ITMO UNIVERSITY

Simulation-based Problem Solving in Transport Domain With the Use of High Performance Computing and BigData

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General research directions

- Global Systems Science
- *Urgent* Computing
- *Multiscale* Computational Models
- *Multidisciplinary* Applications
- Hybrid models

Wide range of domains

- **Computational Infrastructures for e-Science**
- Hydrometeorology
- **Traffic simulation**
- Epidemiology
- Sociodynamics
- …

Multiscale Modeling of an Urban Environment

Development of a complex approach for city-scale modeling and simulation with the use of modern computational technologies for solving of diversity of research problems

Complex Approach to Urban Mobility Modeling and Simulation

- **Data Sources**
  - Map, GIS
  - Society data
- **Models** (multiscale)
  - Macro: population
  - Meso: traffics
  - Micro: pedestrians
- **Problems**
  - Forecasting
  - Scenarios: what-if, evacuation
  - DSS evaluation
- **Infrastructure**
  - Computing: Clouds, HPC
  - Data: BigData
  - Visualization

Data Sources

GIS (e.g. OpenStreetMap)

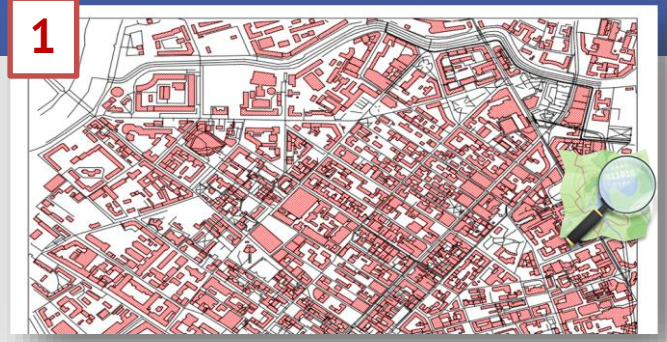
1. Extract buildings [1]
2. Extract a road graph [1]
3. Bind buildings to nodes in the road graph [2]
4. Extract or generate bus stops
5. Bind buildings to bus stops (for passengers modeling)

Population data

- Number of people living in building (FMS) [3]
- Statistical data on people daily activities [4]

Social media

1



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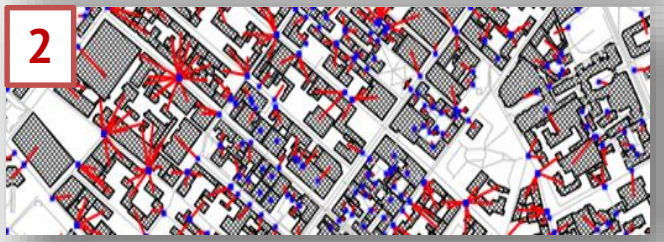

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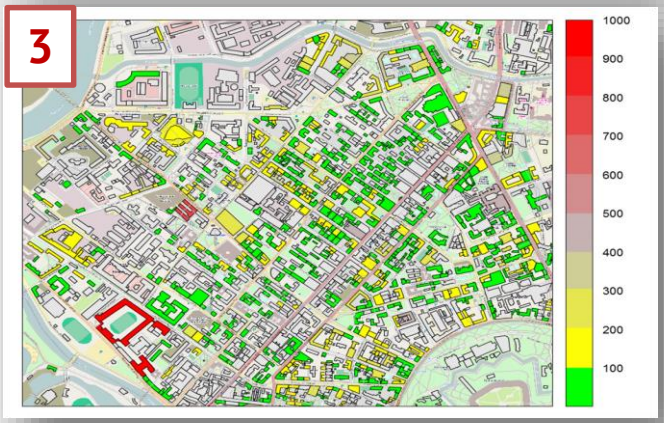
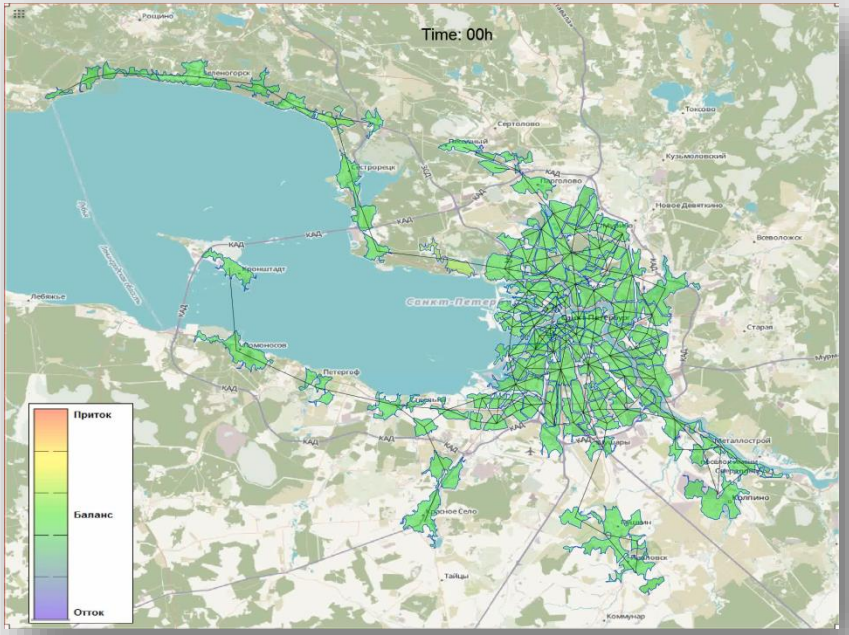
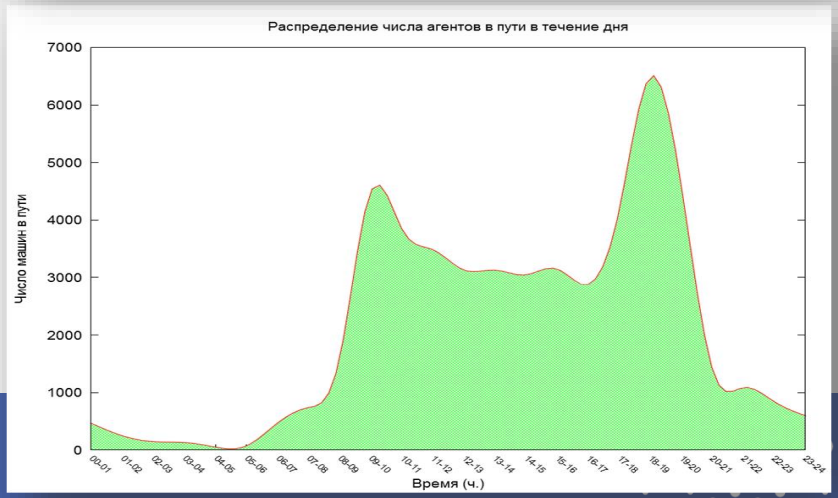


