The application of experimental economy in the cognitive networks using Roth-Erev algorithm

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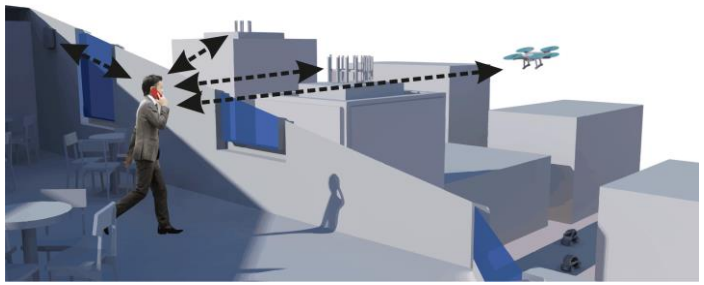
MOTIVATION

Observed enormous increase of data traffic and a number of active network devices changes the way society sees the frequency spectrum and arises the question about the future of current mobile communications markets that are not prepared either suitable for the observed trend as they suffer from outdated regulatory models. Study of novelty techniques is vital to meet the requirements of future demand.



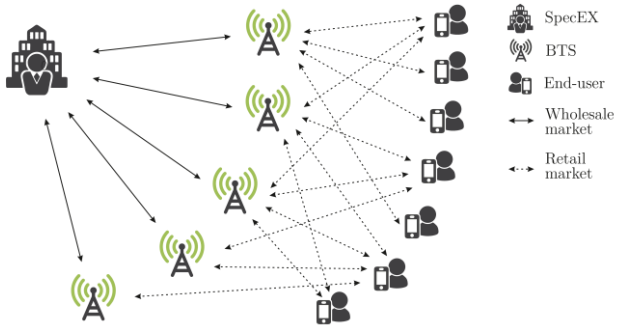
Network switching in an urban area

CONTRIBUTIONS

- Comprehensive overview of various real-time spectrum distribution mechanisms with a focus on one of the promising approaches called network switching.
- Presentation and analysis of unique agent-based model of wireless network implementing dynamic spectrum allocation. This model has the potential to make it easier for operators to enter the telecommunication market where spectrum distribution will take place in real time.
- Software platform capable of multi-user distributed parallel NetLogo simulations execution.

AGENT-BASED MODEL

Two stage NetLogo agent-based model implementing network switching mechanism featuring variable demand, price, end-users with acceptance probability and reinforced learning.



Hierarchy of the agent-based model

Wholesale market

- **Agents:** SpecEX (license holder) and operators
- Constant wholesale price of the spectrum unit
- Variable spectrum demand controlled by the Roth-Erev algorithm

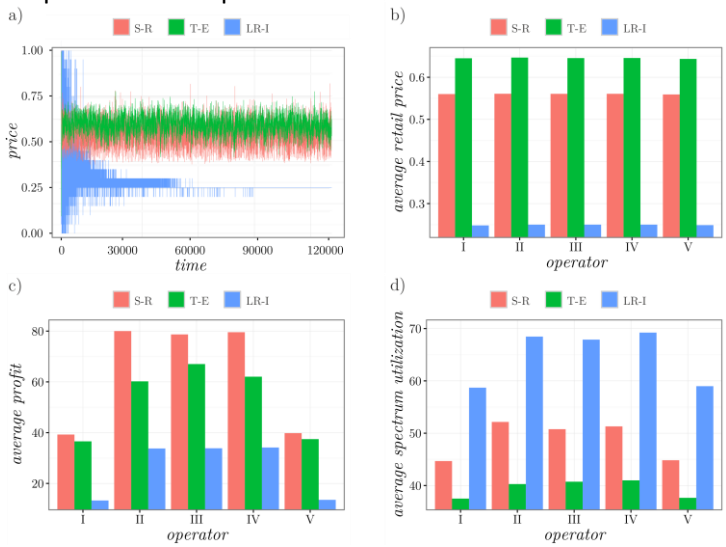
Retail market

- **Agents:** Operators and end-users
- Network switching model with the variable demand
- Real-time operator selection based on QoS and price of spectrum unit
- Retail price controlled by various mechanisms:
  - Linear reward
  - Successful ratio
  - Trial-and-error

Ongoing improvements of model include integration of OSM maps for better environment simulation with the real-world base station locations from OpenCelliD database.

RESULTS AND CONCLUSION

From the simulation results can be concluded, that the operators' profit and spectrum utilization is highly affected by chosen pricing mechanism and the forgetting and experimentation parameters of Roth-Erev reinforcement learning algorithm. In the more advanced pricing schemes, e.g., successful-ratio and linear-reward, the addition of the forgetting parameter significantly improves the performance in terms of the measured indicators, namely, the average profit and Sharpe ratio.



Effect of pricing schemes on the measured indicators

In addition, several notable phenomena emerged from the interactions of the agents. For example, price war between operators when Linear reward method was utilized or the classification of operators who take on the role of spectrum investors as either risk-averse or risk-seeking based on the pricing schemes utilized in the retail market.