

An Evolutionary Framework for Large-scale Experimentation in Multi-agent Systems (with application to MAGNET)

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Overview

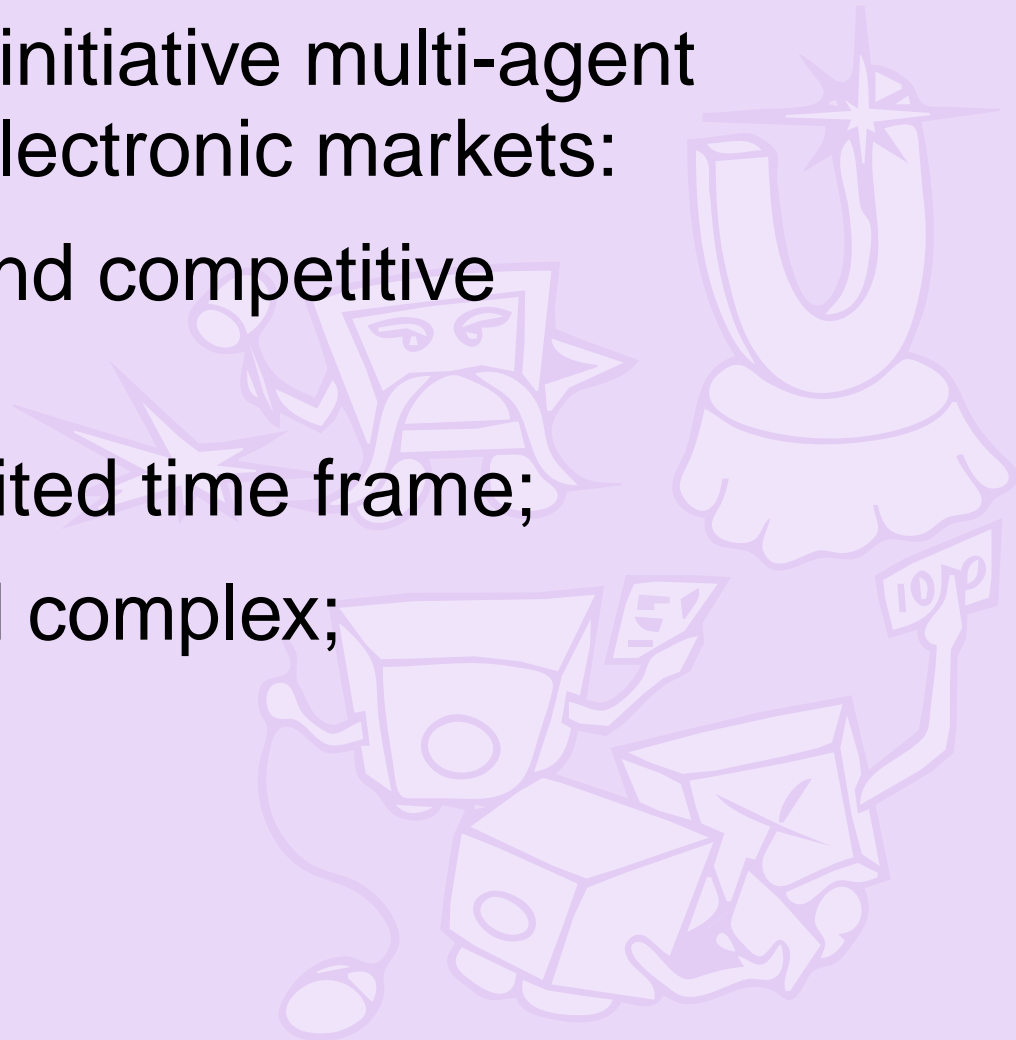
- The problem
- Suggested approach
- Example model and results
- Prospective application
- Conclusion



Problem Domain

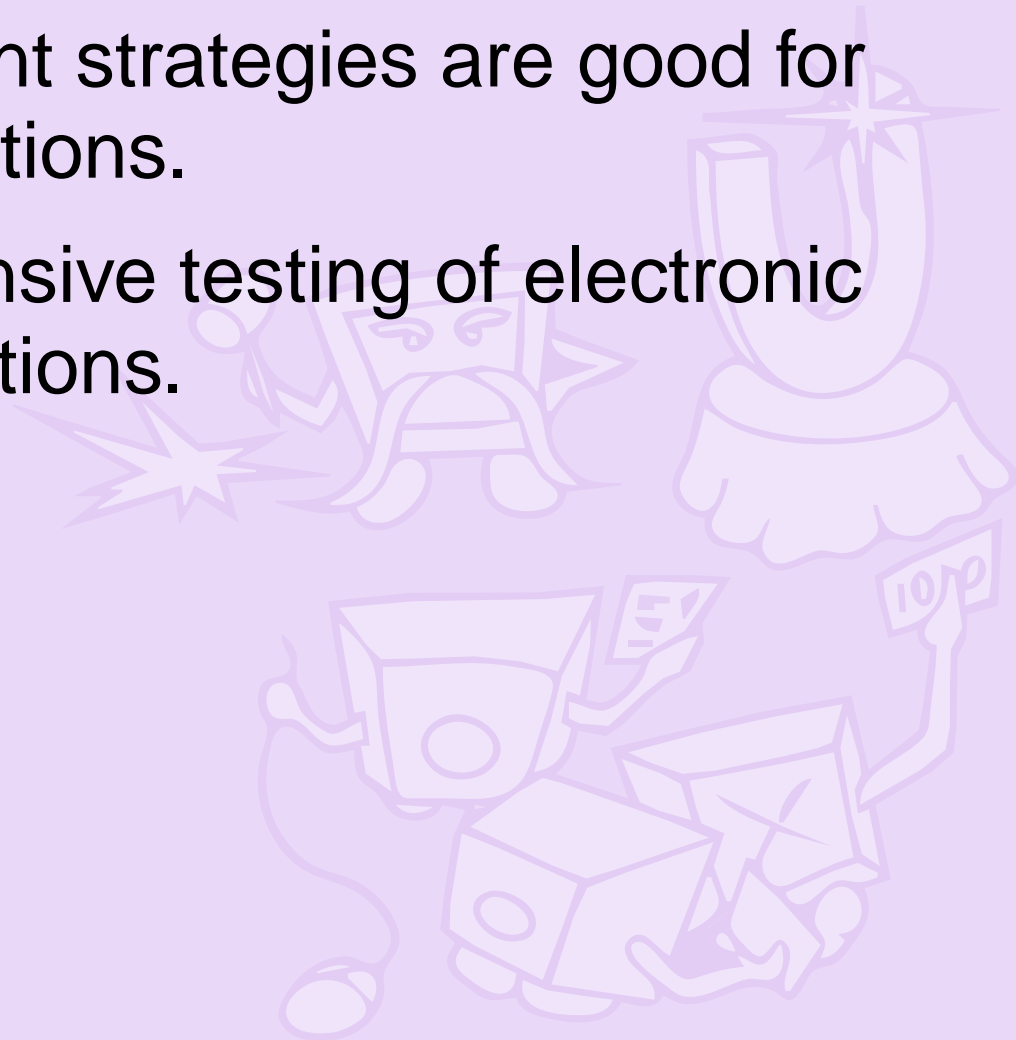
Automated and mixed-initiative multi-agent systems in emerging electronic markets:

- limited resources and competitive environment;
- dynamic with unlimited time frame;
- heterogeneous and complex;
- open environment.