4

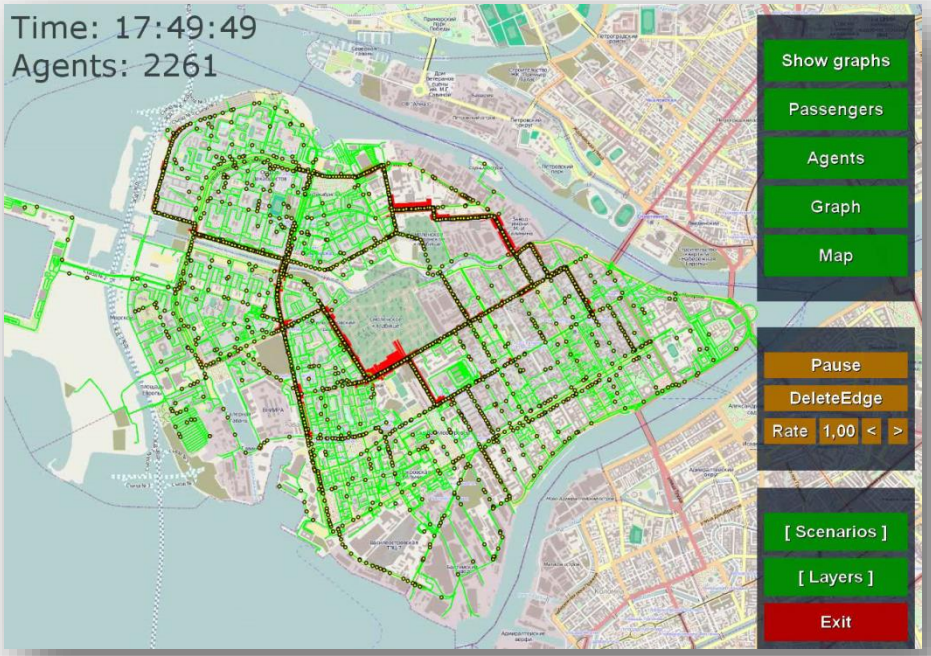
Travel Demand Modeling

- Macro-model of the society (splitted into strata) on the level of municipalities
  - Is used for modeling of city-scale processes
- Macro-model implementing the 4 classical steps: trip generation, trip distribution, mode choice (driver, bus passenger), route assignment.
  - Agents are generated according to results of this model



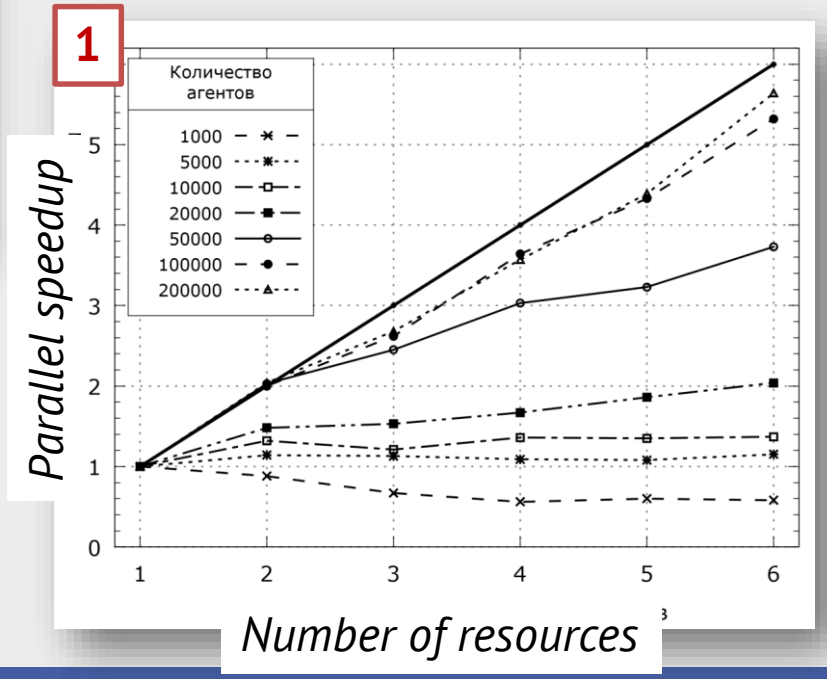


Traffic Dynamics Simulation



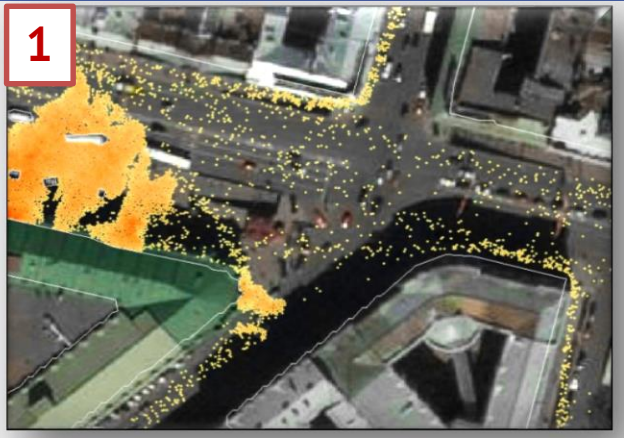
- Agent-Based Model using:
  - Intelligent Driver Model (IDM)
  - Crosses passage
  - Complex agent's behavior
- Simulation result: traffic flow on edges of road graph

