



Algorithmic and Mechanism Design Research in Online Markets (AMDROMA) ERC Advanced Grant 2018 – 2023 PI: Prof. Stefano Leonardi

Aris Anagnostopoulos
Associate Professor

DIPARTIMENTO DI INGEGNERIA INFORMATICA
AUTOMATICA E GESTIONALE ANTONIO RUBERTI



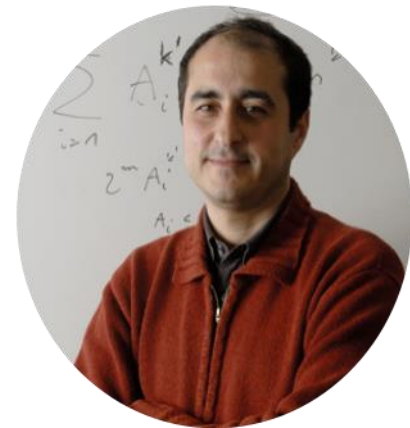
SAPIENZA
UNIVERSITÀ DI ROMA

PI: Stefano Leonardi

- Full Professor, Dept. Computer, Control, and Management Engineering
- Senior Fellow, Sapienza School of Advanced Studies (SSAS)
- Chair of the Master's degree in Data Science, Sapienza
- Chair of the Ph.D. degree in Data Science, Sapienza
- Fellow of the European Association of Theoretical Computer Science

Research Interests

- Algorithmic theory
- Algorithms and Data Science
- Economics and computation



Online markets

- Online markets form an important share of the global economy:
 1. Many classical markets moved to Internet: real-estate, stocks, e-commerce, ...
 2. New markets with previously unknown characteristics have emerged: web-based advertisement, viral marketing, digital goods, online labor markets, online dating, ...

An economy of algorithms

“In 2000, we had 600 humans making markets in U.S. stocks. Today, we have two people and a lot of software.

One in three Goldman Sachs employees are engineers.”

[R. Martin Chavez, Chief Financial
Officer at Goldman Sachs]

Online markets and algorithms

Algorithms take many economic decisions:

- Trade stocks
- Run Ebay auctions
- Price Uber trips
- Sell ads on webpages
- Price electric power in grids
- Decide matching in organ exchange
- Assign interns to hospitals and pupils to schools

Goal of the ERC advanced grant project Algorithmic and Mechanism Design Research in Online Markets (AMDROMA)

- Understand the principles of algorithm and mechanism design in online markets
- Combine several research areas:
 - economics and mechanism design (e.g., pricing, auction design)
 - algorithms for computationally hard problems
 - modeling market uncertainty in algorithms and mechanisms
 - data science and large-scale algorithmic data analysis

Application 1: Internet advertisement

- Major source of revenue of the internet industry, more than 70% for Google
- Electronic auctions are executed billions of times a day within the time frame of few hundred milliseconds
- Many new auction-design and big-data algorithmic problems are motivated by online markets



Application 2: Internet markets

- **Two-sided markets:** multiple service providers matched to multiple users
- Need a theory for markets run by algorithms
- Do prices that induce efficient equilibria between buyers and sellers exist?
- Provide incentives to service providers (convince Uber riders to get up at night!) and to consumers to stay in the market



Application 3: Online labor marketplaces

- Outsource complex tasks to workforce recruited on the crowd marketplace
- Algorithmic methods for job scheduling, task allocation, team formation, and distributed coordination
- Incorporate fairness and diversity in the algorithms



Project objective 1: Algorithms for auction and market design

- Algorithmic problems in online markets are not standard:
 - input is private information of economic agents
- **Algorithmic mechanism design** deals with the design of incentives that make agents to reveal honestly their private information to the algorithm
- We will study **algorithms and mechanisms** for
 - Two-sided markets
 - Market equilibria that are meaningful for online markets and that can be efficiently computed at very large scale

Project objective 2: Coping with uncertainty in online markets

- **Uncertainty** in decision making has been studied since many decades in **economics** and **computer science** to cope with lack of knowledge about input data and models:
 - Computer science: **worst case approach**
 - Economics: **Bayesian/average-case** approach

We plan to:

- Bridge the two approaches by developing new models which are **beyond** worst-case and average-case analysis of algorithms and mechanisms
- Study **machine-learning** techniques in online markets to extract knowledge through **sampling, explore-exploit methods**, and **multi-armed bandit** models

Project objective 3: Large-scale optimization of two-sided matching and clustering problems

- Algorithms for online markets are applied on **millions of users** and **billions of data points**
- We plan to study these big data problems for two fundamental data analysis primitives: **two-sided matching** and **clustering**.

We plan to develop efficient optimization algorithms for:

- **matching tasks to workers** in large-scale **on-demand labor marketplaces**
- **clustering problems** that will allow to better understand the economic structure of online markets

Outcomes and collaborations

- The project will employ about 5 PhDs and 5 postdocs for 3 years each. The postdocs will mostly be recruited from abroad.
- We plan a strong cooperation with University of Tel-Aviv, University of Warsaw, Google, Facebook, and many more academic and industrial partners.
- The project will strengthen Sapienza international leadership in the area of Algorithms and Data Science.