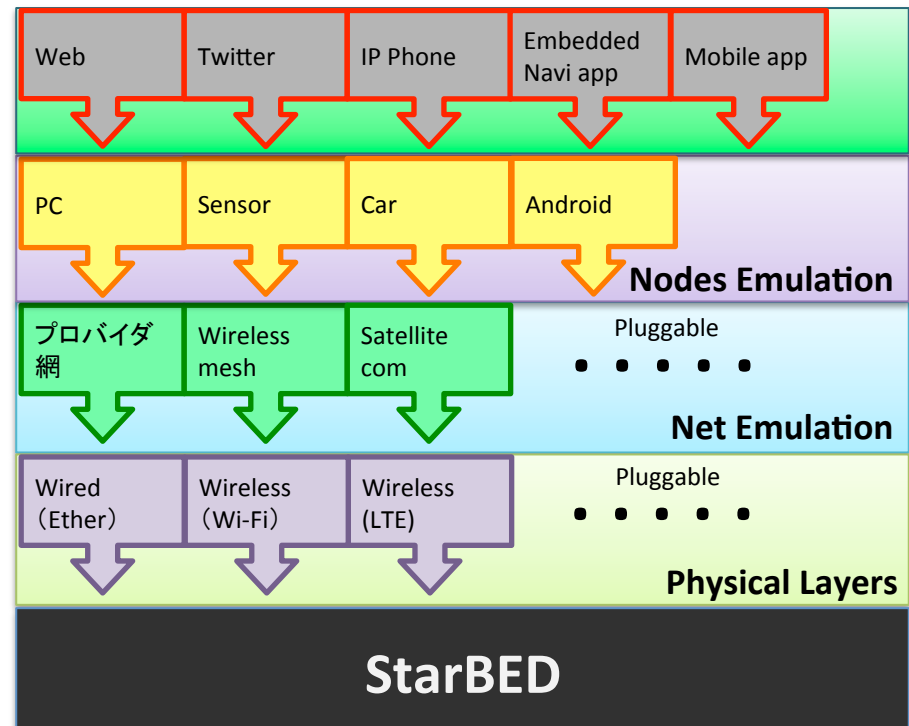
The “agent” paradigm

- An agent can operate in two different ways:
 - Autonomous Interface Agent (AIA) assisting & interacting with humans
 - Autonomous Agent (AA) to simulate the human

