



H.F.R.I.
Hellenic Foundation for
Research & Innovation

Description of the funded research project
2nd Call for H.F.R.I. Research Projects
to Support Post-Doctoral Researchers

Title of the research project: Lifting Algorithms for Evolutionary Dynamics in Networks (LIFT)

Principal Investigator: Christoforos Raptopoulos

Reader-friendly title: Lifting Algorithms for Evolutionary Dynamics in Networks

Scientific Area: Mathematics and Information Sciences (ΕΠ5)

Institution and Country: University of Patras, Greece

Host Institution: Computer University of Patras, Greece

Collaborating Institution(s): -

**Project webpage
(if applicable): under construction**

Budget: 130,000.00 €

Duration: 36 months

Research Project Synopsis

Evolutionary dynamics in networks, i.e. rules through which a network may change its structure and node properties, is currently one of the most active research topics in network science and theory. Evolutionary dynamics originated from Mathematical Biology in the 19th century, for studying evolution in populations. The osmosis with Theoretical Computer Science and Mathematics came much later, among others due to the emergence of the Internet, the evolution of telecommunication networks and the continuously increasing number of networks deployed in dynamic environments.

In particular, in a network that changes based on evolutionary dynamics (e.g. an ad-hoc mobile network, a social network, but also a multicellular organism or a well-mixed solution of molecules) links may appear and disappear either due to random failure or choice. Furthermore, the nodes of the network are entities with various attributes and characteristics and may also evolve through time either actively (by changing the structure of the network) or passively (by updating their characteristics and personal knowledge). It is evident that, to study such networks, proper abstract models and theoretical analytical tools are essential. From an algorithmic perspective, one cannot guarantee that an algorithm designed for static graphs will reach its objective or achieve its complexity guarantees within the reality of today's networks.

Building on the gradually expanding literature on evolutionary dynamics on networks and on experience acquired from our previous research works and projects, in this project we intend to pursue the following objectives: (O1) Develop a bridge theory connecting well-defined parameters on evolutionary dynamics in networks to fundamental graph problems.

(O2) Sharpen the algorithmic toolbox for evolutionary dynamics in networks by exploring new algorithmic trends, paradigms and ideas.

Project originality

The originality of our project resides in the far-reaching objectives of the project. In particular, building on the gradually expanding literature on evolutionary dynamics on networks and on experience acquired from our previous research works and projects, we initially intend to: (O1) develop a bridge theory connecting well-defined parameters on evolutionary dynamics in networks to fundamental graph problems, and (O2) sharpen the algorithmic toolbox for evolutionary dynamics in networks by exploring new algorithmic trends, paradigms and ideas. To the best of our knowledge, such possibilities have not yet been considered systematically in the literature of evolutionary dynamics. With our research, we hope to provide new insights to the complexity of various network related problems, as well as pave the way for the design of new, improved algorithms in this area. To achieve our goals, we will advance the state-of-the-art and combine ideas and techniques from diverse areas of theoretical computer science related to the design and analysis of algorithms (e.g. MCMC methods and derandomization techniques, recent results from the Theory of Moments and the existence of pseudo-distributions, PSD programming and probabilistic rounding).

Expected results & Research Project Impact

Our research in this project will have an immediate impact in the communities of theoretical computer science; our ambitious goal to develop a bridge theory connecting evolutionary dynamics to fundamental graph problems will result in a fresh look to such problems, thus giving new algorithmic ideas to tackle complexity bottlenecks (at least) for special cases. Papers related to evolutionary dynamics in networks are regularly appearing at major international theory conferences, as well as to international journals with high impact factor. During this project, we will also collaborate with researchers from other universities working on related research areas and projects. This will help visibility of our research but will also increase extroversion of our group, thus enforcing career development for the members of the project. Our research will also be promulgated through presentations in conferences and special events, invited talks, research seminars held within the University of Patras but also within other Universities and Institutes.

We also note that, besides complementarity of our research with respect to the current literature and the impact of our envisioned bridge theory to theoretical computer science, we expect that our algorithmic work will be beneficial to various applications related to evolutionary dynamics in networks. Such applications straddle the areas of telecommunication networks (e.g. the study of ad-hoc mobile networks, wireless sensor networks), epidemiology (e.g. the study of virus spread, prediction/prevention of pandemic disease outbreaks), population genetics (e.g. the study of somatic evolution in multicellular organisms, like cancer), and psychology and sociology (e.g. spread of ideas or influence in social networks). Overall, we believe our proposed research can contribute to the improvement of the quality of life in quite broad aspects of modern society.

The importance of this funding

Our research in this project will have a positive impact on the careers prospects for all members of our research team. In particular, publishing in high impact factor journals and major theoretical conferences will improve publication numbers (h-index, citation index). These are important when applying for academic positions either in Greece or abroad. Furthermore, presentation of our work through invited talks and research seminars will strengthen existing collaborations and hopefully extend our collaborations with researchers worldwide that work on related areas. The junior members of our research team in particular, will be introduced to the theory pertaining evolutionary dynamics in networks, they will establish a solid background in topics including the design analysis of algorithms, graph theory, stochastic processes, etc. and will also become familiar with new algorithmic paradigms and ideas. Finally, our collaboration with other research groups worldwide will potentially open up job opportunities.



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