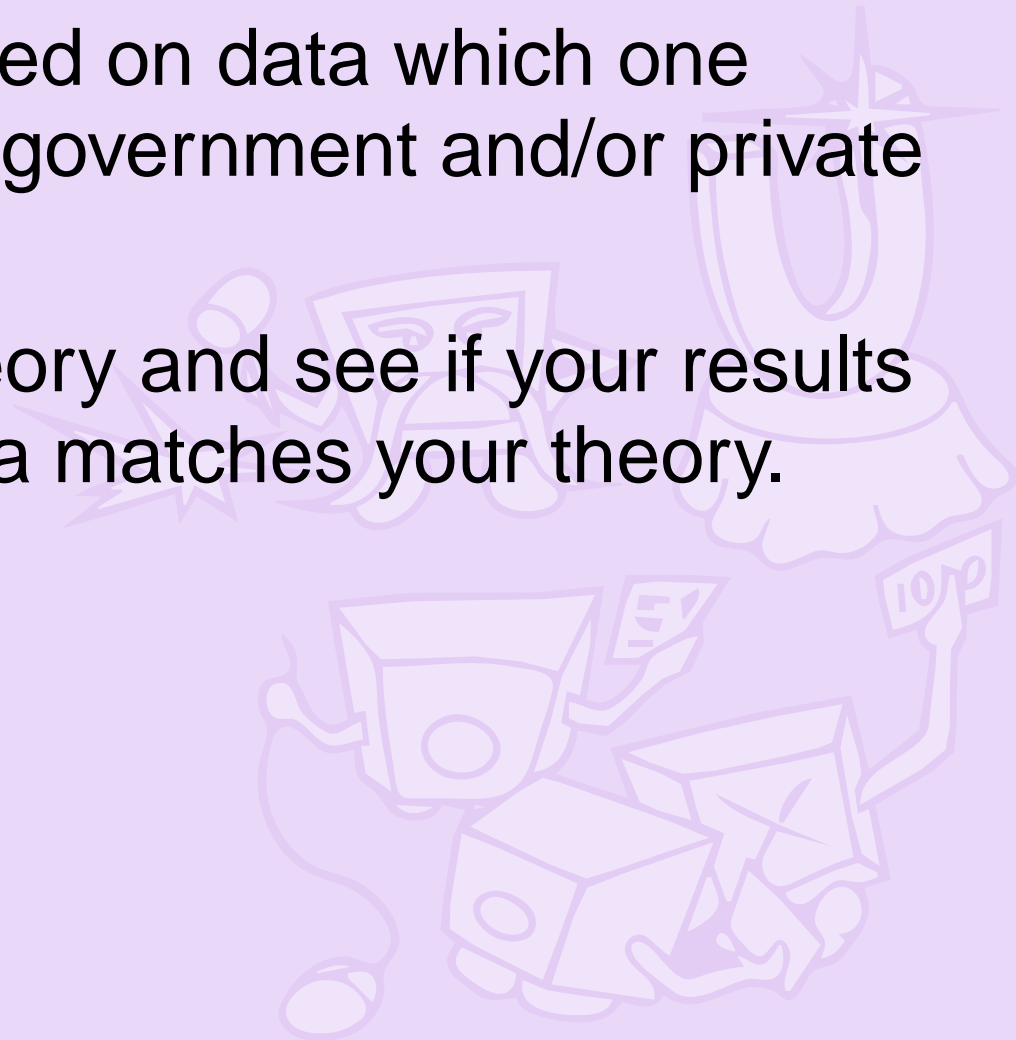
Goals

- Find out which agent strategies are good for which market conditions.
- Perform comprehensive testing of electronic market implementations.



Real market data analysis

- The analysis is based on data which one obtains from either government and/or private organizations.
- Come up with a theory and see if your results of the gathered data matches your theory.