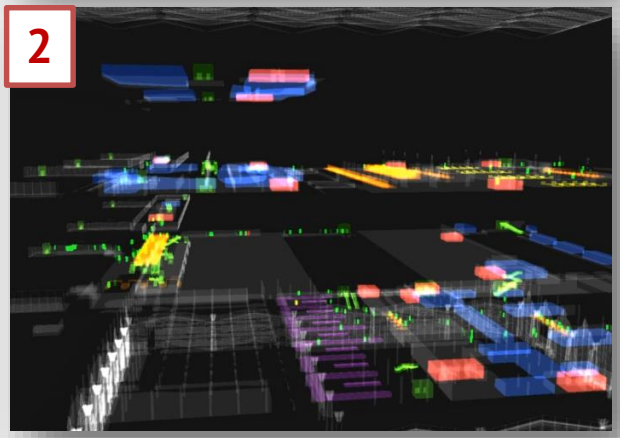
- The model can be integrated with visualization software in order to observe and steer simulation
- Supports distributed simulation. Parallelization is done by decomposition of map into zones [1]



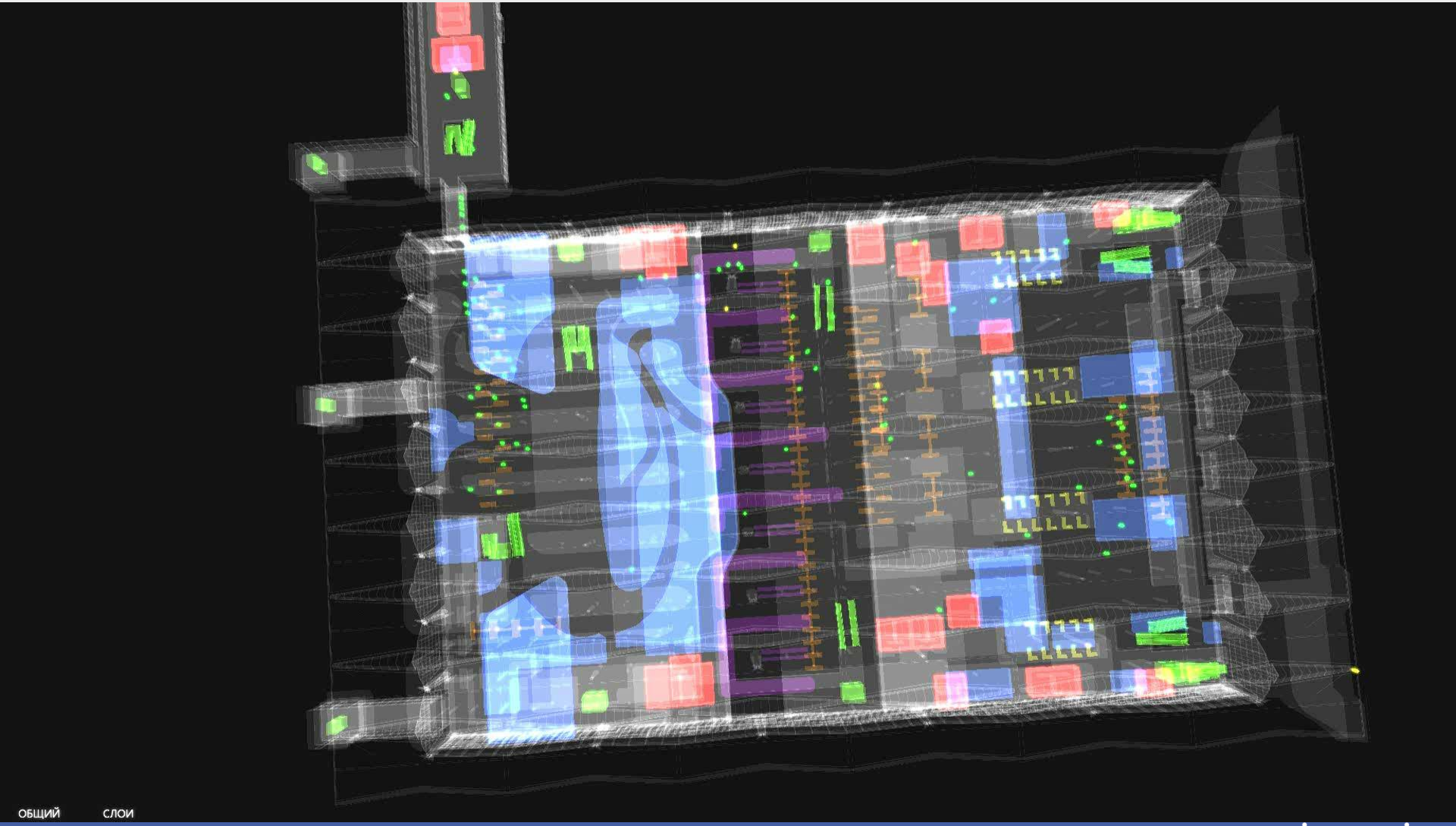
Pedestrian Mobility Models

- Agent-Based Simulation in spatial environments:
  - urban environment [1] [3]
  - complex transport hub [2]
  - city-scale virtual society
- Movement models: social-force model, RVO2
- Capability to connect with visualization software

