Applications of Multi-Agent Systems

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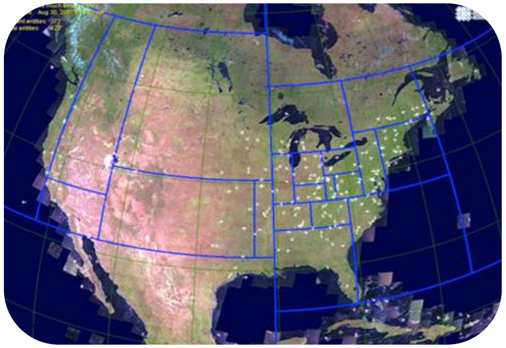
OTEVŘENÁ
INFORMATIKA

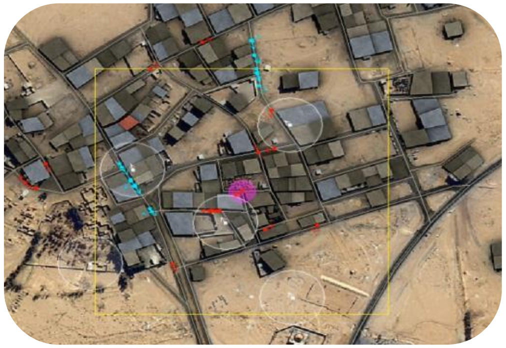
Application Areas

- **manufacturing and logistics** – production planning, inventory management, supply chain/network management
- **markets** – automated trading/auctioning, auction mechanism analysis and design, strategy modeling, market modeling,
- **internet and networks** -- advertisment markets, search optimisation, intrusion detection, bandwith management
- **utility networks** – smart grid management, virtual powerplants, smart appliances, consumption modeling
- **transport** – demand responsive transport, autonomous vehicles, cooperative driving, real-time ridesharing, dynamic pricing, demand modelling
- **security and defense** – mission planning and execution, optimum patrolling and surveillance, opponent modeling, vulnerability assessment
- **computer games and computer animation** - game AI, behavioral animation, NPC implementation

Application Areas (at ATG)