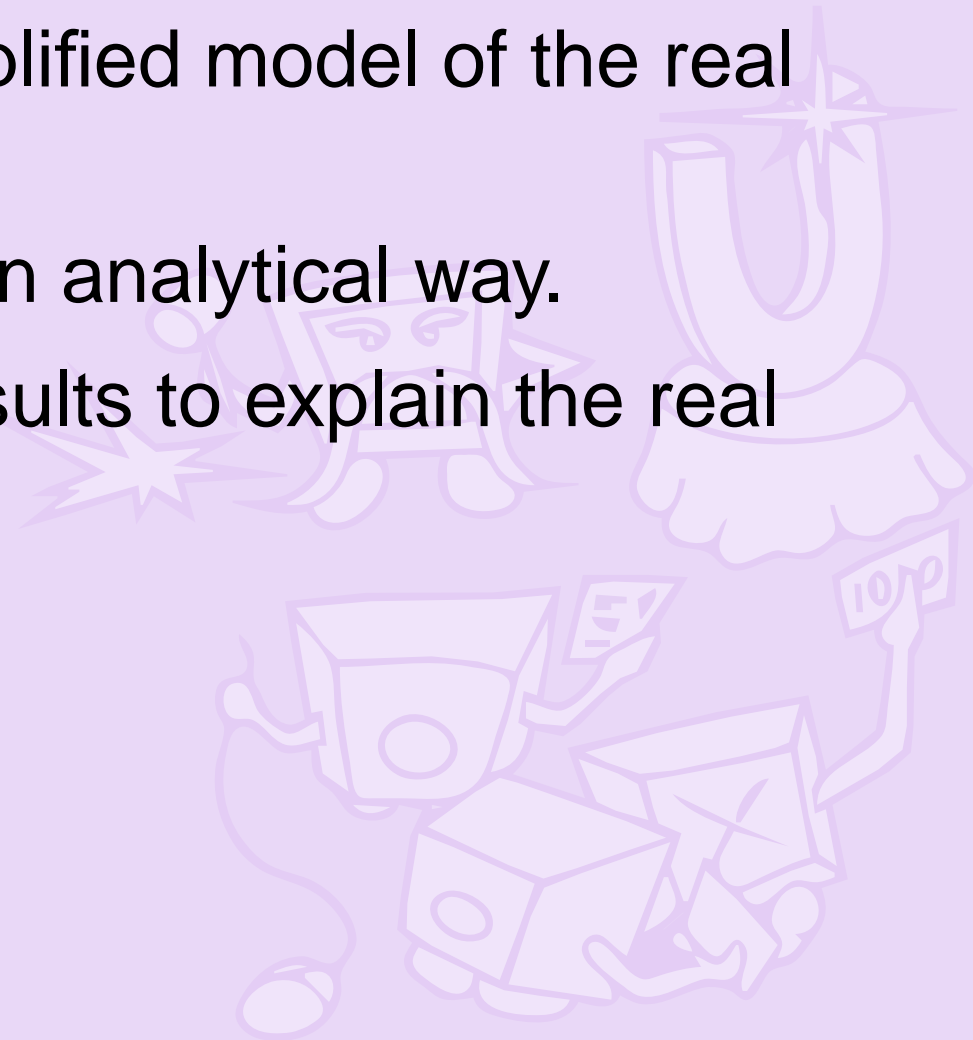


Cons of Real market data analysis

- Requires real data, which is often either private or inadequate or both.
- Some emerging electronic markets have no mapping to the real world.
- Data what one obtains serves the purpose of other organizations, not one's own. This means the data could be useless.
- Postmortem analysis: One can not test new strategies.

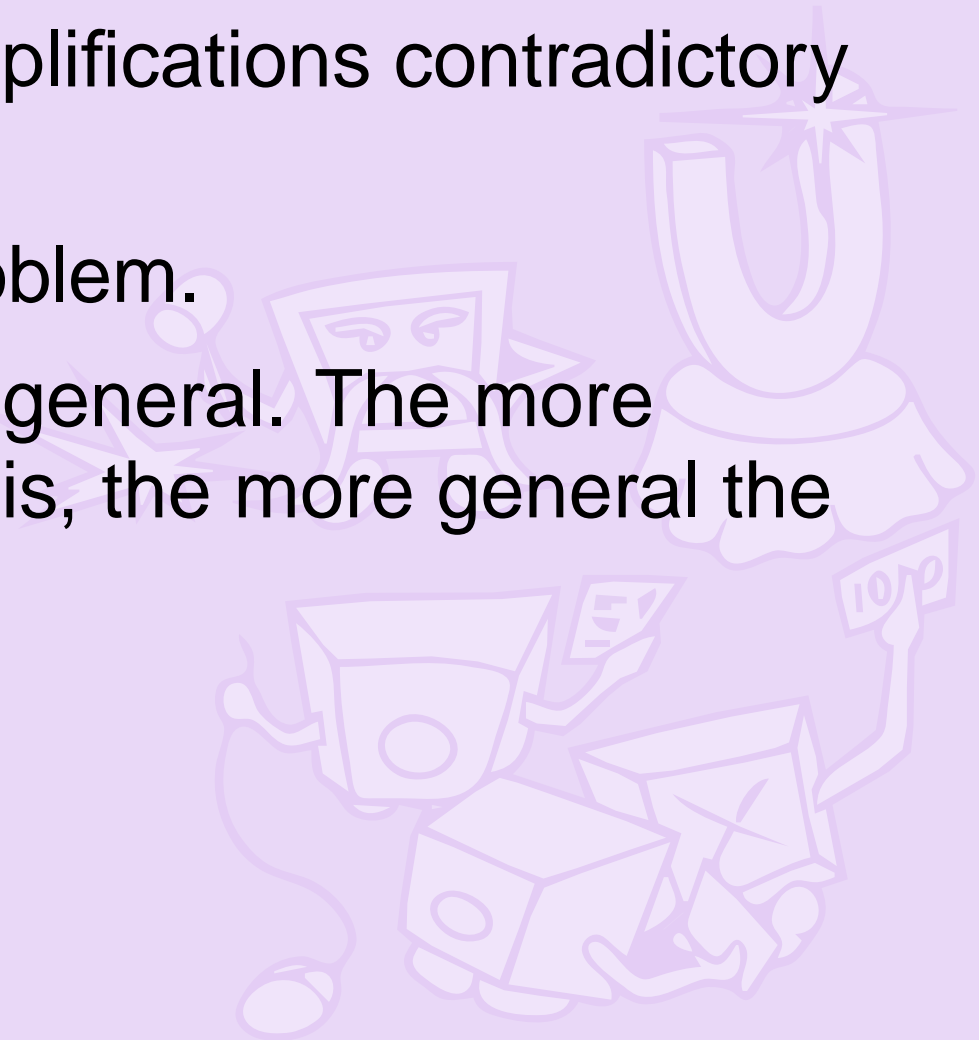
Analytical analysis

- Come up with a simplified model of the real world.
- Solve the model in an analytical way.
- Use the obtained results to explain the real world trends.



Cons of Analytical analysis

- Requires a lot of simplifications contradictory to the domain.
- Double transition problem.
- The results are very general. The more simplified the model is, the more general the results.



Competition

- Provides a formalized market environment with strict rules.
- Provides standard means of interaction in the market, such as servers, protocols, and APIs.
- Stimulates creation of a variety of different approaches (strategies) by a diverse community of scientists.

Cons of Competition

- Fixed number of rivals and equality of initial conditions.
- Tournament structure disregards non-transitivity.
- One is able to exploit the weak points of the system.
- Fixed closing date and related boundary problems.
- Requires substantial organizational effort.
- Double transition problem.

Candidate Approaches

- Real market data analysis? Requires real data, which is often either private or inadequate or both. Some emerging electronic markets have no mapping to the real world.
- Analytical analysis? Requires a lot of simplifications contradictory to the domain.
- Competition? Requires strict rules and closing date, disregards non-transitivity, requires fixed market structure on competitors' side.

Evolutionary Approach (1)

General Characteristics:

- Controllable environment and data collection.
- A large range of problems can be studied.
- Testing over a long-time period is possible.
- The type and number of agents change frequently.
- Reputation building is a vital part of any real system.
- Fully specified strategies.

Evolutionary Approach (2)

Generalized setup:

- a dynamic society of many customer and supplier agents
- who enter the market with one of available strategies and initial parameters as determined by a reproduction rule
- and survive in the market according to their accumulated wealth.