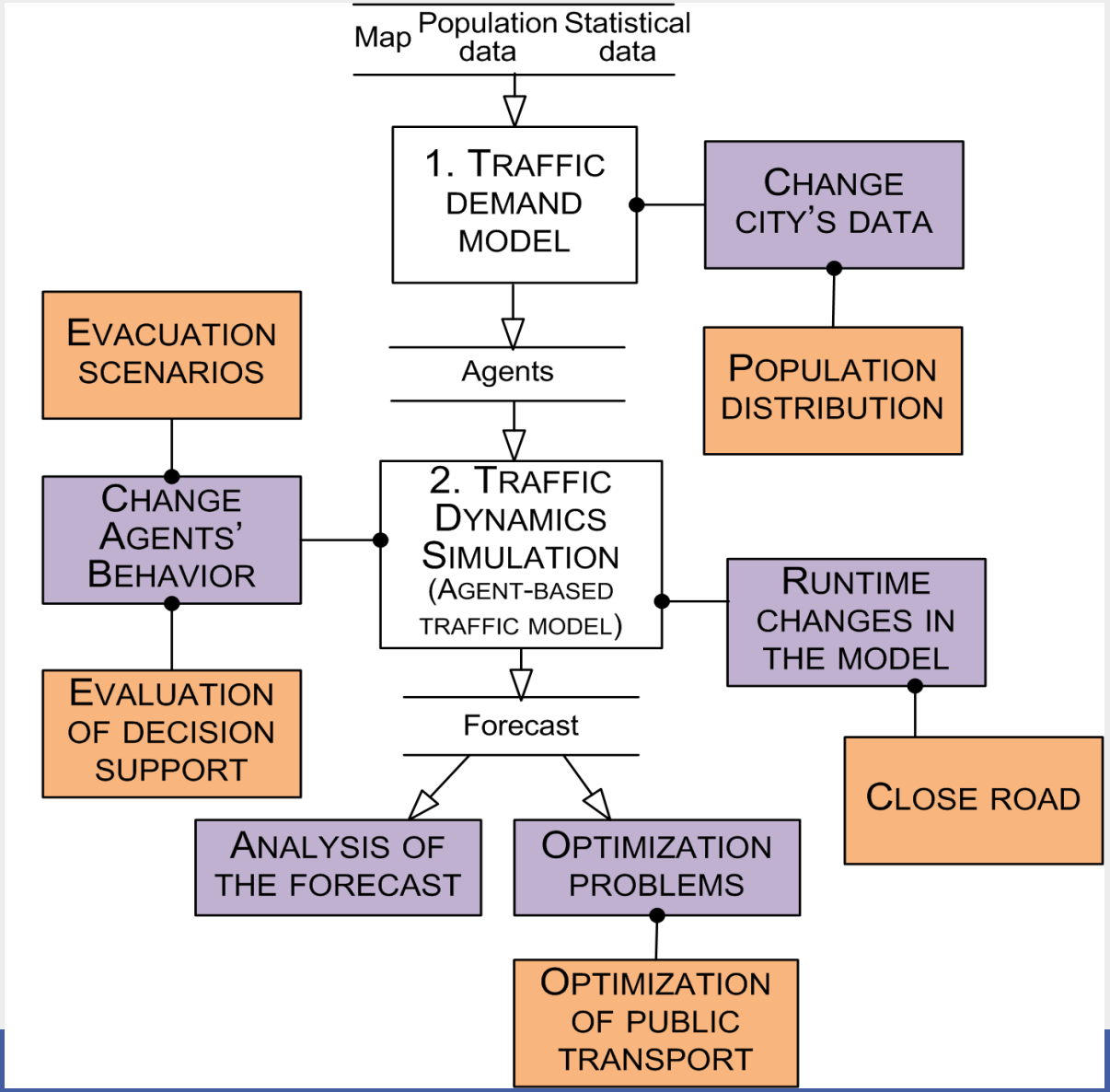




Simulation of Pedestrian Mobility in the Pulkovo Airport

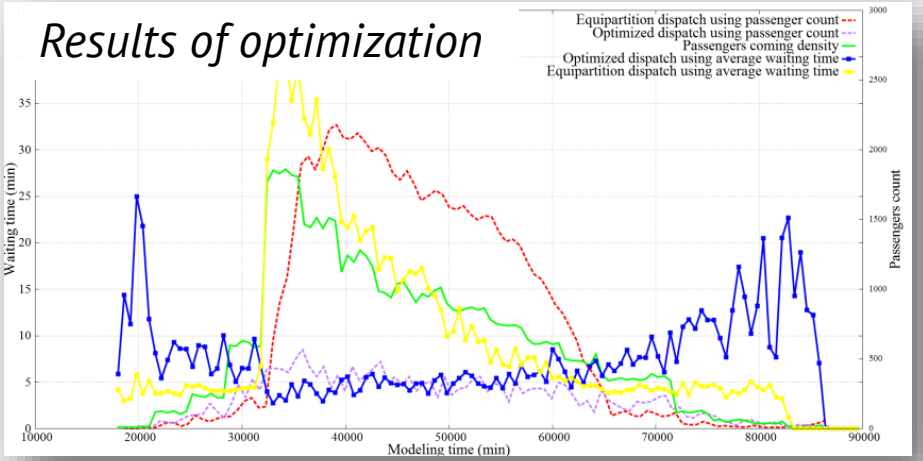


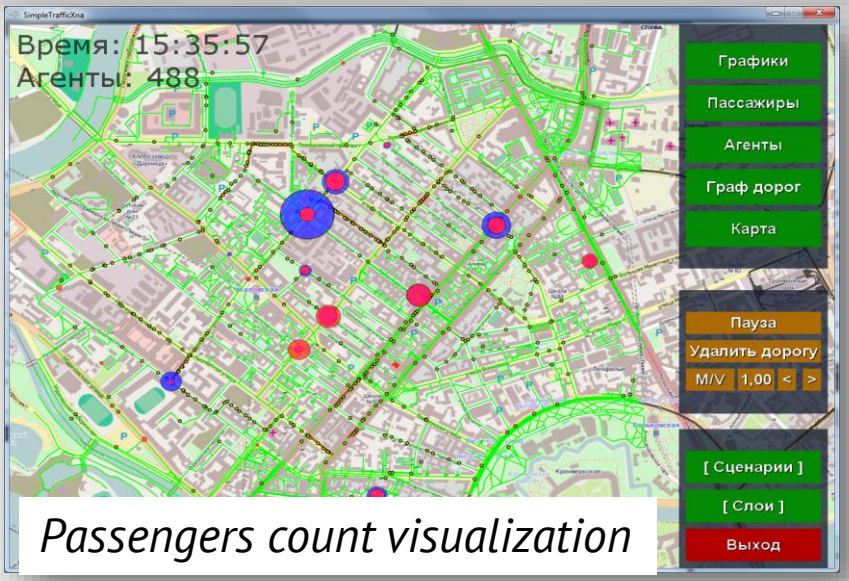
EXAMPLES OF PROBLEMS



Public Transport Optimization

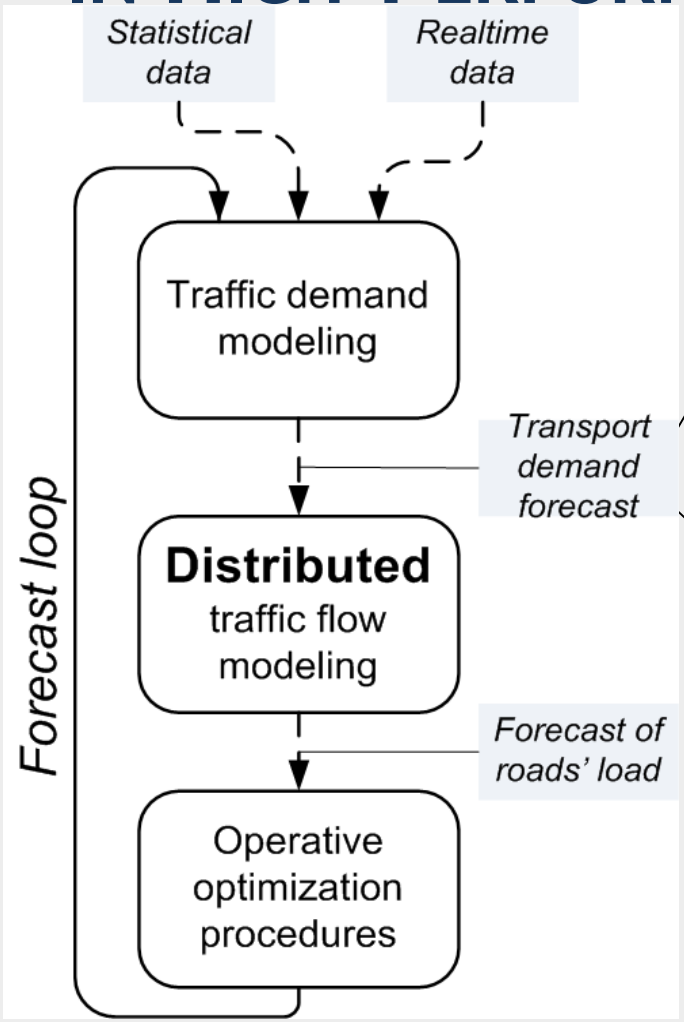
- **Two optimization problems** based on forecasted roads' load
  - Dynamical optimization of bus routes between their stops (avoiding traffic jams)