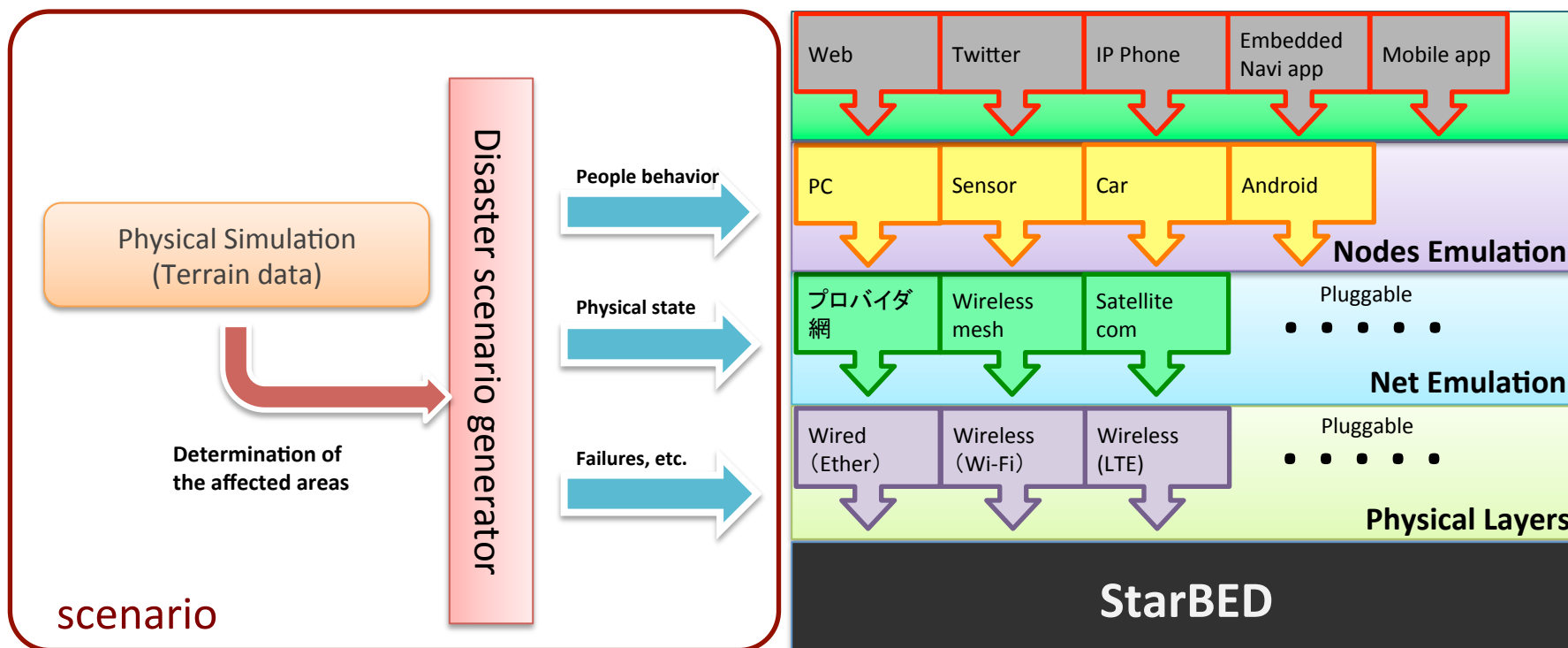


MAS on StarBED stack

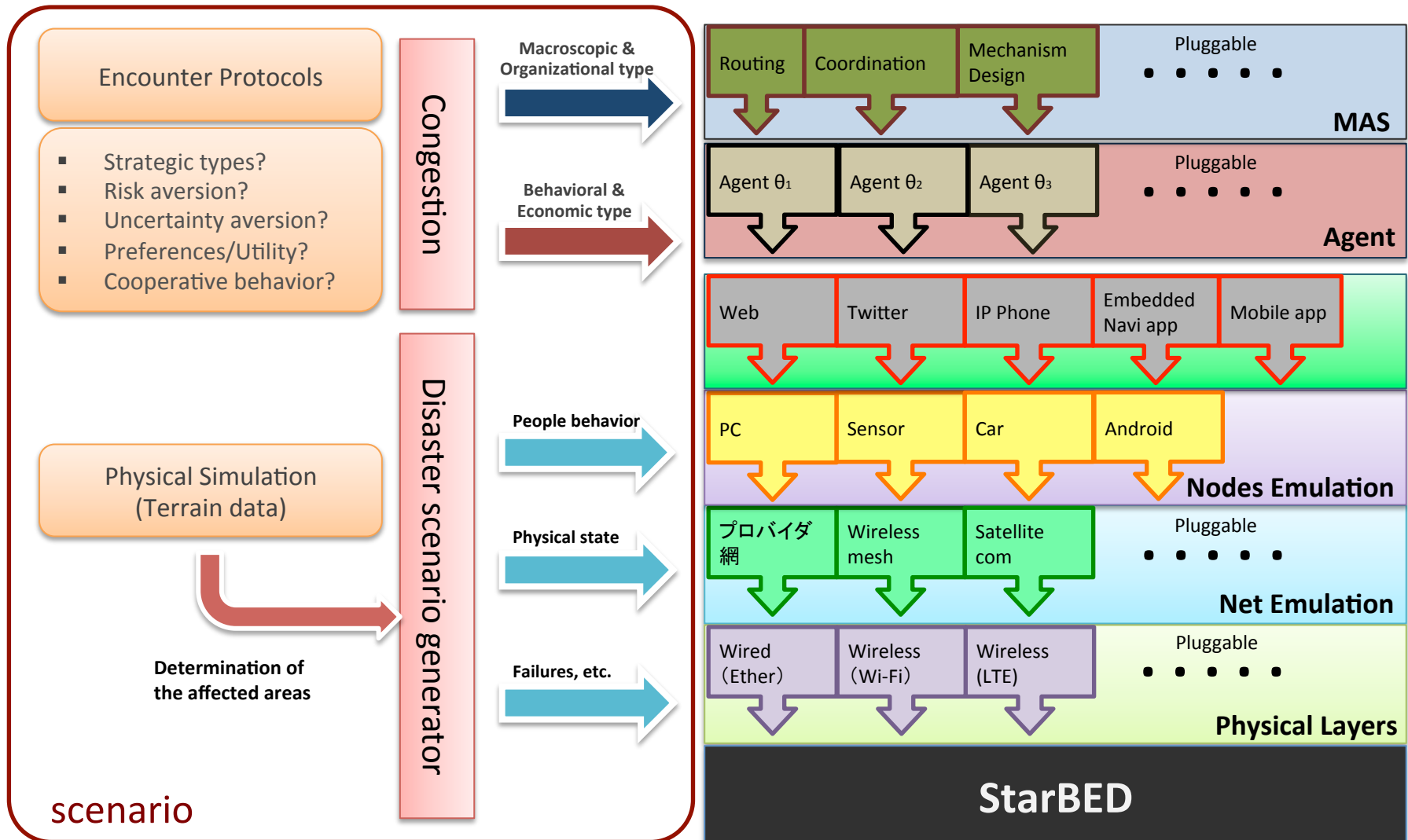
MAS on StarBED stack



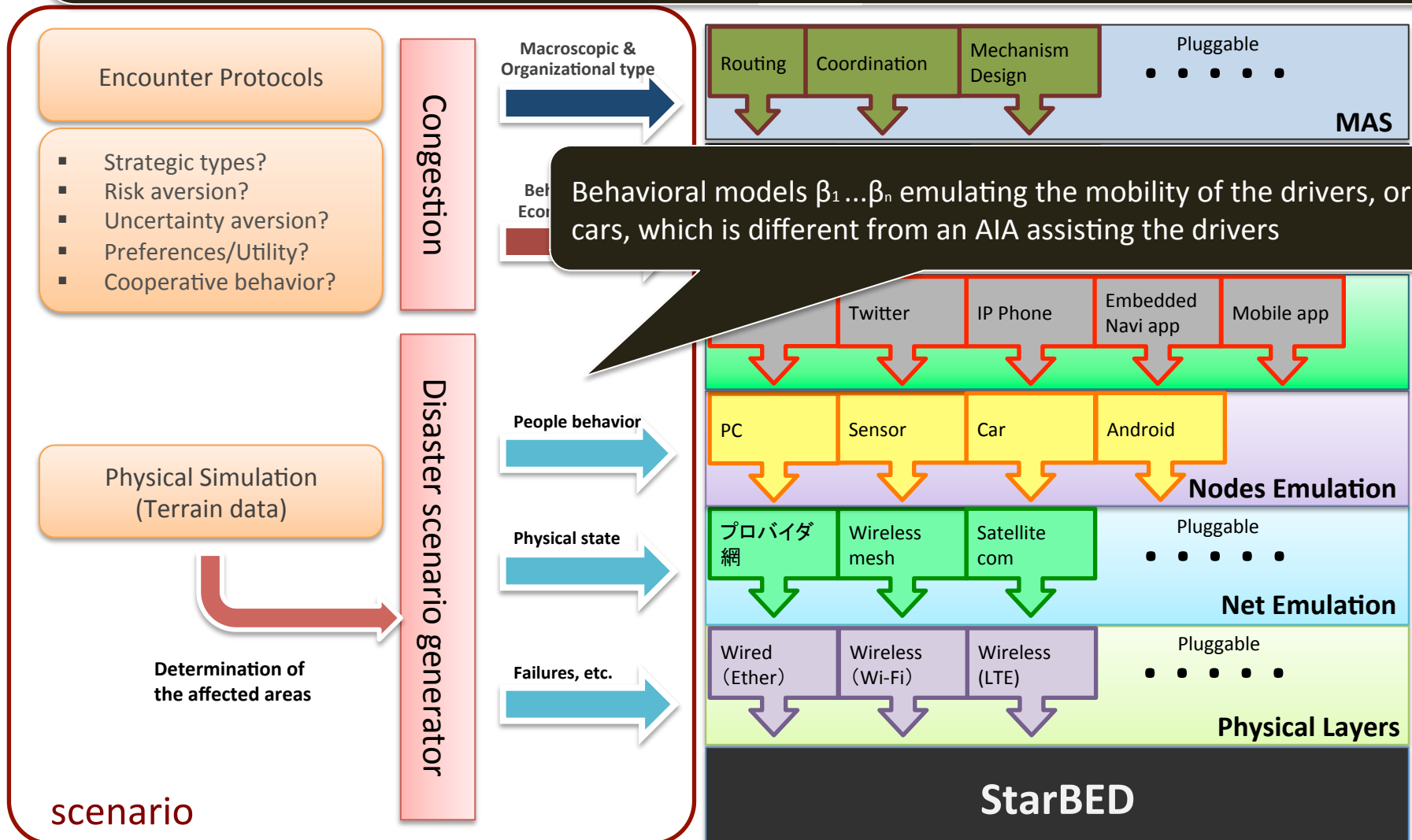
MAS on StarBED stack



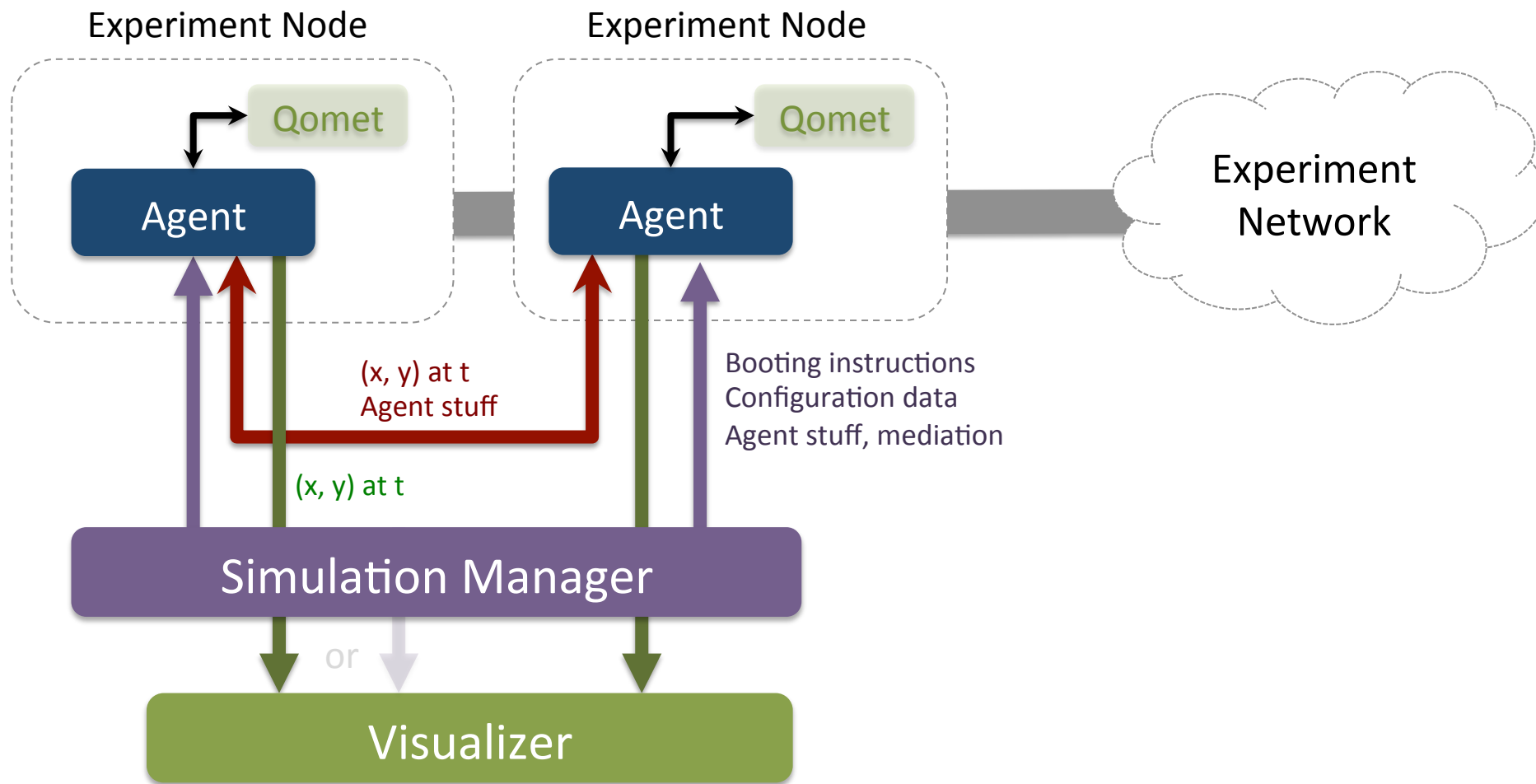
MAS on StarBED stack



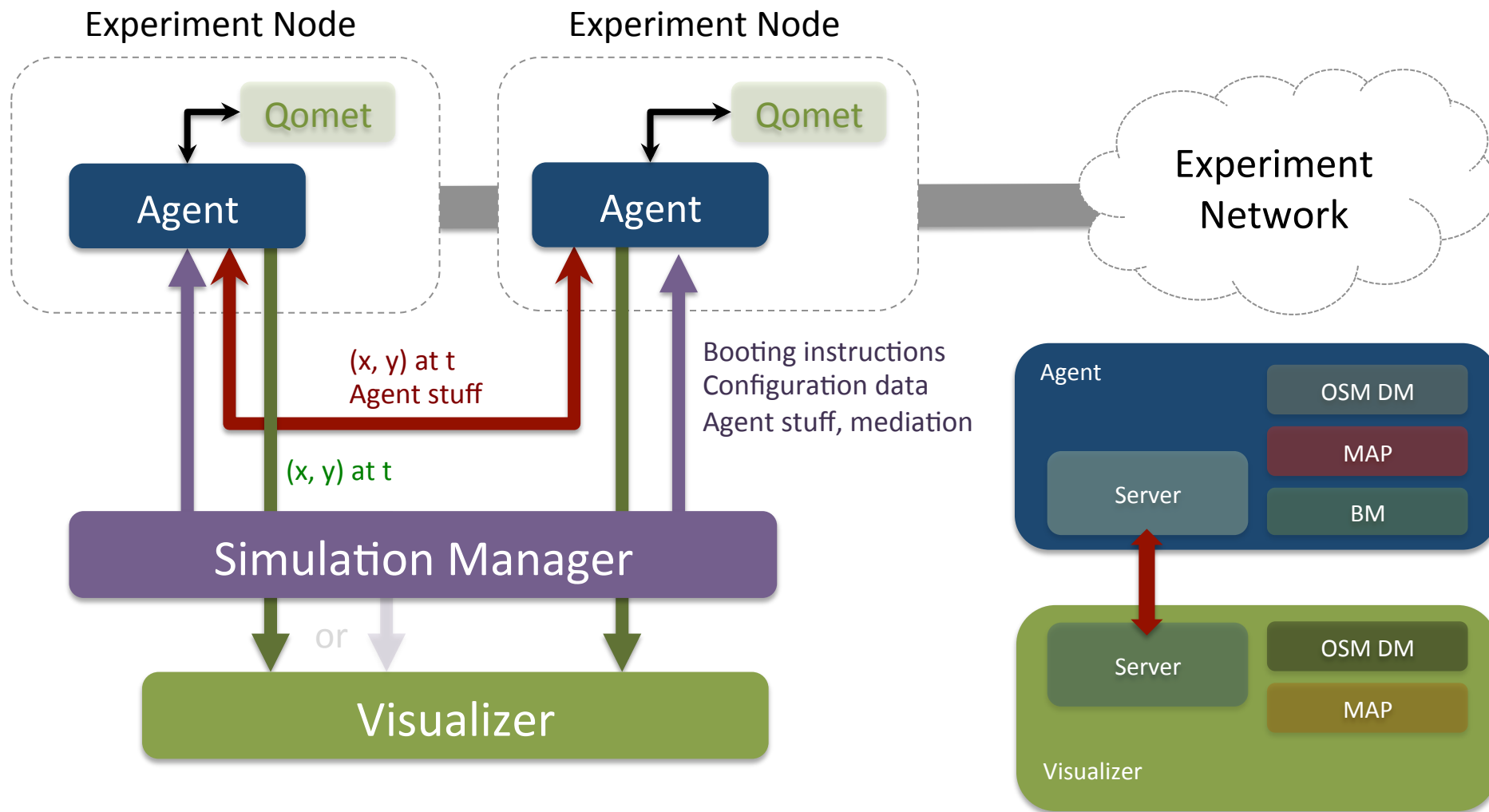
Example: Emulating a traffic **coordination** task in a **disaster** scenario (congested) involving **car-embedded** & **mobile app agents** representing **risk seeking, uncertainty averse** drivers (only $\alpha\%$ are **cooperative**). The coordination mechanism uses a sensor network



MAS on StarBED stack



MAS on StarBED stack



Traffic simulation

- Agents will have to emulate drivers behavioral models
- Dynamic and interactive mobility generation based on 3 forces
 - Speed v
 - Acceleration a
 - Breaking b
- Interaction with external forces
 - Driver actions, through the steering wheel
 - Environment: traffic lights, routes
 - Interaction with other vehicles

Default speed, or "desired" speed

Traffic simulation

Current speed, resulting from the interaction with the environment

Speed modulation

Speed difference: $\delta \vec{v} = obj\vec{v} - \vec{v}$

Example of rules:

$$\delta \vec{v} < -3$$

$$\vec{a} = 0$$

$$\vec{b} = \delta \vec{v} * urgency$$

$$\delta \vec{v} > 3$$

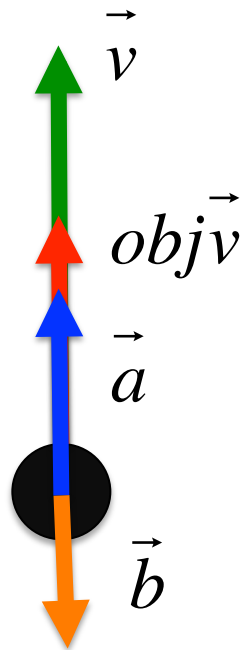
$$\vec{a} = \delta \vec{v} * urgency$$

$$\vec{b} = 0$$

$$obj\vec{v} = 0$$

$$\vec{a} = 0$$

$$\vec{b} = -\vec{v}$$



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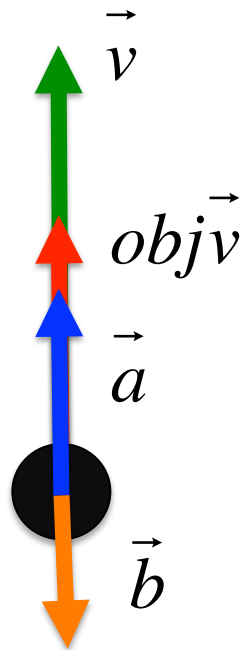
$$\vec{a} = \delta \vec{v} * urgency$$

$$\vec{b} = 0$$

$$obj\vec{v} = 0$$

$$\vec{a} = 0$$

$$\vec{b} = -\vec{v}$$



Angle modulation

is based on the steering wheel position and how it changes given any change in the overall direction of the vehicle and its velocity angle (θ)