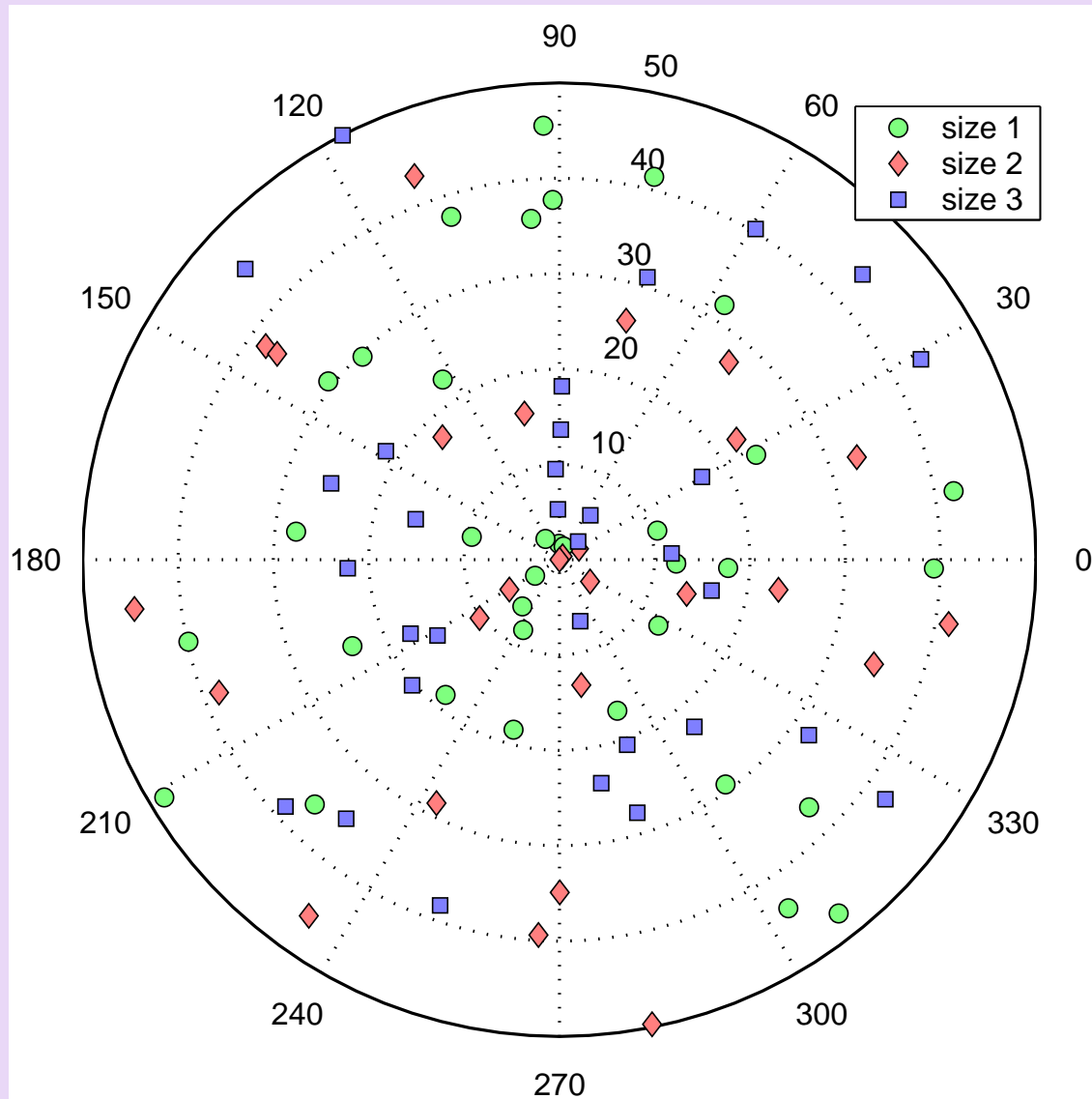
Example: Citysim Model (1)

Citysim — a discrete event simulation of the evolving society of service suppliers and their customers living in one city:

- Customers come to the market with a fixed frequency with a higher density close to the center of a city.
- Customers seek for the cheapest provider of the service where cost is a linear function of a price, distance to supplier and wait time.

Example: Citysim Model (2)

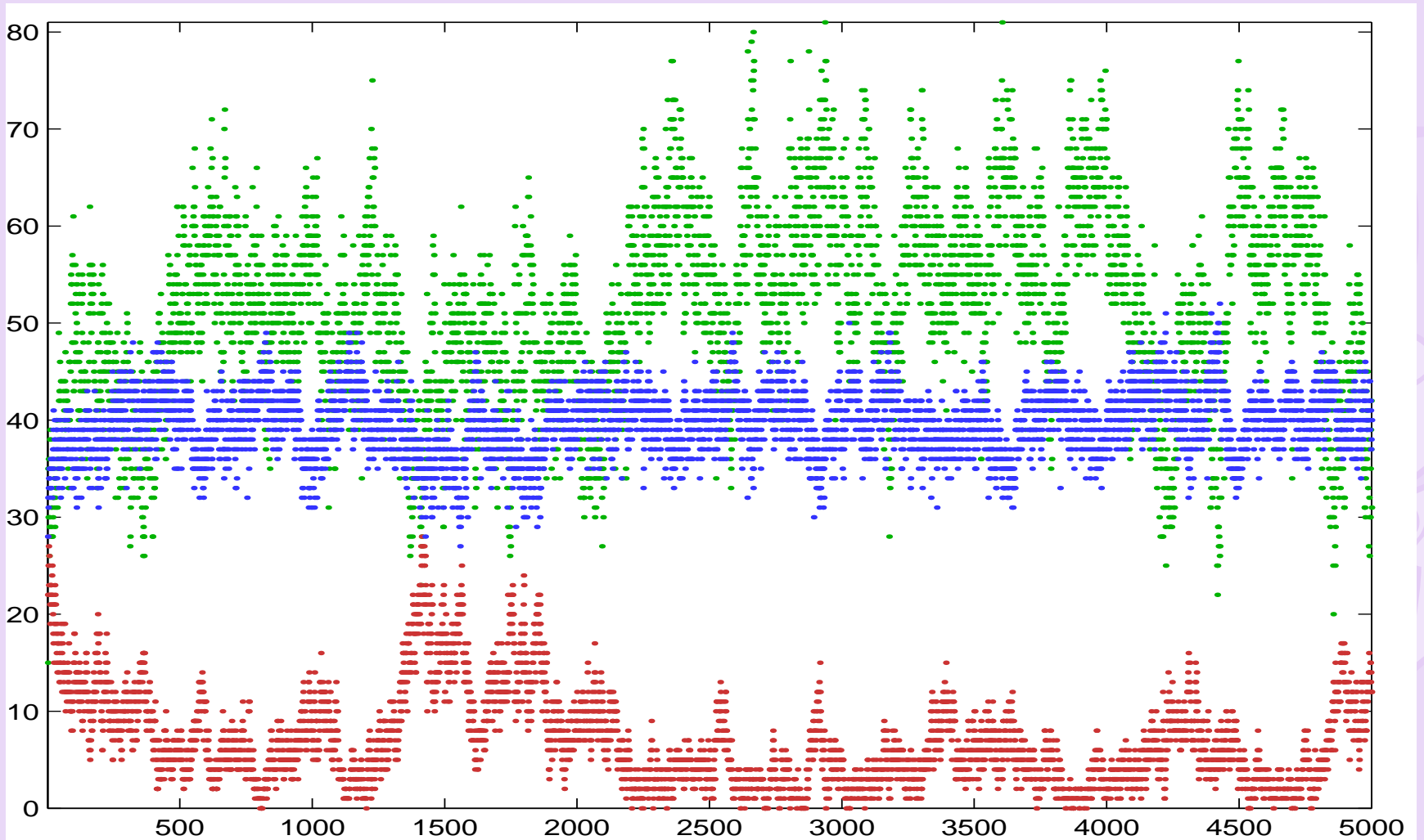
- Suppliers are divided in 3 classes: they can serve either 1, 2 or 3 customers simultaneously.
- Bigger suppliers have lower production costs.
- A new supplier's price is determined based on the distribution of prices of its potential "parents" (i.e. suppliers of the same class) conditional on the distance from the center.



