THE NETWORKS-COFUND PROJECT

Information Package for Postdoc Applicants

The NETWORKS members

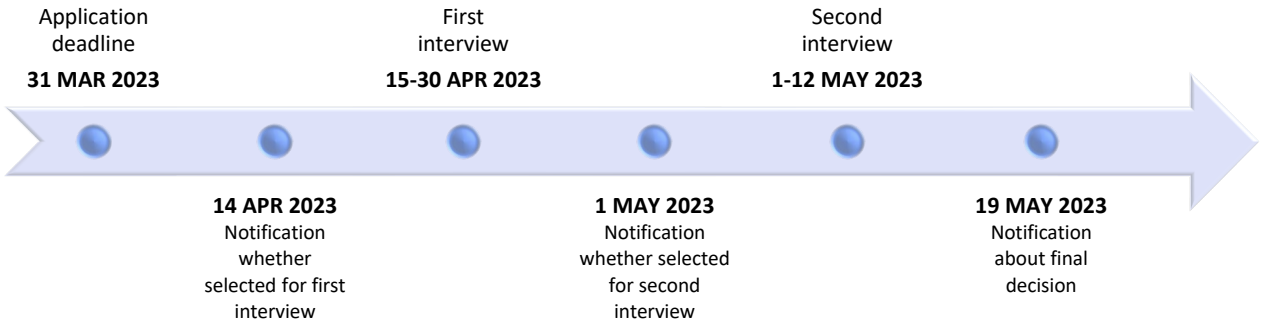
The NETWORKS project is a collaboration of world-leading researchers from four institutions in The Netherlands – TU Eindhoven, University of Amsterdam, Leiden University and the Centrum Wiskunde & Informatica (CWI) – focusing on the stochastics and algorithmics behind network problems. It offers a highly stimulating research environment and an extensive training program for PhD students and postdoctoral fellows from all over the world. Recently NETWORKS was awarded a COFUND grant from the Marie Skłodowska-Curie Actions (MSCA), funded by the European Commission. The grant allows NETWORKS to expand its activities by opening positions for 14 international postdoctoral fellows.

From the start of the programme in September 2021, 8 positions have been filled. Another 6 positions are offered in the present call. In this document you can find more information about the research themes studied in the project, the potential supervisors and their research projects, and the application procedure, including eligibility criteria.

Contents

Overview of selection process and important dates

In a nutshell, the selection process is as follows. After the application deadline (31 March 2023) the Selection Committee will make a longlist of candidates who will be invited for a first interview. Based on these first interviews, the Selection Committee will make a shortlist of candidates who will be invited for a second interview. During the second interview you will be asked to give a 15-minute presentation: 30% about your PhD project or your first postdoc project and 70% about your research plans. After the second interview, a final decision will be made about whether you will receive an offer for one of the available positions. The dates of the various steps in the process are listed below.



Possible research projects

Research in NETWORKS focuses on *stochastics* (including queueing theory, random graphs, stochastics processes, stochastic optimization) and *algorithmics* (including computational geometry, graph theory and algorithms, combinatorial optimization, quantum algorithms, algorithmic game theory) for *network* problems. In Appendix A you can find a list of supervisors and their research interests.

For more information on potential supervisors and their research interests, see Appendix A.

Research opportunities and Training Program

The core of your appointment will be to perform research, in collaboration with and coached by your supervisor(s). NETWORKS offers an excellent environment for research. In addition to the main supervisor, you will be assigned a second supervisor who brings in additional expertise. Supervisors work very closely with their postdoctoral fellows and PhD students, to maximize the quality of the research. You will also have a generous travel budget, allowing you to visit international conferences, workshops, summer schools and research visits to universities outside The Netherlands.

NETWORKS offers an extensive and inspiring training program. The program includes the components listed below. In addition, there are several other NETWORKS events that you will participate in.

Training Weeks. NETWORKS organizes two Training Weeks per year. Each Training Week comprises two *mini-courses*, one on a topic from stochastics and one on a topic from algorithmics. Next to the mini courses there are *research presentations* by NETWORKS researchers (PIs or other staff members, postdocs and PhD students) about their current work, and *working sessions* where participants can collaborate on research problems. The Training Weeks are held at off-campus locations, to maximize social interaction and community building among the NETWORKS researchers.

Community building event

Industrial Internships. Each postdoc will be involved in an internship of 2-3 months in a non-academic environment, either as co-supervisor of a PhD student doing an extensive internship or working on your own project.