  - Optimization of buses time-table
- **Optimization objectives**
  - minimization of waiting passengers number
  - minimization of bus waiting time
  - accordance to time-table
- Evolutionary Computation Approach
  - Distributed genetic algorithm

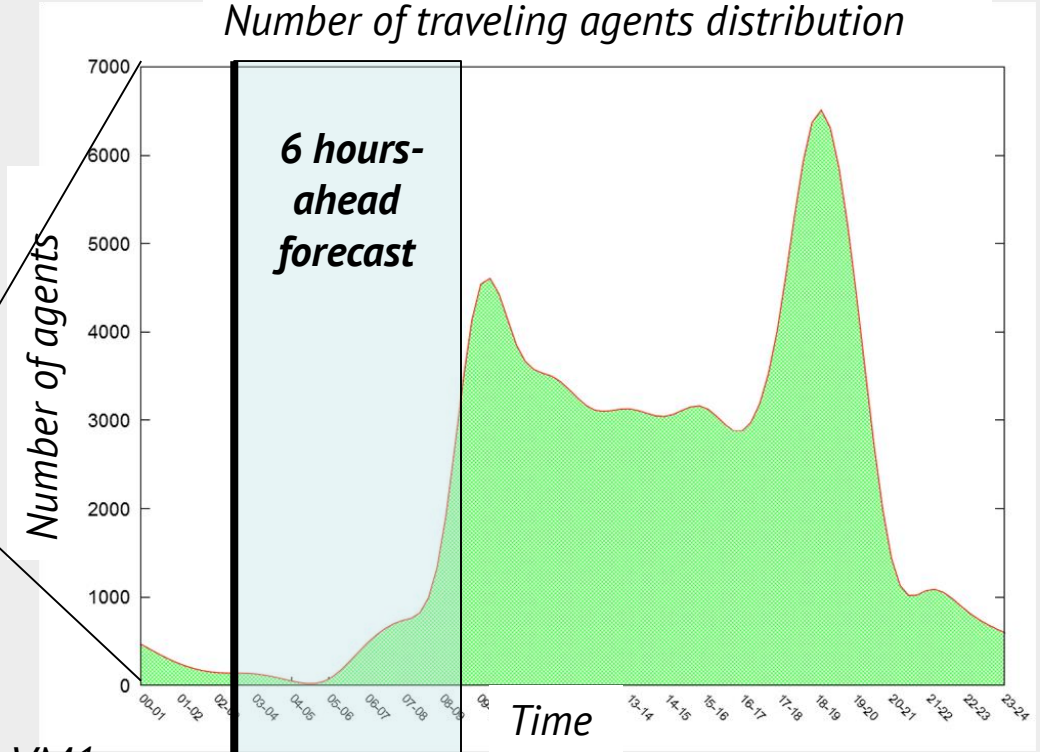




Passengers count visualization

Forecast-based Public Transport Optimization in High-Performance Cloud Environment