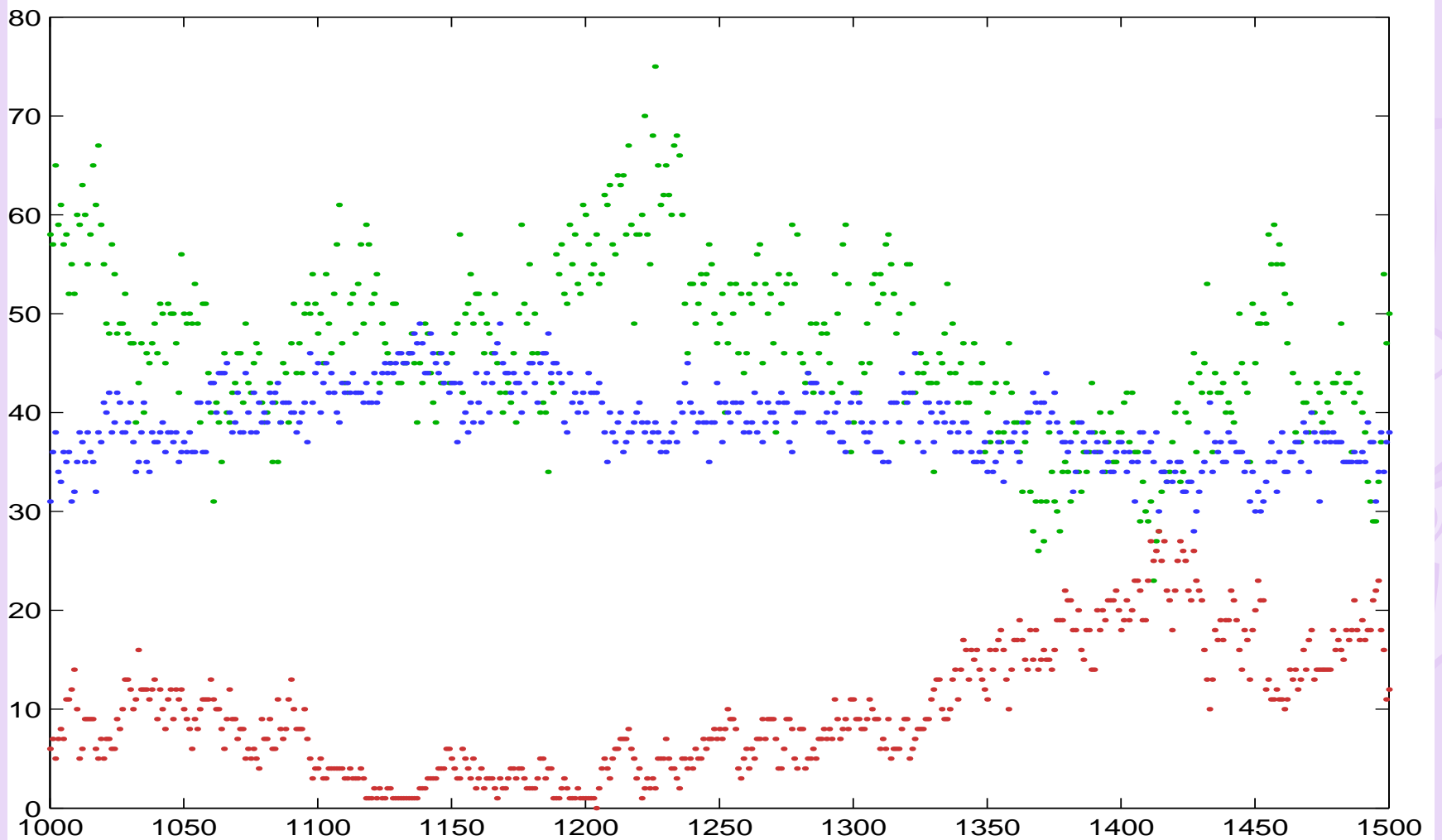
The snapshot
of a city after 2
years of
simulation.

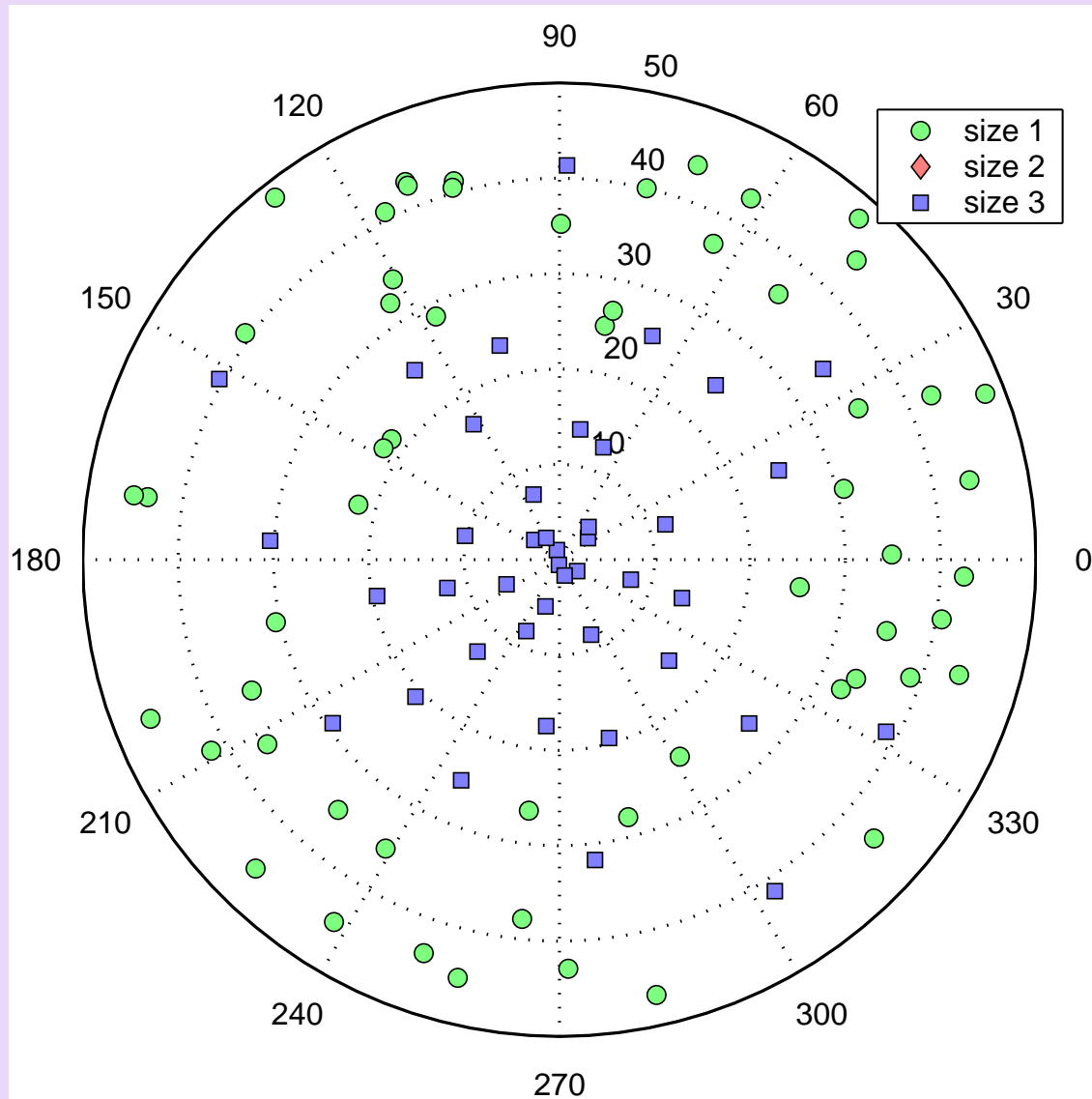
Suppliers of
all sizes are
distributed
evenly.