Professional skills courses. There is a variety of courses on professional skills and personal development available to NETWORKS members. These include courses on technical writing and giving presentations, developing teaching skills, personal effectiveness, and more. Together with your supervisor, you decide on a personal course program. A course on Analytic Story Telling is mandatory.

The research and training program of NETWORKS offers you excellent opportunities for a future career, be it in academia, government, or industry. NETWORKS graduates found jobs at top academic institutions, both in and outside Europe (including MIT, Georgia Tech, Warwick University, and Max-Planck-Institut für Informatik), at major multinationals in the high-tech and financial industry (including Microsoft, Google, PriceWaterhouseCoopers and ABN-AMRO), and at medium-size companies and start-ups.

Selection criteria

We are looking for enthusiastic and motivated applicants with a background in *mathematics* (in particular stochastics) and an affinity for *computer science*, or with a background in *computer science* (in particular algorithms) with affinity for *mathematics*. You have strong analytical skills, are creative, are open to collaborations with a wide range or partners, and are motivated to do top-level research in an interdisciplinary setting.

The evaluation criteria are:

- Quality of your research proposal (50%):
  a) the originality and ambition of the project, the extent to which it is feasible, appropriate consideration of inter- and multi-disciplinary aspects;
  b) the approach and proposed research methodology, feasibility of proposed time-scale;
  c) societal use, exploitation and dissemination.
- Your experience as a researcher and your skills (40%):
  a) track record in performing research, knowledge and experience, evidence of creative thinking, independence and leadership potential;
  b) verbal and oral communication skills (in English), potential for rapidly gaining new skills.
- Commitment to the project, open mindedness, motivation for NETCO-PD (10%).

Application procedure and eligibility criteria

In order to be eligible, make sure you send **your complete application before the deadline** of the call. At the starting date of your employment as a postdoctoral fellow in the NETWORKS COFUND program, you should be in possession of a PhD degree or obtain one within three months. We focus on training researchers in the early stages after their PhD, so you have ***at most*** three years full-time post-PhD-degree research experience at the date of recruitment.

Moreover, you meet the mobility requirement of the MSCA, which encourages transnational, intersectoral and interdisciplinary mobility. The mobility requirement is: You may not have resided or carried out your main activity (work, studies, etc.) in the Netherlands for more than twelve months in the three years immediately before the call deadline.

You should fill in the online application form and **provide the following documents combined in one pdf**, in English:

- A proposal (about 3-5 pages) with your research idea and main aim(s), briefly describing approach, methodology, challenges, originality, time table, required training, ethical issues, and potential societal use.
- A motivation letter that must, among other things, mention the research theme(s) you are interested in and/or the NETWORKS research groups or supervisors you would like to work with.
- A CV, a copy of your PhD degree and your PhD thesis.
- The names and email addresses of up to three references, who will be contacted by us for recommendation letters.

Diversity and equal-opportunities policy

NETWORKS values an inclusive and diverse working environment, and we encourage all candidates to apply, irrespective of their gender, religion, sexual orientation or disabilities. When evaluating the candidates, we will take parental leave and other personal circumstances into account, and we will strive for a diverse composition of the appointed postdoctoral fellows.

Employment conditions and support

As a postdoctoral fellow in the NETWORKS-COFUND program, you will be appointed at the institution of your main supervisor (TU Eindhoven, University of Amsterdam, Leiden University, or CWI). Appointments at TU/e, UvA and LU will follow the Collective Labour Agreement (CAO) of Dutch Universities, and the appointments at CWI will follow the CAO for Research Centres (which is essentially the same). The salary will be €2,960 to €4,670 gross per month, based on a fulltime contract (38 hours a week).

The starting date is flexible, but must be no later than 1 January 2024.

The HR department of the institution where you will be employed will assist you in obtaining a visa and work permit if needed. They can also help you with looking for housing.

Appeal procedure

If you feel your application has been rejected on improper grounds, then you can appeal the decision. You should do so within 14 days of the decision by sending an email to the Managing Director of the Mathematical Institute at Leiden University, dr. P.M. Overgaauw (mi-instituutsmanager@math.leidenuniv.nl).

Contact

If you have any questions, please contact info@thenetworkcenter.nl.