Dynamic number of virtual resources depending on the predicted number of agents

SIMULATION-BASED EXPERIMENTATION

- «What-If» experiments
- Change map (close the road) in time of model
- Increase district's population and investigate changes in traffic flow
- *Evacuation scenarios*

VEHICULAR EVACUATION

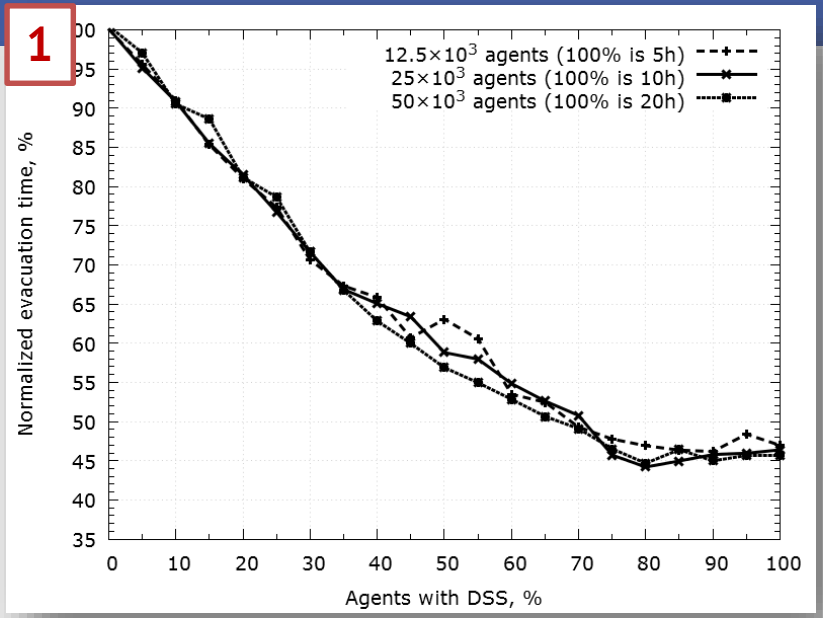
Model changes

- Behavioral Model (population notification, different DSS, agent perception)
- Coupling with geosimulation models (e.g. flooding) [2]

Simulation-based researches:

1. Efficiency of DSS. Influence of count of drivers guided by DSS on the total evacuation time [1]
2. Evaluate the influence of driver trust to the system on the evacuation process (ignoring notification,)
3. Evaluation of different personal Decision-Support Systems in **flood** [2]