Simulation Time-Line (1)



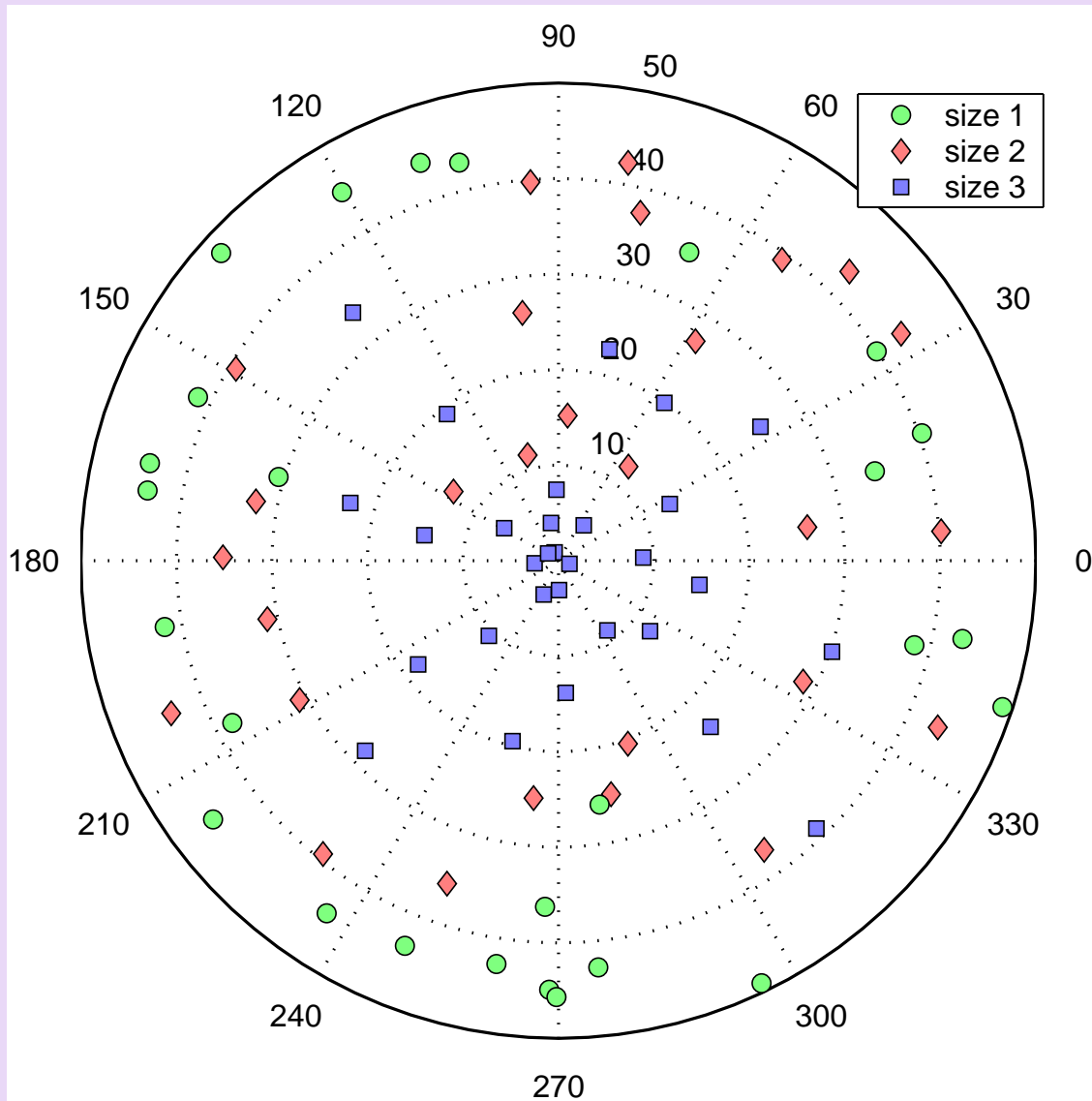
Simulation Time-Line (2)





The snapshot of a city after 1204 years of simulation.