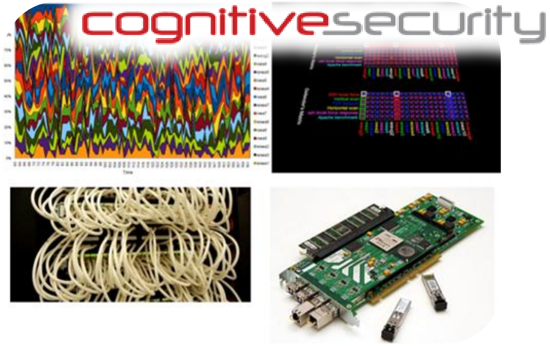
Air Traffic Management



Tactical Operations

Autonomous Aerial Vehicles

Physical/ Critical Infrastructure Security



Cybersecurity and Steganography

Intelligent Transport Systems

Invited Presentations

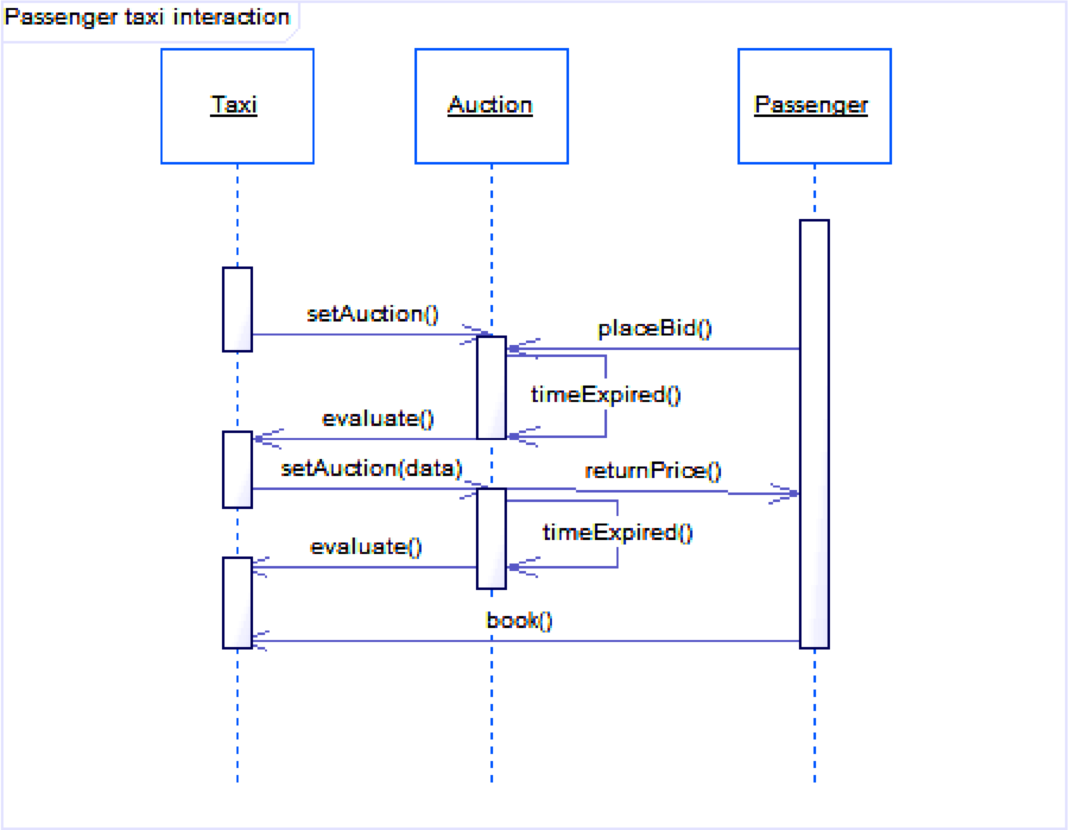
- Game-theoretic approach to network intrusion detection (Viliam Lisy)
- Cooperative Path Finding (Michal Cap)
- *(see standalone slide sets)*

Auction-based Taxi Booking

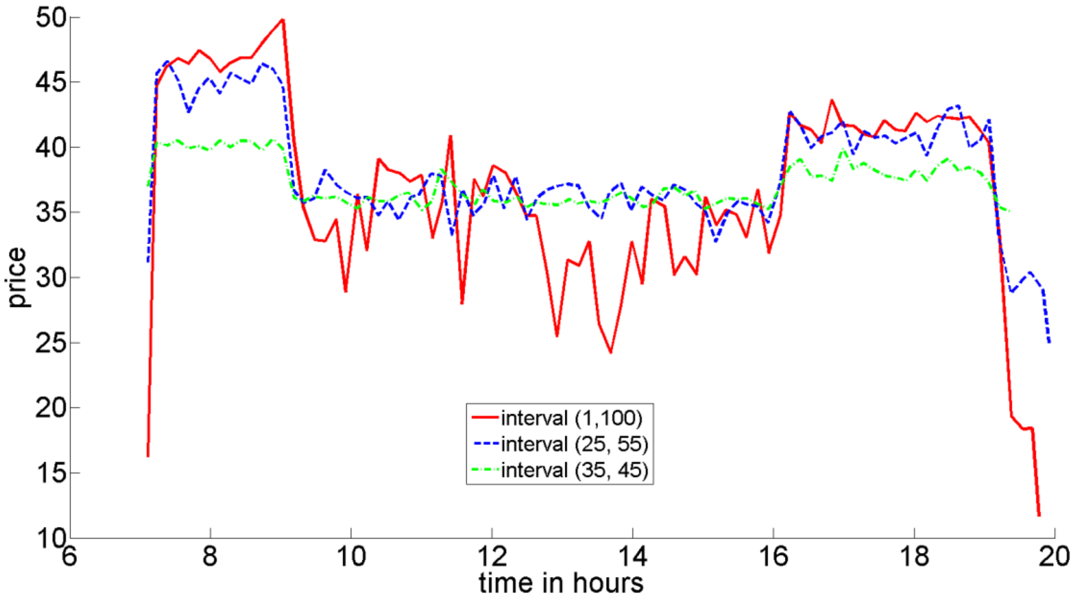
- Goal: Allocate a limited number taxi vehicles to passengers
  - allow trading trip cost for waiting time
  - maximize taxi drivers income
- Passenger requests
  - origin – destination
  - max unit price
  - urgency
- Taxi drivers
  - current location
  - minimum unit price
  - (maximum unit price)
- (Based on bachelor thesis of Jan Zikes)