Default direction

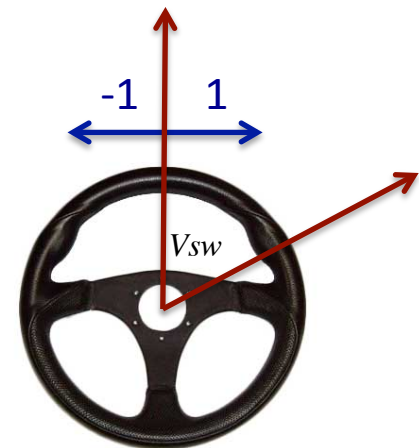
$$\delta \theta = obj\vec{d} - \theta$$

$$V_{sw} = V_{sw_t} - V_{sw_{t-1}}$$

Steering wheel value at t-1

Update rule

$$V_{sw} = V_{sw_{t-1}} + \delta \theta$$



Traffic simulation

- Rule-based directives or programmable goal-oriented agents

```
</Lane>
</Driver>
</Vehicle>
->
<Vehicle type="Ferrari">
  <Location>0 300</Location>
  <Direction>0</Direction>
  <Driver type="Normal">
    <Lane>
      <Intersections>G H I F N</Intersections>
    </Lane>
  </Driver>
</Vehicle>

<Vehicle type="Ferrari">
  <Location>0 200</Location>
  <Direction>0</Direction>
  <Driver type="Speedy">
    <Lane>
      <Intersections>D A B C F I H G S</Intersections>
    </Lane>
  </Driver>
</Vehicle>

<Vehicle type="Twingo">
  <Location>0 100</Location>
  <Direction>0</Direction>
  <Driver type="Normal">
    <Lane>
      <Intersections>A B C F I 0</Intersections>
    </Lane>
  </Driver>
</Vehicle>

<Vehicle type="Ferrari">
```

```
driver.cpp  Driver::drive(bool): void

void Driver::drive(bool urgent)
{
  if (m_Vehicle)
  {
    float speed = m_Vehicle->speed(true),
      AccelerationValue = 0.0,
      BreakingValue = 0.0,
      diffSpeed = 0.0f;
    diffSpeed = m_ObjSpeed - speed;

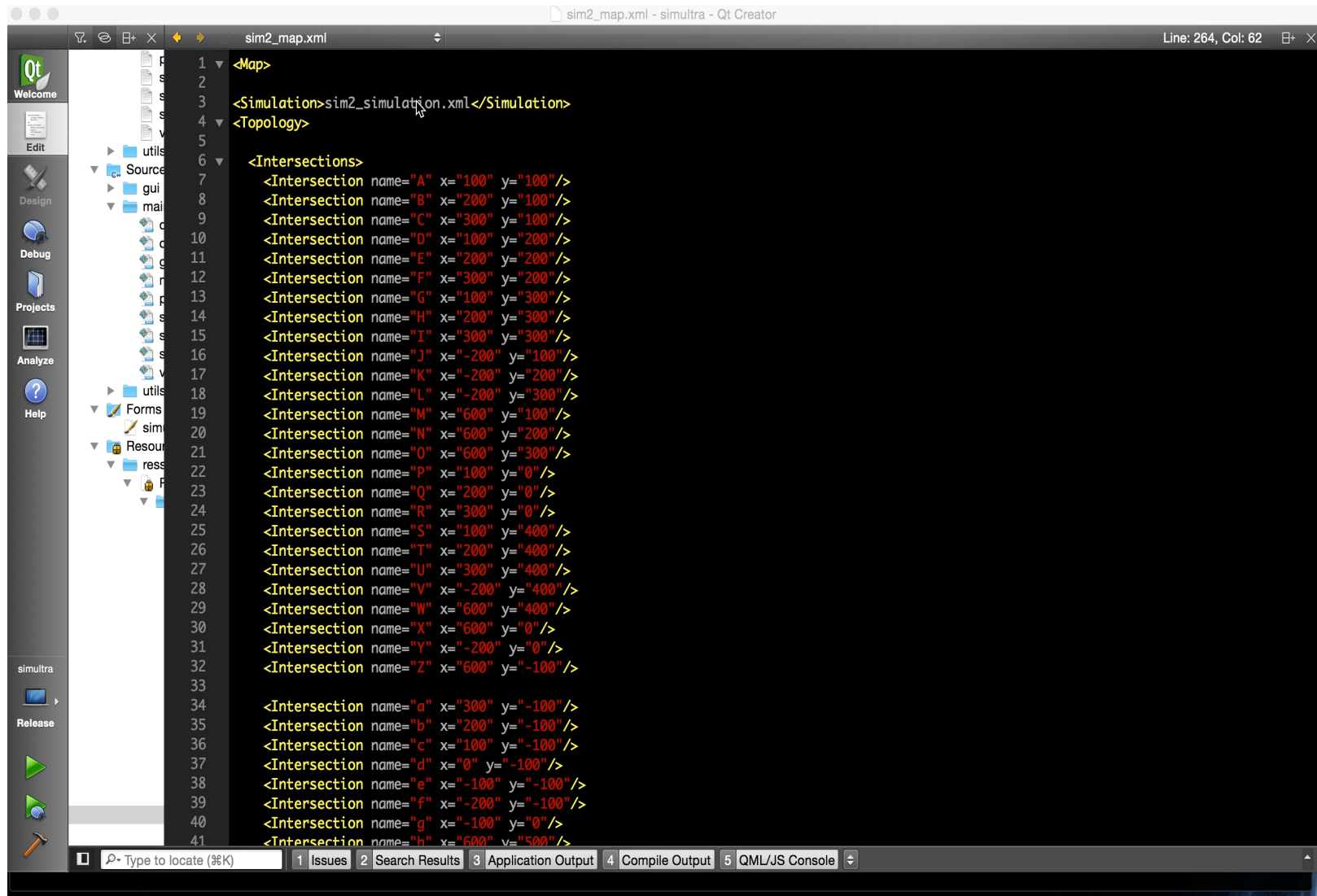
    if (diffSpeed < -3.0f) {
      AccelerationValue = 0.0;
      BreakingValue = qAbs(diffSpeed * (urgent ? 100 : 3) / 100.0f);
    }
    else if (diffSpeed > 3.0f) {
      AccelerationValue = qAbs(diffSpeed * (urgent ? 100 : 3) / 100.0f);
      BreakingValue = 0.0;
    }
    else if (m_ObjSpeed==0.0) {
      AccelerationValue = 0.0;
      BreakingValue = 1.0;
    }

    float diffAngle = m_ObjectifDirection - m_Vehicle->direction().angle;
    float valSteeringWheel = 0.0f;

    diffAngle = Point::reinit0and180(diffAngle);
    valSteeringWheel = 2 * (diffAngle) / 180.0;
    qreal diffSTRW=0;
```