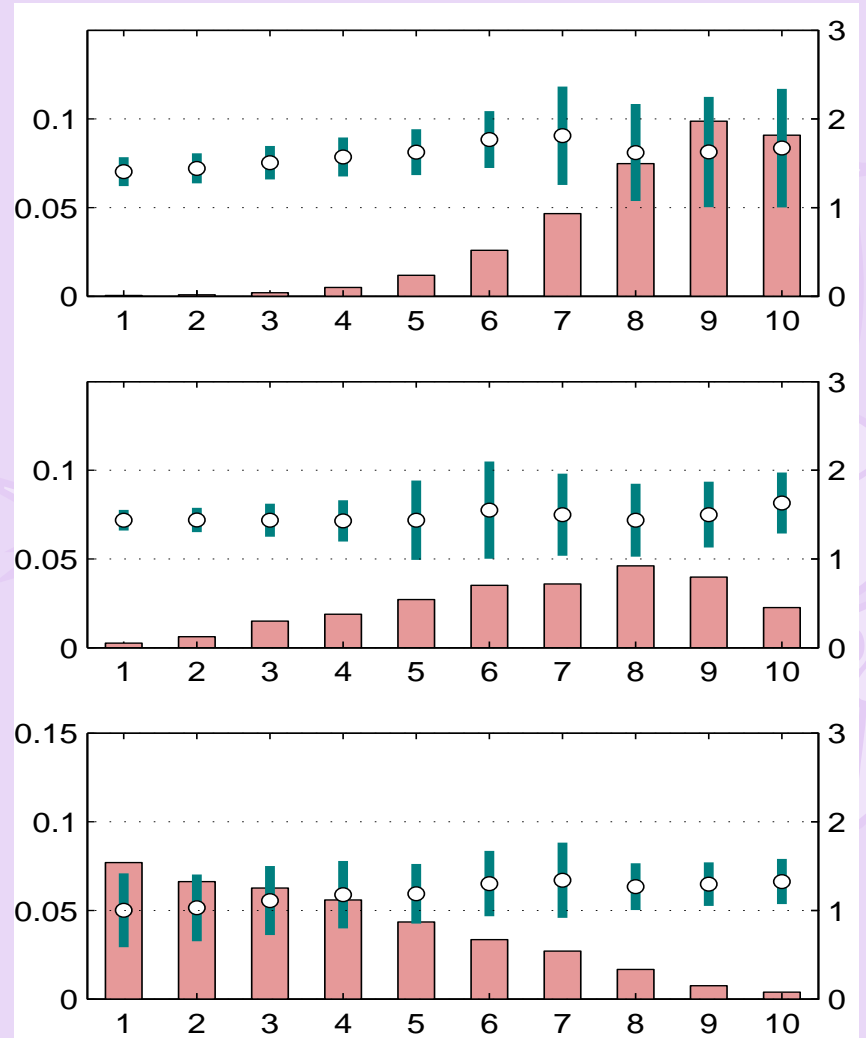
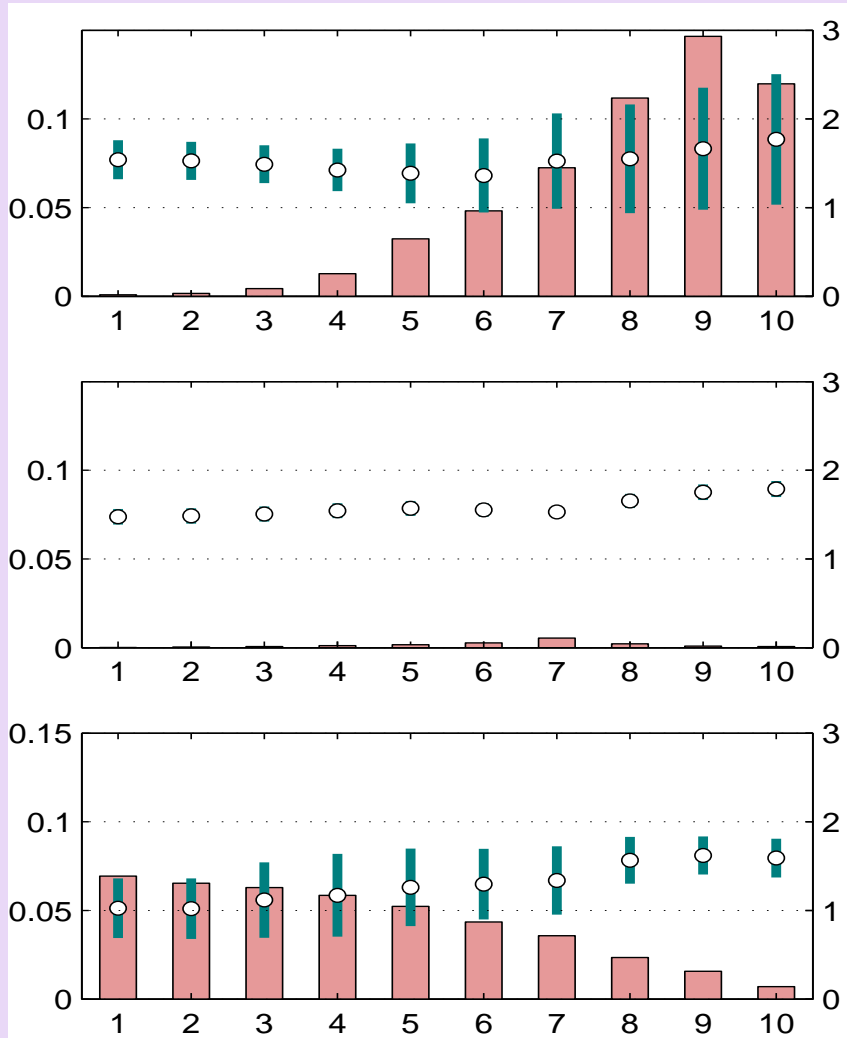
Suppliers of size 1 and 3 have divided “zones of control.”



The snapshot of a city after 1414 years of simulation.

Suppliers of size 2 are in the market again after they had been washed away from the market.

Results (4)