1



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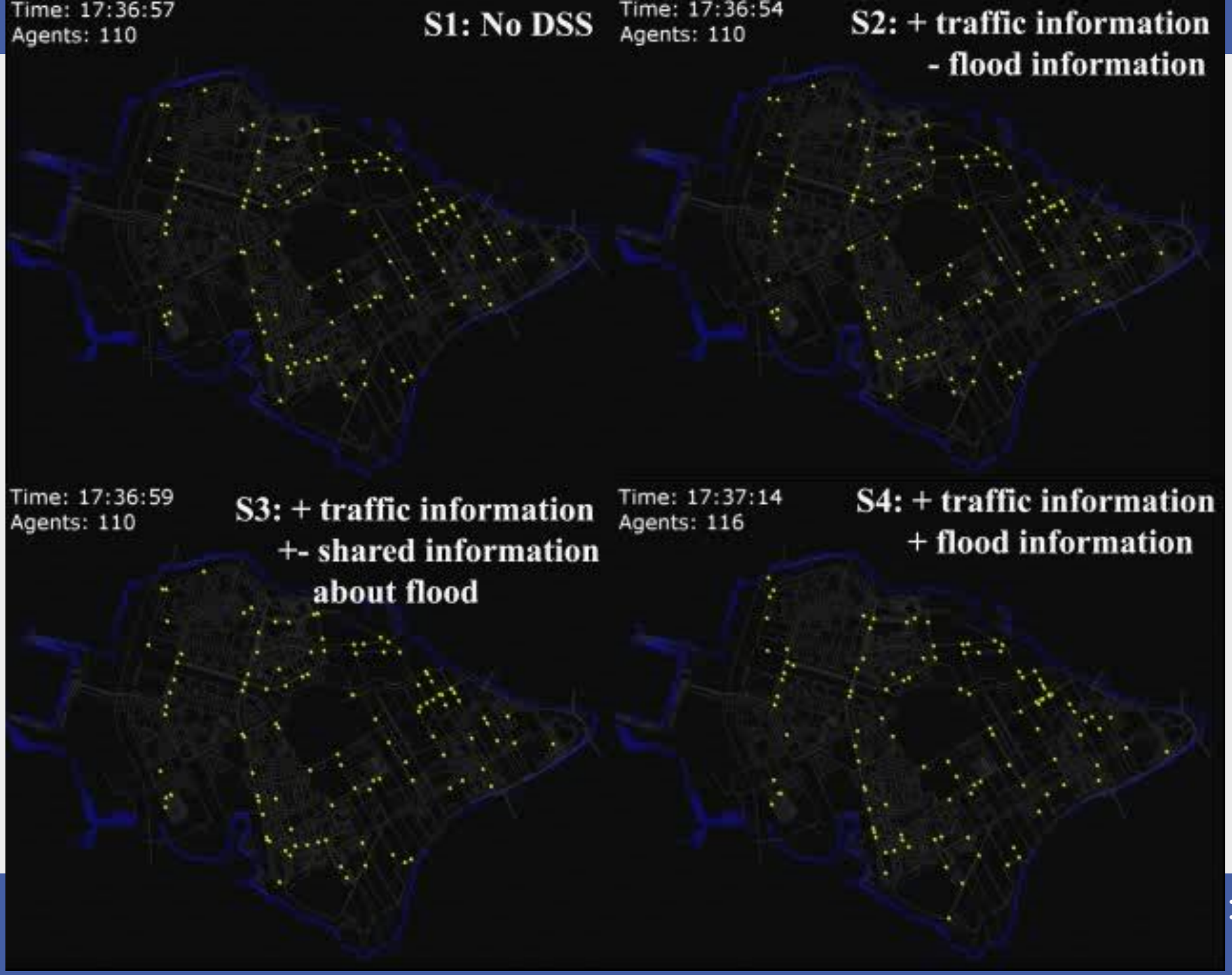
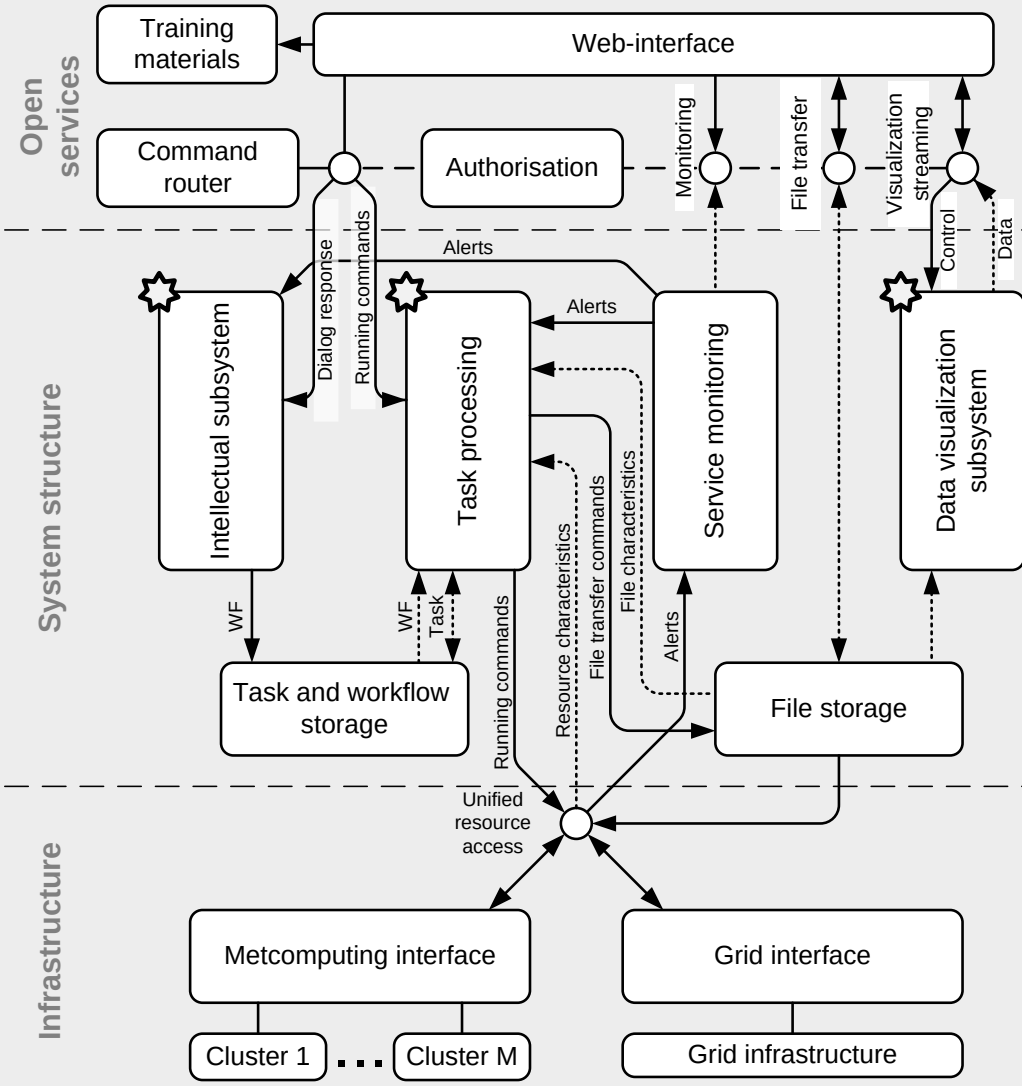
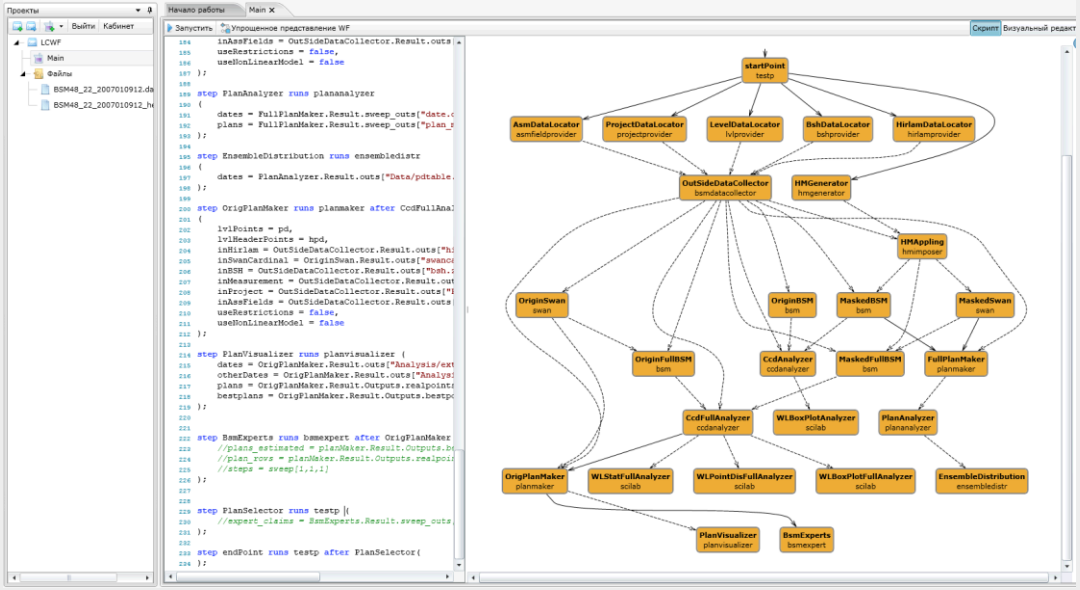