Appendix A: List of NETWORKS supervisors

Mark de Berg (TU Eindhoven)
Mark de Berg's research focuses on algorithms and data structures for spatial data. Spatial data—points, lines, or other geometric objects in 2- or higher-dimensional space – play an important role in many application areas and give rise to challenging algorithmic problems. A central theme in Mark de Berg's work is the question: How can we exploit the properties that real-world spatial data sets often possess to obtain provably efficient algorithms? His current research interests include algorithms for geometric intersection graphs and other types of geometric networks, and algorithms for maintaining near-optimal solutions to dynamic geometric optimization problems.

Frank den Hollander (Leiden University)
Research of Frank den Hollander is on probability theory, with a focus on interfaces with statistical physics, population genetics and complex networks. This includes the study of phase transitions and other critical phenomena in random graphs, random matrices, and disordered media.

A possible topic for a research project is on co-evolution: dynamic processes on dynamic graphs.
In past years, extensive research has produced a comprehensive theory for static networks, focusing on the structure of networks and on the processes that evolve on them, such as flow of information, disease, traffic or energy. In contrast, the understanding of processes on dynamic networks, themselves evolving over time, is still in its infancy and is presently limited to a handful of instructive examples. Since double dynamics are prevalent in most real-world networks, there is an urgent need for breakthroughs.

The target in this project is the highly challenging setting of co-evolution, where the network dynamics not only influence the processes evolving on the network, but also vice versa. This leads to a complex two-way feedback interaction, which we want to capture mathematically. Our focus will be on two examples of co-evolution: (1) voter-model-like opinion dynamics on evolving random graphs, with the goal to describe polarisation; (2) contact-process-like infection dynamics on evolving random graphs, with the goal to describe super-spreading.

Other researchers involved in the project: Luca, Avena (Leiden University), Rajat Hazra (Leiden University), Michel Mandjes (University of Amsterdam).

Stella Kapodistria (TU Eindhoven)
Stella Kapodistria performs research in the field of applied probability and stochastic operations research (SOR). One of her current research interests is in designing of optimal or near optimal online polices for decision making under uncertainty. The research is fundamental in nature, but is inspired by real-lifeproblems arising from practical situations.

The proposed topic for the postdoc is primarily focused on binary decisions for SOR applications. Decisions of the form 'act' versus 'do not act'. Such binary decisions have a wide appeal in logistics applications (e.g., in maintenance and in supply chains) and in communication networks (e.g., in call centers and in queueing). This line of work extends the theory of multi armed bandit problems as here

the decision affects the future dynamics of the underlying process. Furthermore, in contrast to the classical exploration vs exploitation setting typically seen in multi armed bandit problems, for the aimed SOR applications, data is very limited (dreath of data) and the problems are vastly complex. Leading to significant computational limitations and algorithms that do not scale efficiently (scalability of approaches for complex problems). The aim is to gain a better understanding on the nature / structure of the underlying optimal policies, to define indexes that can lead to the efficient computation of the optimal policy, and to develop efficient, scalable algorithms with guaranteed performance (e.g., convergence, rate of convergence, gap to optimality).

Nelly Litvak (TU Eindhoven)

Nelly Litvak performs research on algorithms for complex networks, in particular, social networks, and the world wide web. The main goal of this research is to explain structures and processes in real-world networks. The tools are the mathematical theory of stochastic processes, random graphs, randomized algorithms, and, since recently, machine learning. Applications include web ranking, community detection, prediction of changes in the world wide web, and prediction of spreading of infectious diseases. Since the start of the COVID-19 pandemic, she leads an interdisciplinary consortium that develops data- and model-driven tools for pandemic prediction and preparedness.

We are looking for a motivated excellent postdoc candidate in the field of random graphs and network science. The project aims to mathematically predict performance and outcomes of algorithms for inference and control of real-life complex networks, such as social networks, mobility networks, and the World Wide Web. The analysis will mainly rely on recent methodological developments in the theory of random graphs. The algorithms of interest include, but are not limited, to clustering and community detection, ranking, epidemic containment, and graph embedding. While there is a lot of research on design, implementation and applications of such algorithms on real-world data, the problem of their rigorous mathematical analysis is much less addressed. Such rigorous analysis will shed light on applicability of the algorithms, and ensure the correct interpretation of their outcomes. The candidate will have significant freedom in defining their own specific research questions and methods.

