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.

The postdoctoral fellows are recruited in two calls: the first call is open from 1 October 2021- 15 November 2021; the second call will open in Spring 2022. 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.

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Overview of selection process and important dates

In a nutshell, the selection process is as follows. After the application deadline (15 November 2021) 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 these second interviews, 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. The listed dates refer to the first call. There will be a second call opening May 1, 2022.

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) for network problems. In Appendix A you can find a list of supervisors. Part of the application procedure is to write a research proposal. Based on your preference for one or more supervisor(s) and your proposal, you will be matched with one of the research groups.

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 this. 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 can participate in.

Training Weeks. NETWORKS organizes two Training Weeks per year. The morning sessions in each Training Week are devoted to two *mini-courses*, one on a topic from stochastics and the other on a topic from algorithmics. The afternoon sessions feature *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 PhD student will do an internship of 2-3 months in a non-academic environment, typically in the second or third year of her/his PhD.

Professional skills courses. There is a variety of courses on professional skills and personal development available to NETWORKS PhD students. 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.

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 for 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 obtaining 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 starting date of your employment.

Applications should be done through the online system available at the NETWORKS website. 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;

In the online application system you can supply 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 Employment 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 €2,836 tot €4,474 gross per month, based on a fulltime contract (38 hours a week).

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 when looking for housing.

Appeal procedure

If you feel your application has been rejected on improper grounds, 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. A.E.M. (Mieke) Schutte (A.E.M.Schutte@math.leidenuniv.nl).

Contact

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

Appendix A: List of NETWORKS supervisors

Luca Avena (Leiden University)
Luca Avena's research activity is in probability theory with a focus on problems coming from statistical physics and network science, related to the theory of so-called random walks and disordered media. Fundamental interests are on the rigorous analysis of models of random motion in non-homogeneous networks with possibly random space-time features. From a more applied side, he has been recently active in developing randomized exploration algorithms for network data sets using random walks and related random combinatorial objects such as rooted spanning trees and forests. Both these fundamental and more applied lines of investigation heavily rely on a deep understanding of the delicate interplay between the behaviour of Markovian dynamics on a given graph and the spectral properties of the associated adjacency and Laplacian matrices.

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?

Sem Borst (TU Eindhoven)
The research activities of Sem Borst focus on evaluating and optimizing the performance and reliability of large-scale systems that operate under randomness and uncertainty. Typical examples of such systems are communication networks like the Internet, data centers, energy systems, supply chains, transportation networks and hospital operations. While the research topics are strongly inspired by applications, the approach is foundational in nature and driven by mathematical rigor. Key methodological tools in the analysis are stochastic processes, random walks, queueing theory and asymptotic scaling methods. The optimization involves distributed control, resource allocation and scheduling algorithms, with data-driven optimization and stochastic learning techniques playing an increasingly prominent role as well.

Jop Briët (Centrum Wiskunde Informatica)
Jop Briët does interdisciplinary research that combines areas including quantum information theory, additive combinatorics and Fourier analysis and Banach / operator spaces. Examples of how these areas meet include using classical operator space results to characterize quantum algorithms in terms of multivariate polynomials and applying additive combinatorics techniques in the study of quantum entanglement. His current interests include developing non-commutative branches additive combinatorics and of Fourier analysis over the boolean hypercube.

Rajat Hazra (Leiden University)
Rajat Hazra's research focuses on spectral properties of random matrices with dependence and inhomogeneity. Random matrices are important in the study of high dimensional problems in statistics, compressed sensing, random graphs etc. Due to the complex structure of modern networks, inhomogeneity and dependence becomes an inherent part of them. The study of a random matrix requires tools from graph theory, combinatorics, non-commutative independence like free independence. His current interest lies in the spectrum of adjacency and Laplacian matrix of inhomogeneous random graphs. Apart from random matrices and random graphs, he is interested in random interface models, sandpile models and long range percolation.