Time: 17:36:57
Agents: 110
S1: No DSS
Time: 17:36:54
Agents: 110
S2: + traffic information
- flood information
Time: 17:36:59
Agents: 110
S3: + traffic information
+- shared information
about flood
Time: 17:37:14
Agents: 116
S4: + traffic information
+ flood information

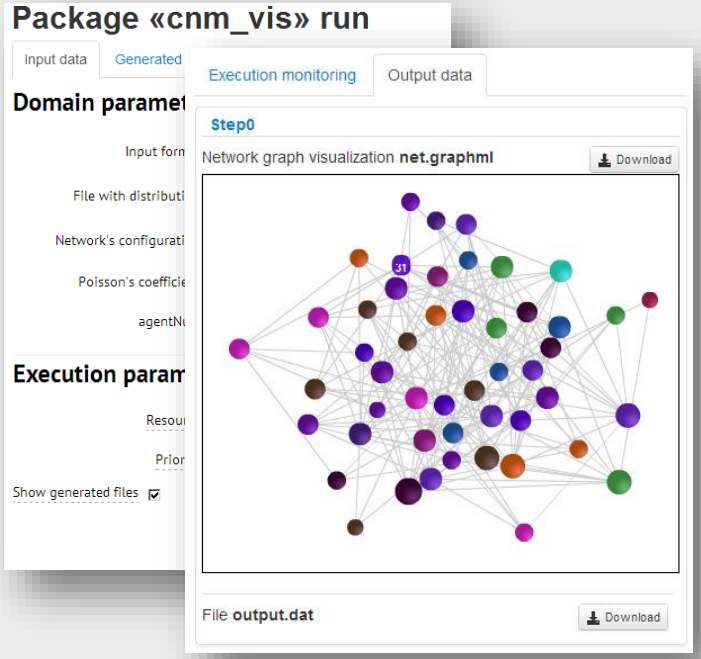
CLOUD APPLICATIONS VIRTUAL ENVIRONMENT (CLAVIRE)

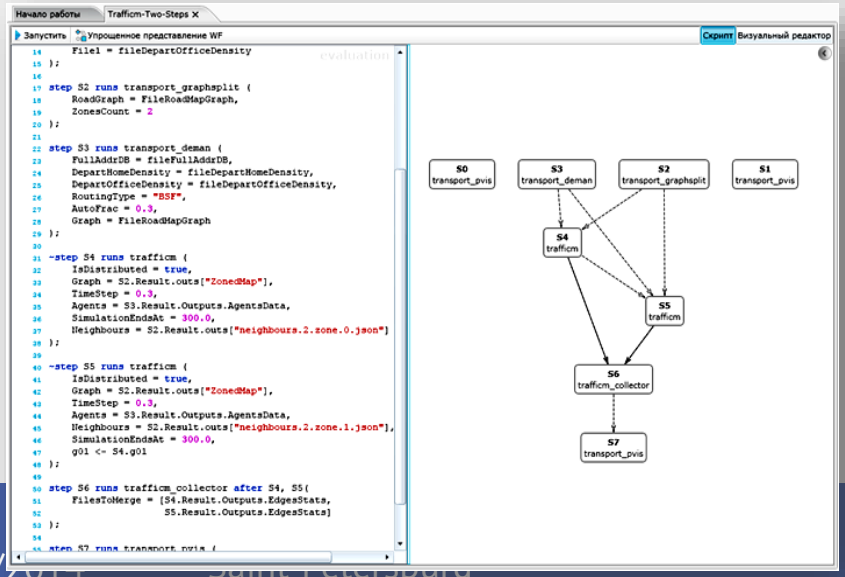
- CLAVIRE is the domain-independent platform for abstract composite application execution in form of workflows
- CLAVIRE can be transformed into domain-specific Problem Solving Environments by filling with
  - Resources: various computational resources are supported (PC, clusters, Grids, IaaS)
  - Software: models, utilities
  - Composite applications
- Other features
  - Uses formal expert knowledge about platform components
  - Interactive workflows
  - BigData storage with implementation of MapReduce

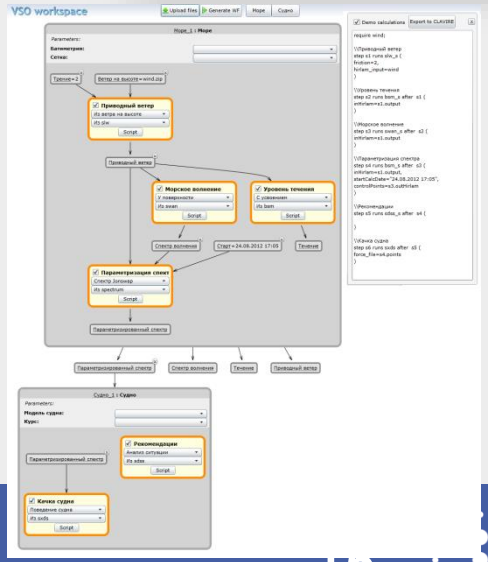


CLAVIRE http://clavire.com/









Conclusions

- Computational infrastructure of the CLAVIRE platform allows us to integrate different transport models into one system and use them within the HPC environment
- Intention is to create fully-functional problem solving environment in domain of virtual cities simulation