Solution

- One second-prize Vickerey auction between passengers and each taxi vehicle



Results



urgency	(1-100) t_w	(25-55) t_w	(35-45) t_w
1	26.14	20.58	8.6
2	9.87	9.46	5.85
3	5.99	5.22	5.4

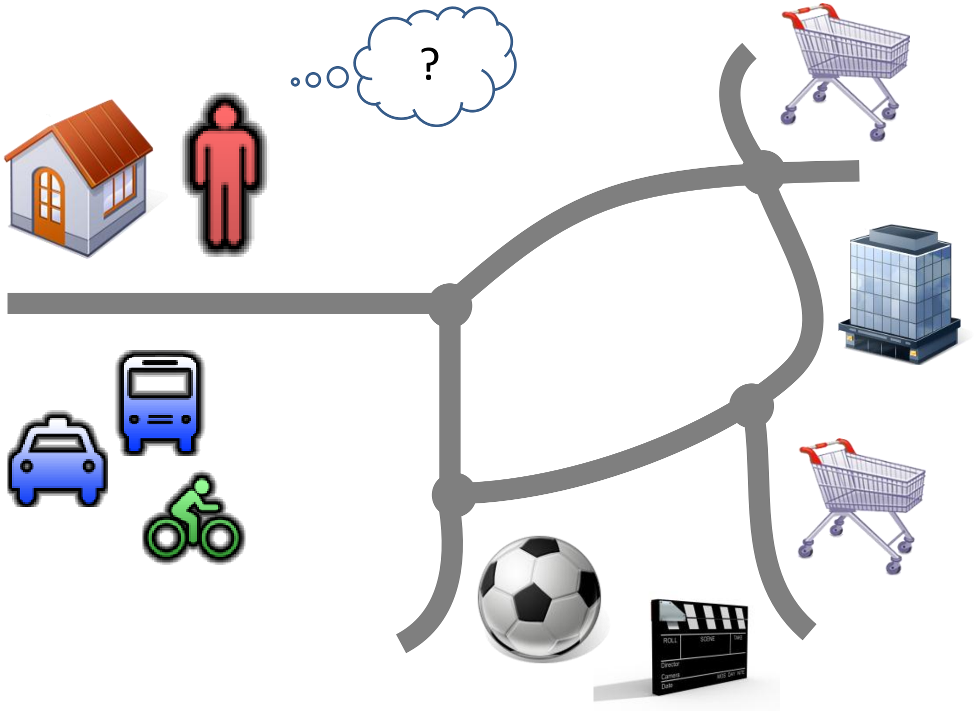
Table 6.3: Average waiting time for the given urgency

Mobility Modelling

- Transport system is a massive, highly dynamic, spatially distributed multi-agent system
- Understand how people will travel under different circumstances
- Input to policymaking and urban planning