Remco van der Hofstad (TU Eindhoven)
The research of Remco van der Hofstad focuses on the structure and function of random graph models for complex networks, as well as mathematical statistical physics particularly in high dimensions, and the relations between these topics. The research is fundamental in nature, but is inspired by, and reaches out to, application domains. Examples are the study of the critical nature of percolation and the behavior of random walks on static and dynamic random graphs, as well as more realistic models for the spread of diseases on random graph models with and without geometry. A particular challenge lies in the development of dynamic random graph models whose dynamics is spurred by the dynamics on the network, a topic that is highly relevant for models of the brain and of disease evolution.

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.

Bart M. P. Jansen (TU Eindhoven)
Bart Jansen's research focuses on algorithms which solve NP-complete problems exactly, but whose running time scales exponentially with some complexity parameter of the input. Modeling a network as a graph yields many interesting ways to measure the complexity of the graph, for example via the notion of treewidth. Many NP-complete problems are known to be efficiently solvable on input graphs whose treewidth is bounded, but graphs of bounded treewidth are quite restricted. A central goal in Bart Jansen's research is therefore to develop algorithms which are provably efficient on larger classes of inputs by exploring less restrictive complexity parameters.

Stella Kapodistria (TU Eindhoven)
Stella Kapodistria performs research in the field of applied probability and stochastic operations research. 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.

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 developing "inversion techniques" which infer the characteristics of the stochastic processes that feed into a network, solely based on performance measurements from that network. 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.

One of Mandjes' ambitions in the context of the COFUND program is to apply concepts of complex networks so as to develop techniques to assess the vulnerability of economic networks. Such an econophysics-based approach has huge application potential for major banks (and national banks) to manage the systemic risk of their portfolio.

Viresh Patel (University of Amsterdam)
Viresh Patel's research interests lie in the general area of graph theory and combinatorics. A specific topic of interest is extremal combinatorics: which conditions imposed on graphs guarantee the existence of certain desired substructures? For example, how can we guarantee the existence of a Hamilton cycle in a graph? This is often well understood for "dense" graphs but often more difficult for "sparse" graphs; it has connections to the famous travelling salesman problem. Other topics Viresh Patel is interested in, are decomposition problems (when is it possible to partition the vertices or the edges of the graph such that each part has some desired property?) and computational counting (this is about fast algorithms to approximately count combinatorial objects and more generally to evaluate graph polynomials and partition functions).

Solon Pissis (Centrum Wiskunde Informatica)
Solon Pissis conducts research in the broad area of algorithms and data structures. Research topics he is interested in include algorithms and data structures on strings and labeled networks for pattern matching, indexing, comparison, and finding regularities. These topics are collectively known as combinatorial pattern matching. Combinatorial pattern matching methods are typically the workhorse of computational molecular biology applications, where the raw data to be analysed are DNA, RNA or protein sequences. We are interested in such applications but also in other applications processing sequential data, such as data mining (in particular, data privacy), data compression or information retrieval applications.

Frits Spieksma (TU Eindhoven)
Frits Spieksma is interested in combinatorial optimization problems—for example routing, clustering, and scheduling problems (in particular sport scheduling)—and he studies both their theoretical properties as well as in their applications. Understanding the precise solvability of such problems is the driving theme of his research.

Leen Stougie (Centrum Wiskunde & Informatica, Amsterdam)
Leen Stougie's main research area is the design and analysis of algorithms for combinatorial optimization problems, usually in relation to complexity theory. Optimization under uncertainty is recurring theme: stochastic programming, on-line optimization. Main application areas for his work are in the life sciences (phylogeny, metabolic networks) and logistics (routing and scheduling). In scheduling he studies classical models from a new point of view, usually inspired by a practical application, like introducing scenarios to model uncertainty, and fixed order scheduling with buffers. Recently he joined Solon Pissis in projects on data privacy with application in health data. Even more recently he got involved in exploring optimization with machine learning.

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