Traffic simulation

Agent-based, microscopic prototype (before distribution)



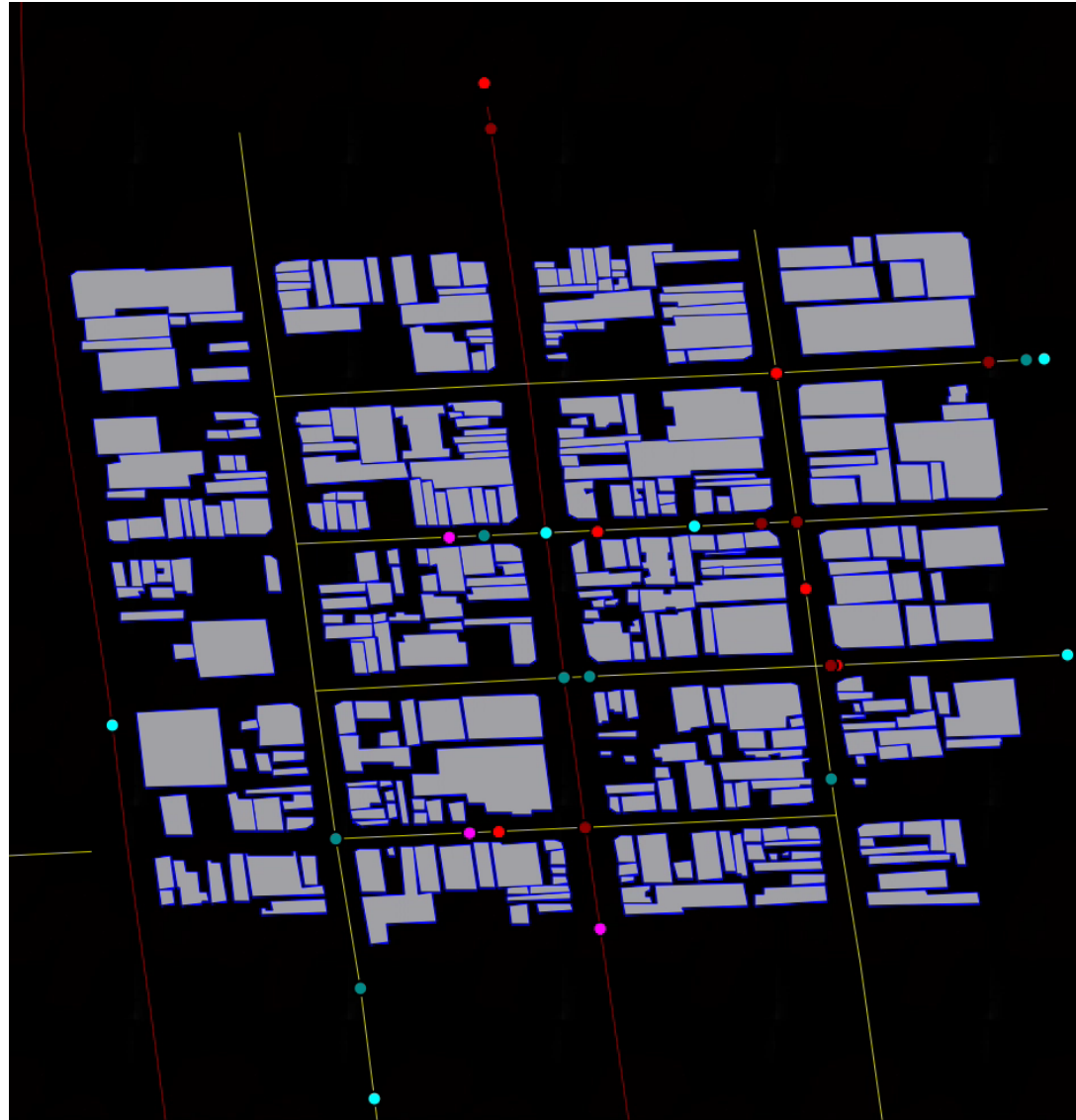
The image shows a screenshot of the Qt Creator IDE with the file `sim2_map.xml` open. The code defines a simulation map with various intersections. The XML structure is as follows:

```
<Map>
  <Simulation>sim2_simulation.xml</Simulation>
  <Topology>
    <Intersections>
      <Intersection name="A" x="100" y="100"/>
      <Intersection name="B" x="200" y="100"/>
      <Intersection name="C" x="300" y="100"/>
      <Intersection name="D" x="100" y="200"/>
      <Intersection name="E" x="200" y="200"/>
      <Intersection name="F" x="300" y="200"/>
      <Intersection name="G" x="100" y="300"/>
      <Intersection name="H" x="200" y="300"/>
      <Intersection name="I" x="300" y="300"/>
      <Intersection name="J" x="-200" y="100"/>
      <Intersection name="K" x="-200" y="200"/>
      <Intersection name="L" x="-200" y="300"/>
      <Intersection name="M" x="600" y="100"/>
      <Intersection name="N" x="600" y="200"/>
      <Intersection name="O" x="600" y="300"/>
      <Intersection name="P" x="100" y="0"/>
      <Intersection name="Q" x="200" y="0"/>
      <Intersection name="R" x="300" y="0"/>
      <Intersection name="S" x="100" y="400"/>
      <Intersection name="T" x="200" y="400"/>
      <Intersection name="U" x="300" y="400"/>
      <Intersection name="V" x="-200" y="400"/>
      <Intersection name="W" x="600" y="400"/>
      <Intersection name="X" x="600" y="0"/>
      <Intersection name="Y" x="-200" y="0"/>
      <Intersection name="Z" x="600" y="-100"/>
      <Intersection name="a" x="300" y="-100"/>
      <Intersection name="b" x="200" y="-100"/>
      <Intersection name="c" x="100" y="-100"/>
      <Intersection name="d" x="0" y="-100"/>
      <Intersection name="e" x="-100" y="-100"/>
      <Intersection name="f" x="-200" y="-100"/>
      <Intersection name="g" x="-100" y="0"/>
      <Intersection name="h" x="600" y="500"/>
    </Intersections>
  </Topology>
</Map>
```

The IDE interface includes a sidebar with toolbars for Welcome, Edit, Design, Debug, Projects, Analyze, Help, and Release. The status bar at the bottom shows the current line and column (Line: 264, Col: 62) and a search bar with the text "Type to locate (%K)".

Traffic simulation

Agent-based, distributed, macroscopic prototype



Thank you