Reproduction of Strategies

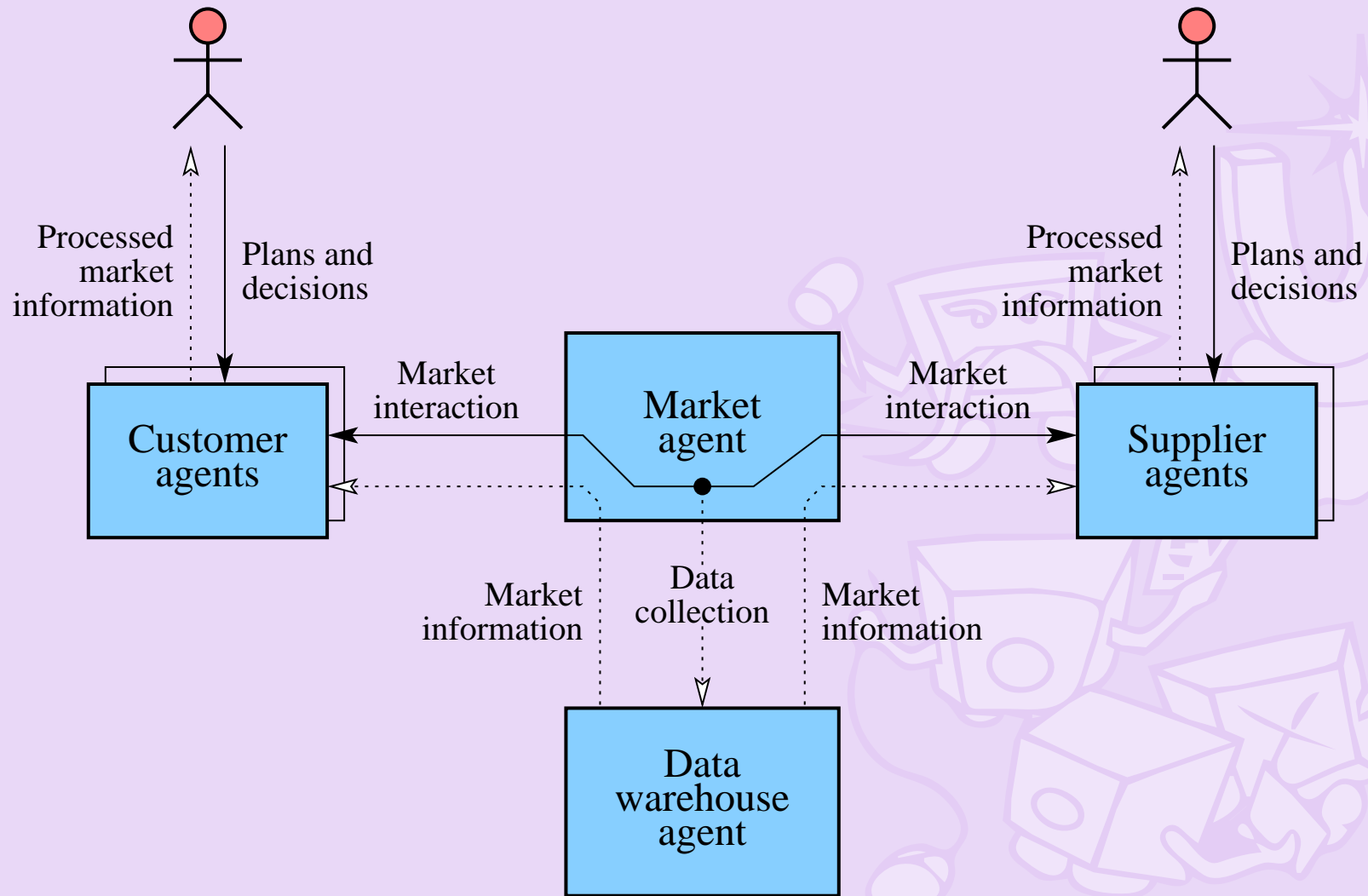
Generalized reproduction rule:

1. Choose a type of a new agent, its class and general initial parameters based on general demographic information.
2. Call a strategy-specific reproduction rule to select the rest of the initial parameters based on the initial parameters of all currently present agents of the same class.

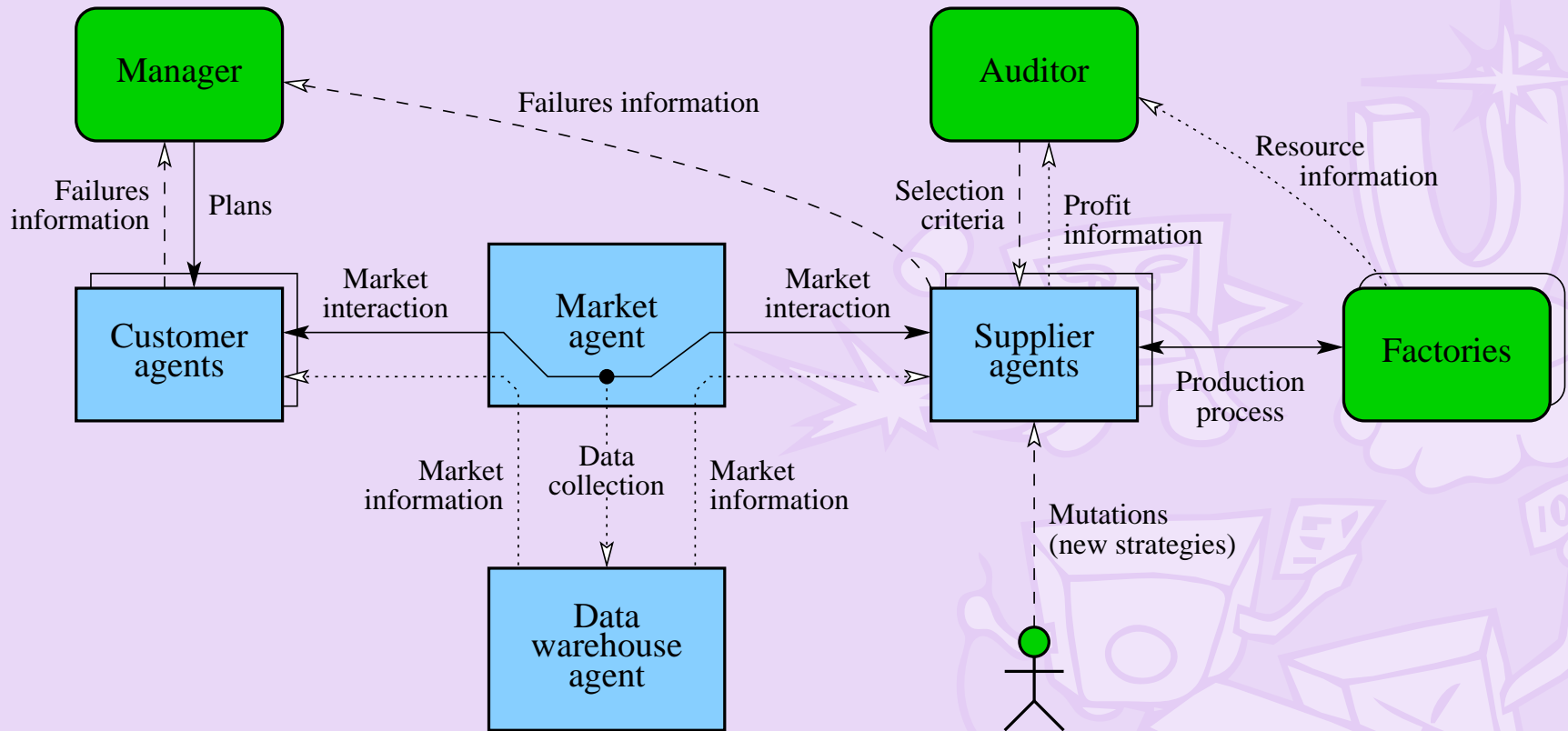
Prospective Application

- MAGNET \equiv Multi-AGent NEgotiation Testbed
- Current MAGNET design supports
 - multiple agents (customers and suppliers)
 - negotiating contracts with temporal and precedence constraints
 - in automated first-price sealed-bid combinatorial auction environment.

MAGNET: Mixed-initiative Architecture



MAGNET: Evolutionary Architecture



Conclusion

- We showed the evolutionary approach for large-scale experimentation in multi-agent systems.
- The suggested approach has shown good results in a simple economic model.
- In our future work we plan to integrate the evolutionary approach in the MAGNET system.

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