Michel Mandjes (University of Amsterdam)

Michel Mandjes performs research in the field of applied probability and stochastic operations research. A main role is played by applications of stochastic network theory in the design and control of various types of service systems. One of his current topics of interest lies in problems related to systemic risk, in which a financial network is to be reconstructed from partial observations. In addition, he has recently focused on algorithms for traffic management in large scale transport systems, including statistically sound procedures to estimate the required input parameters.

Two positions are available.

For position 1 we are seeking a postdoc candidate in the field of the broader area of stochastic processes and their applications. Research could focus on any special class of processes, such as population processes, queues, (reflected) Gaussian processes, Hawkes processes etc., with emphasis on multivariate versions and network models. Potential research lines could concern scaling limits, large deviations, and rare-event analysis. Another possible direction lies in the estimation of model primitives from network data (for instance in the context of stochastic processes flowing on a randomly evolving graph). Depending on the specific topic chosen, prof. Roger Laeven could be involved in the supervision.

For the second position we are seeking a postdoctoral fellow interested in studying mathematical network models and their applications. Potential application areas cover the social sciences (opinion dynamics, polarisation phenomena), economics (systemic risk, resilience) and civil engineering (road traffic models, congestion). The precise angle is still open: the research topic chosen could focus on gaining insight into qualitative behaviour (e.g. polarisation versus consensus), or rather in the design and control of networks (e.g. load balancing in transport networks). Depending on the specific topic chosen, prof. Frank den Hollander or prof. Drona Kandhai could be involved in the supervision.

Appendix B: The NETWORKS project and research themes

Networks for communication, transportation, finance and energy form the backbone of modern society. Reliable and efficient network infrastructures are of enormous economic and social value, and their importance will only increase in the coming years. Researchers in the NETWORKS project perform research in *stochastics*, to model and understand large-scale networks (and to predict network growth and network processes) and *algorithmics*, to control and optimize networks and network processes in the best possible way. The research is of a fundamental nature: the goal is to develop new theory in the areas of stochastics and algorithms, thus proving a deeper understanding of mathematical and algorithmic techniques needed to model, control and optimize (processes on) networks.

The NETWORKS research program is organized around eight themes. These themes should not be interpreted as disjoint research lines, but rather as "views'' that stress different aspects. Some themes focus on algorithmic techniques (Approximate and exact network methods, Quantum network algorithms), others on different structures of networks (Spatial networks), on dynamic networks and network processes (Dynamics on networks, Dynamics of networks), and on specific applications (Transportation networks, Communication networks and Energy networks).

Theme 1: Approximate and exact network methods. Algorithmic problems concerning the design, optimization, and control of networks are often NP-hard, meaning that no efficient algorithms exist that solve these problems optimally on all possible instances. We study two approaches to deal with this. One is to develop approximation algorithms, which are guaranteed to compute near-optimal solutions. Another is to exploit that not all input instances are equally hard: some enjoy structural properties that can be exploited to efficiently compute an optimal solution.

Theme 2: Spatial networks. Many real-world networks are spatial: nodes have a location in space and edges are defined by physical connections or geographic proximity between the nodes. Typically, connections between nearby nodes are more abundant than connections between distant nodes, yet long-range connections play a crucial role in the behaviour that these networks exhibit. In addition, a high variability in the degrees of the nodes is observed. We study how and in which situations it is possible to exploit the geometry of the network, to obtain better solutions to network problems.

Theme 3: Quantum network algorithms. Quantum computers are based on the laws of quantum mechanics. They hold great promise as a future generation of hardware, since computing with qubits—a qubit is the quantum equivalent of a classical bit—allows for massive parallel computing. NETWORKS focuses on quantum software for networks problems. A key question is which computational problems can be solved significantly faster on quantum computers, and which are still very hard. NETWORKS collaborates with QuSoft Amsterdam, the first research centre in the world exclusively dedicated to quantum software.

Theme 4: Dynamics of networks. Networks evolve over time, in a way that is typically closely related to their functionality. The theory of random graphs is an essential mathematical tool to model real-life network structures as stochastic objects that grow in time according to certain local growth rules. By adapting these rules, different types of dynamic network behaviour can be captured and analysed. Within NETWORKS we develop and analyse random-graph models and we investigate which models are best for which applications.

Theme 5: Dynamics on networks. Network functionality can often be described in terms of stochastic processes taking place on networks. Mathematical theory that applies to real-world networks is scarce, however, since existing theory focuses on random processes in very regular networks such as grids, while real-world networks are usually highly irregular. Within NETWORKS we investigate how the behaviour of stochastic network processes is affected by the irregular structure of the network, in particular, the presence of “hubs”.