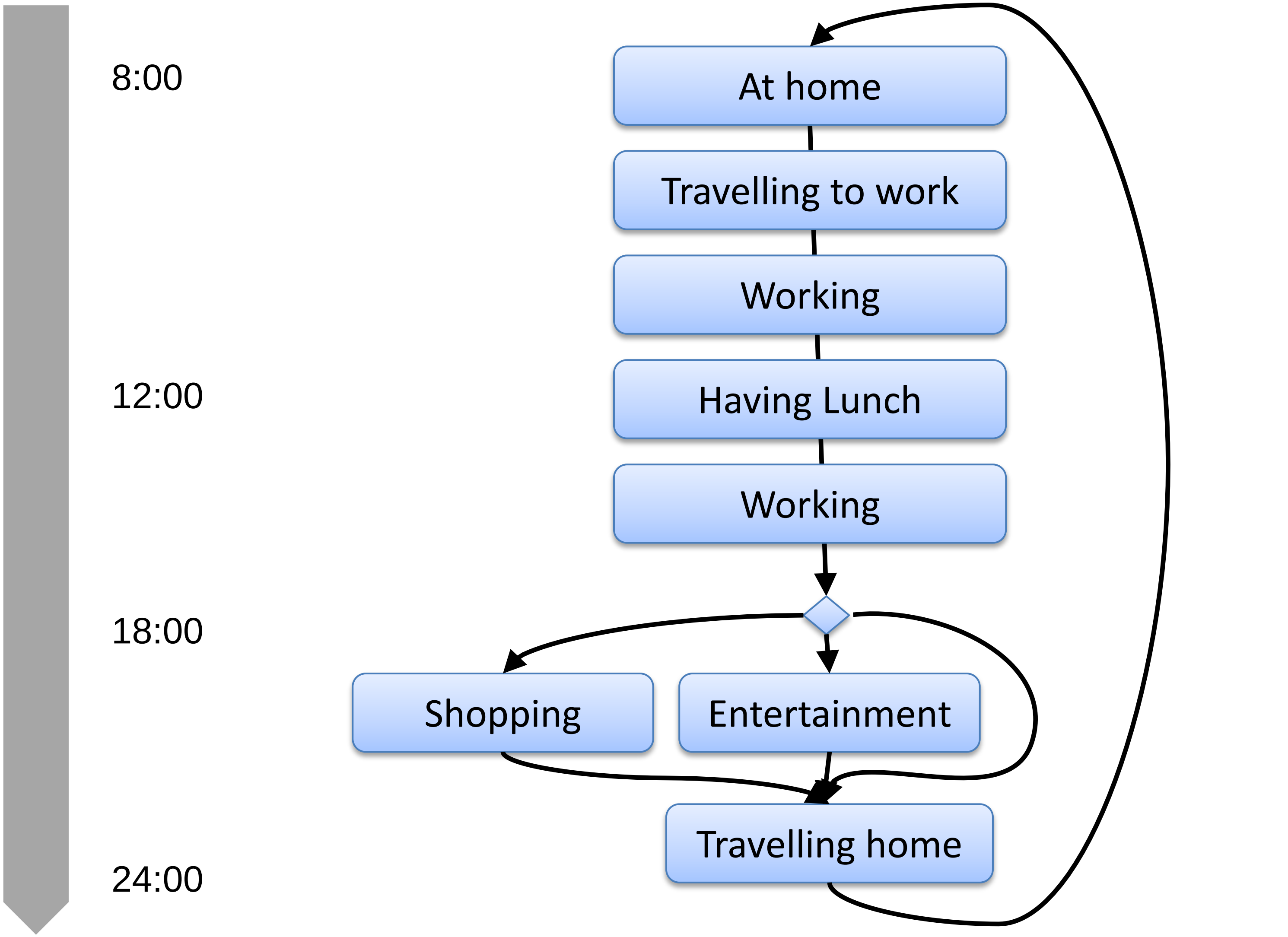
Agent-based Activity-based Approach

Travel is a **derived demand**

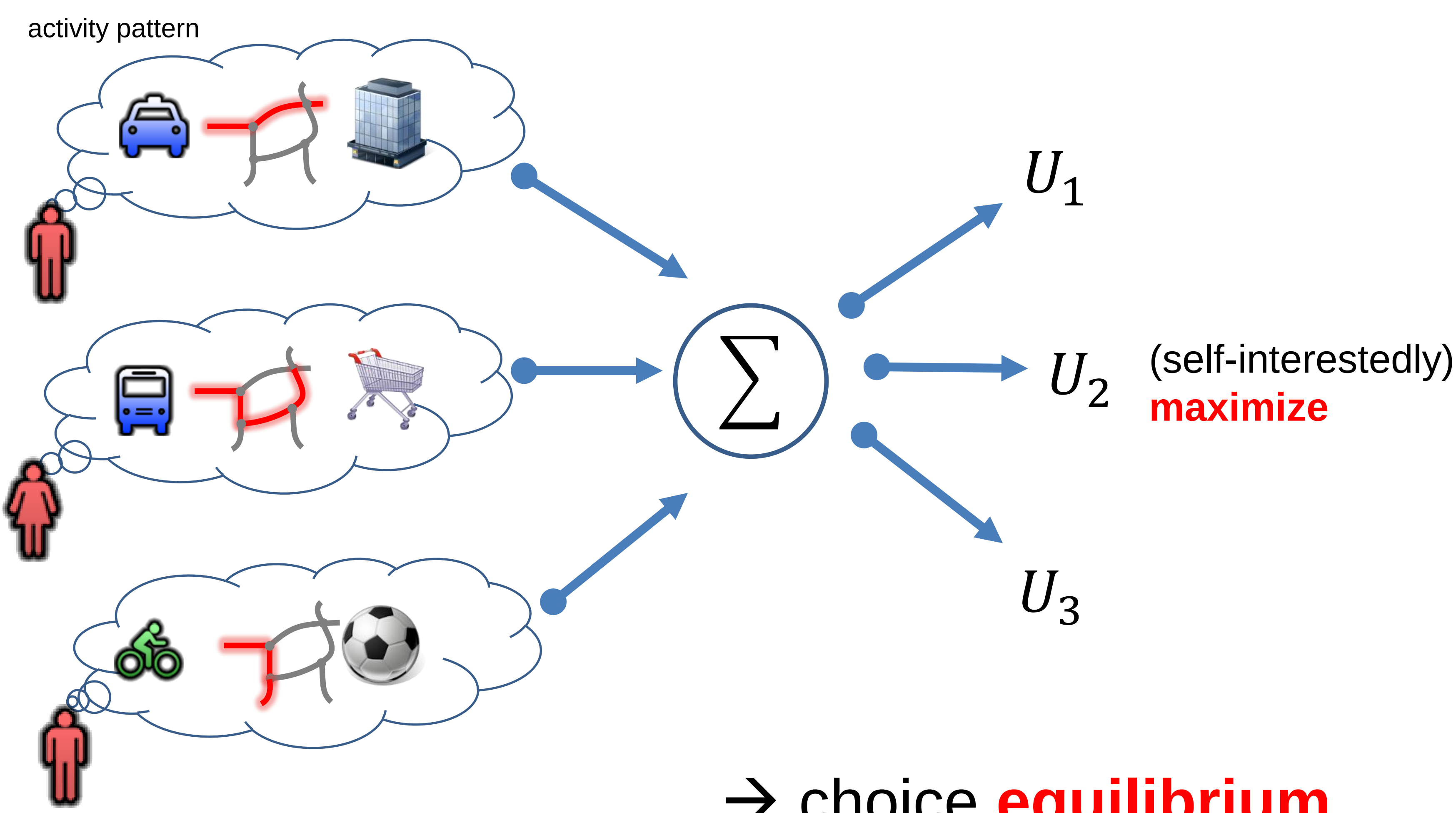


➔ Only travel if it’s **worth it**!