Theme 6: Transportation networks. The efficient usage of road, railway and other transportation networks poses many mathematical challenges. The challenges arise in all stages, from the design of the network, to the regulation of network traffic, and the maintenance or expansion of the network. Research within NETWORKS deals both with structure-related issues (planning and dimensioning of transportation and traffic networks) and with the operations on existing networks (routing, scheduling and other traffic management mechanisms relating to shorter time scales).

Theme 7: Communication networks. Communication networks need to be designed to consistently achieve high levels of performance and reliability, and yet be cost-effective to operate. This is highly challenging because of the variability in network traffic as well as the enormous complexity of communication networks such as the internet. We study e.g. how processes on networks (such as the spreading of viruses, fake news, etcetera) evolve and can be controlled, and how to construct and control communication networks to maximize efficiency.

Theme 8: Energy networks. The shift towards renewable energy sources such as wind and solar energy is causing a significant variability in supply to electricity networks. As a result supply and demand may no longer match at any given time, leading to serious reliability issues and loss of efficiency. Our research aims at getter a better grip on this by developing and analyzing novel mathematical models for energy networks.

Appendix C: Information about the four institutions

TU Eindhoven

The TU Eindhoven (TU/e) is a technical university with nine departments, approximately 2000 scientific staff (including PhD students) and 8000 BSc and MSc students. The Department of Mathematics and Computer Science is the largest of these departments, offering several bachelor and master programs, all of which are taught in English. The TU/e campus is in the center of Eindhoven, a lively city in the heart of the high-tech industry in the Netherlands. Including suburbs, Eindhoven has about 400,000 inhabitants, making it the fifth largest city of the Netherlands. There is no need to own a car: within Eindhoven everything is reachable by bike, and other cities in the Netherlands can be easily reached by public transport.

More information:

- General information about TU/e and the Department of Mathematics and Computer Science
- Employment conditions at TU/e
- Support for internationals

University of Amsterdam

The University of Amsterdam is the Netherlands' largest university, offering the widest range of academic programmes. At the UvA, 30,000 students, 6,000 staff members and 3,000 PhD candidates study and work in a diverse range of fields, connected by a culture of curiosity. The UvA counts over a hundred different nationalities. The UvA is consistently ranked among the world's best universities in global rankings. It is a top 100 university in the THE Rankings, QS Rankings and Leiden Ranking. The UvA is also member of the League of European Research Universities and Universitas 21. The UvA is working to consolidate its teaching and research activities within four campuses including Amsterdam Science Park. Amsterdam Science Park is a centre for research innovation and entrepreneurship. Major research institutions are located here alongside about 120 companies and spin-offs.

- General information about UvA and the Faculty of Science
- Working at UvA
- The UvA in Amsterdam

Leiden University

Leiden University was founded in 1575. It is one of Europe's leading international research universities, with currently 31,000 students and 7100 staff, spread over locations in Leiden and The Hague. The university hosts 3000 international and exchange students each year, and has 1000 international PhD students and 800 international academic staff. Leiden University features among the top 100

universities in international rankings. Its membership in the League of European Research Universities is of particular strategic importance. The city of Leiden has 125,000 inhabitants and is known for its centuries-old architecture. University buildings are scattered throughout the city and students give the city a bustling and vivid atmosphere. The many important scientific discoveries made at the university over the past centuries have led to the motto: 'Leiden: City of Discoveries'.

- About Leiden university
- Working at Leiden University

Centrum Wiskunde & Informatica (CWI)
CWI is the Dutch national research institute for mathematics and computer science. Next to other research topics, main research themes are artificial intelligence, computation, data, networks, software, and quantum. By creating a synergy between mathematics and computer science, CWI pursues fundamental and long-term innovation and has been the birthplace of numerous pioneering breakthroughs. Our strength is discovering and developing new ideas that benefit society. Located at the Science Park of the vibrant city of Amsterdam, CWI is surrounded by many inspiring people and organizations. CWI plays a key role in academic networks, and maintains excellent relations with universities and industry. At CWI over 175 researchers conduct pioneering research and share their acquired knowledge with society. Over 30 researchers are also employed as professors at universities.

More information:

- General information about CWI
- Working at CWI