Individual-Centric Mobility Modelling

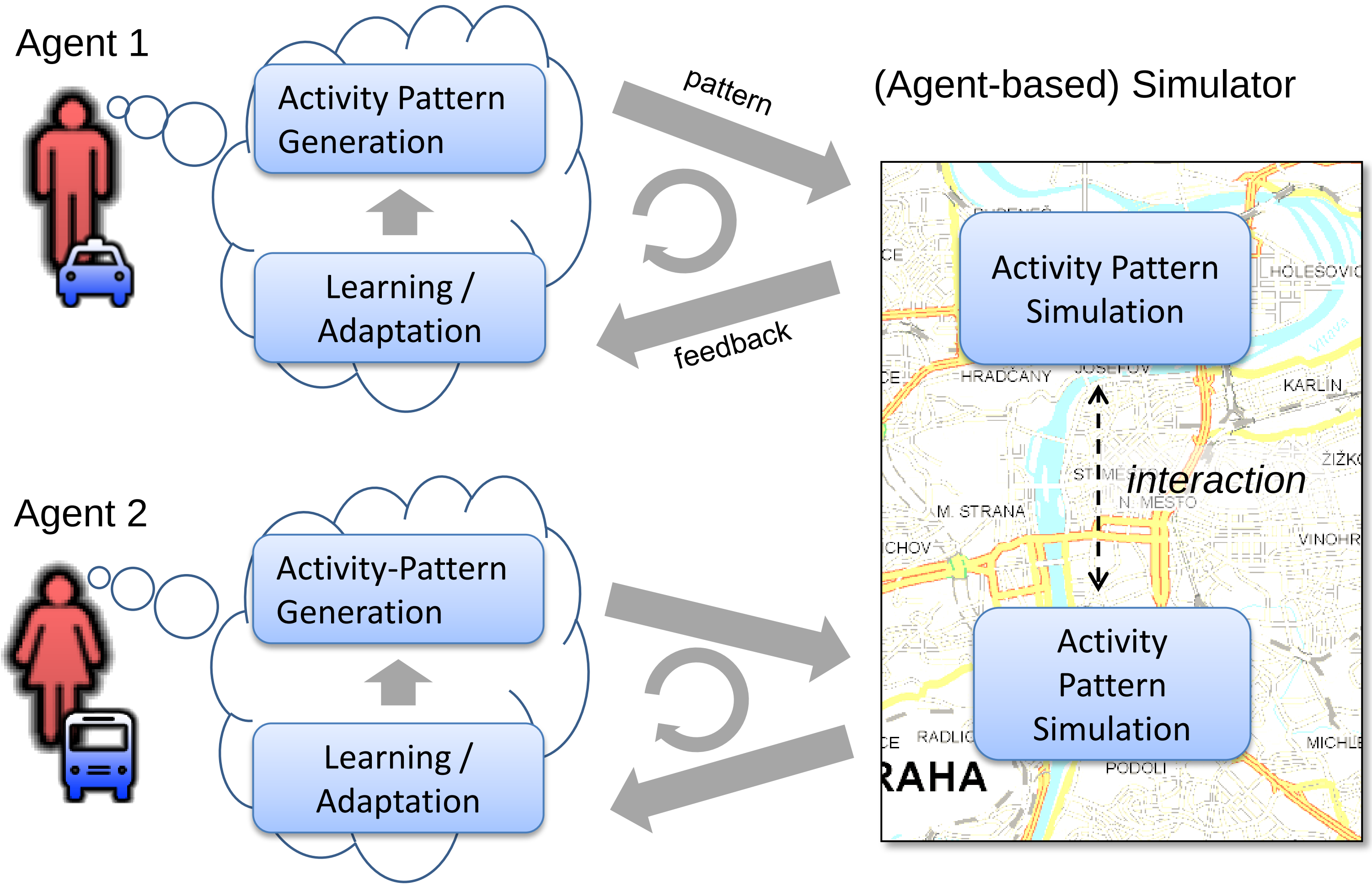


Activity-based Travel: **Equilibrium**



→ choice **equilibrium**

Activity-based Model: **Bottom-up** Solution



Agent 1

Activity Pattern Generation

Learning / Adaptation

pattern

feedback

(Agent-based) Simulator

Activity Pattern Simulation

interaction

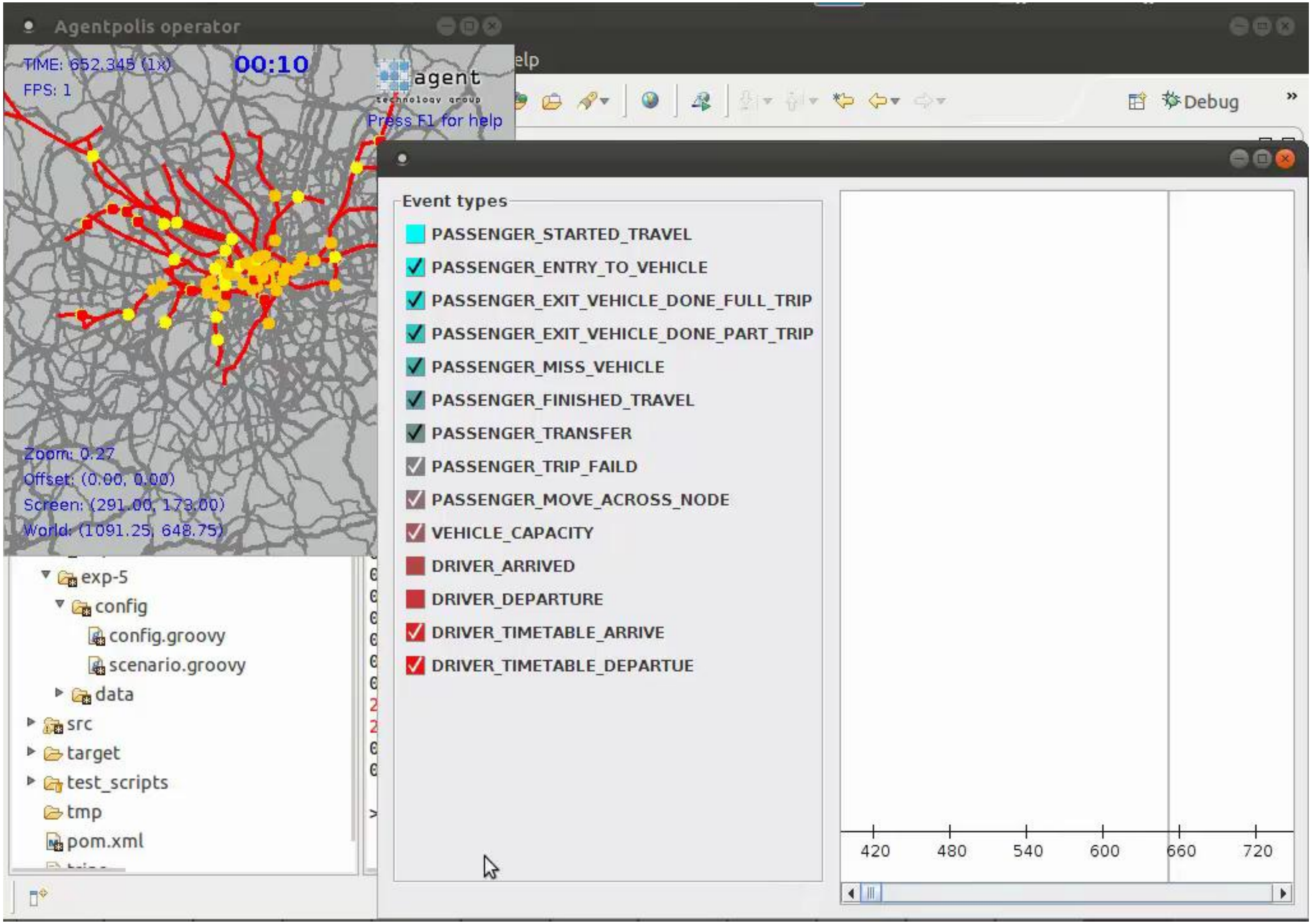
Activity Pattern Simulation

Agent 2

Activity-Pattern Generation

Learning / Adaptation

AgentPolis Framework - Demo



Agentpolis operator

```
TIME: 652.345 (1x)    00:10
FPS: 1

Zoom: 0.27
Offset: (0.00, 0.00)
Screen: (291.00, 173.00)
World: (1091.25, 648.75)
```

Event types

- ■ PASSENGER_STARTED_TRAVEL
- ☑ PASSENGER_ENTRY_TO_VEHICLE
- ☑ PASSENGER_EXIT_VEHICLE_DONE_FULL_TRIP
- ☑ PASSENGER_EXIT_VEHICLE_DONE_PART_TRIP
- ☑ PASSENGER_MISS_VEHICLE
- ☑ PASSENGER_FINISHED_TRAVEL
- ☑ PASSENGER_TRANSFER
- ☑ PASSENGER_TRIP_FAILD
- ☑ PASSENGER_MOVE_ACROSS_NODE
- ☑ VEHICLE_CAPACITY
- ■ DRIVER_ARRIVED
- ■ DRIVER_DEPARTURE
- ☑ DRIVER_TIMETABLE_ARRIVE
- ☑ DRIVER_TIMETABLE_DEPARTUE

When to use MAS?

Competitive setting => **use always** especially if automation needed; two cases:

- central trusted authority => centralized algorithms
- no trusted authority => fully distributed (peer-to-peer) algorithms

Cooperative setting => use if one or more of the following is true

1. **spatially distributed** and/or **highly dynamic** with insufficient connectivity where creating and maintaining shared global information state is difficult
2. **heterogenenous** where designing a single shared information model is difficult
3. **mission critical** where single point of failure must be avoided

Conclusions

- MAS still and emerging paradigm
- Some application areas well established (e.g. trading agents or auctions)
- Many more coming with the increasing automation and digitization of the world
- In general: trend from monolithic all-encompassing multi-agent platforms to the application of specific techniques on top of general ICT stacks
- If it all sounds interesting, join us (Ph.D., research programmers)! See http://agents.fel.cvut.cz/open_positions/