NET WORKS

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THENETWORKCENTER.NL

ANNUAL REPORT 2019

The year 2019, the sixth year of NETWORKS' funding period, has again been highly successful. The core of the program remains its high-quality scientific research, but also in other dimensions many highlights can be reported.

2019 was a year in which we have been looking forward as well as back. Most PhD students of the 'first batch' have defended their theses, or will do so very soon, and the 'second batch' is now gradually starting. Motivated by this changing of the guards, we have been intensively rethinking the program's organization, orientation, and objectives.

Many of the measures we have developed over the past years have turned out to be very effective, and will therefore remain in force in the next years of the program. From the start of NETWORKS, our policy was that each PhD student is assigned two supervisors, preferably from different partners and with different scientific backgrounds. Looking back, we have concluded that this approach worked out extremely well for the students, providing them with the broadest possible education. Moreover, it gave supervisors the chance to tap into each other's expertise, the side effect being that the connections between the senior researchers became tighter. In addition, all students are expected to do an internship at either another research team within the consortium or at a research institute abroad.

Another important element of our educational program is formed by the Training Weeks. These are aimed at all NETWORKS members, junior and senior, and consist of mini courses, research presentations and (typically very lively) open problem sessions. This interaction between the program members has triggered various new projects, also between researchers from different consortium partners.

Based on the advice provided by a committee of "Critical Friends", who helped us prepare our midterm review in 2017, as well as our Scientific Advisory Board, we have decided to put a stronger focus on valorization and interdisciplinarity. In this respect, we'd like to mention that we have been setting up ties with research teams from the social sciences and economics, culminating in a joint workshop early 2020. In addition, a substantial research effort is devoted to various aspects of road traffic networks, in which we team up with researchers from TNO, TU Delft, and other leading institutes. In various sub-projects, methods from statistics, and the data sciences at large have become considerably more prominent.

After the first PhD defenses in 2018, many PhD students who joined NETWORKS in the first years have graduated in 2019. In this respect, we are proud to mention that three PhD students obtained their degree with distinction: Sándor Kisfaludi-Bak, supervised by Mark de Berg at TU/e, for his thesis "ETH-Tight Algorithms for Geometric Network Problems", Pieter Kleer, supervised by Guido Schäfer at CWI, for his thesis "When Nash met Markov: Novel results for pure Nash equilibria and the switch Markov chain" and Clara Stegehuis, supervised by Remco van der Hofstad and Johan van Leeuwaarden at TU/e for her thesis 'Networks with communities and clustering'. Both Sándor and Pieter have joined the Max-Planck-Institut für Informatik in Saarbrücken as postdocs. Clara has been appointed at Twente University as Assistant professor. We are happy to see that all graduated students found prestigious new

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positions, in academia as well as industry, so that the NETWORKS legacy is spreading.

The outreach activities of NETWORKS have been scaled up due to the appointment of Nicos Starreveld by the end of 2018. As a consequence, we could allocate more capacity to the organization of masterclasses and the development of the Network Pages. The masterclass “NETWORKS goes to school” has been set up in a slightly different way than before, in order to facilitate a higher number of high school students to participate: in Eindhoven as many as 25 students registered, and in Leiden 48 students. Within the context of the Network Pages, collaborations have been started with Pythagoras (a math journal for young people) and the Quantum Universe (a popular-scientific website about physics), so as to reach out to a broader audience.

Much attention has been paid to intensifying interactions with partners from outside the consortium. In addition to earlier realized alliances with the ARC Center of Excellence for Mathematical and Statistical Frontiers (ACEMS, Australia) and the Indian Statistical Institute (ISI), we have set up a partnership with the EPSRC Centre for Doctoral Training in Statistical Applied Mathematics (SAMBa) in Bath, United Kingdom. In addition, there are joint PhD students between TNO and UvA, working in the field of road traffic networks, and between TNO and TU/e, working on wireless networks. A collaboration with CBS and ING is currently taking shape, aiming at applying network-theoretic techniques to describe banking and inter-company networks, and to understand their dynamics.

This annual report provides an overview of the NETWORKS activities in 2019. Additional information can be found on our website (www.thenetworkcenter.nl) and on the Network Pages.

Michel Mandjes (Project Leader)
Marieke Kranenburg (Project Manager)

Best Paper Award ceremony at ISCAAC 2019

RESEARCH THEMES

THEME 1: APPROXIMATE AND EXACT NETWORK METHODS

The design, optimization, and control of networks lead to a large variety of challenging algorithmic problems. Unfortunately, many of these problems are NP-hard, which means that there are no efficient algorithms that solve these problems optimally on all possible instances. Nevertheless, NP-hard network problems need to be dealt with in practice. One approach to is to develop approximation algorithms, which are guaranteed to compute solutions that are very close to an optimal solution. Another approach is to exploit the fact that not all input instances are equally hard: some instances enjoy structural properties that make it possible to compute an optimal solution in an efficient manner. In Theme 1 we explore these and other approaches to algorithmic network problems.

HIGHLIGHTS

- Determining the robustness of a network is one of the most prominent problems in network analysis. The Vertex Multiway Cut problem is a prime example. Given a graph and a set of terminal vertices in the graph, the problem asks to find the smallest number of node failures that can leave the terminals unable to communicate with each other. Bart Jansen (TU/e), together with Marcin Pilipczuk (University of Warsaw) and Erik Jan van Leeuwen (Utrecht University), develops a provably efficient preprocessing algorithm for dealing with the problem for planar graphs: it gives a procedure that, given any planar graph G with terminal set T and desired multiway-cut size k, can be compressed to an equivalent instance on a graph G' whose size is polynomially bounded in k. The same procedure can also be used to obtain a deterministic polynomial-size kernel for the Odd Cycle Transversal problem, which was an open problem from the literature ever since a randomized algorithm to compute such a kernel was presented in 2012.

- Computing the number of induced copies of a given pattern H in a graph G generalizes many classic graph problems. For example, deciding if G has an independent set of size k can be reduced to computing the number of induced copies of a pattern H consisting of k isolated vertices. Computing induced subgraphs is also closely related to determining subgraph counts and homomorphism counts, which play a central role in the theory of graph limits and frequently appear in statistical physics. Viresh Patel and Guus Regts (UvA) developed a novel approach for this problem, which significantly improves the previously best-known algorithms and which is optimal under the Exponential-Time Hypothesis.

- Optimization problems on networks arise in many practical applications, and NETWORKS researchers contribute to a better understanding of and more effective solutions to such problems. An inspiring example is the problem of matching donors and recipients in kidney exchange programs. Such programs try to capitalize on the fact that certain patients (potential recipients) may know someone who is willing to be a donor, but where the donor and patient are incompatible. If there are multiple such patient-donor pairs, then it may be possible to create a cycle of patient-donor pairs such that each patient in the cycle receives a kidney from a compatible donor in the cycle. Frits Spieksma (TU/e) and co-workers show how to model this as an optimization problem on a directed graph. They also discuss the constraints

put on the solutions in the kidney-exchange programs currently active in various countries in Europe and solutions strategies for the resulting optimization problems. Future cross-national exchange initiatives as well as future algorithmic research may benefit from this.

THEME 2: SPATIAL NETWORKS

In many applications, the networks under consideration are embedded in space, leading to geometric networks. Examples are railway networks, where nodes correspond to stations and edges to railway tracks, and large molecules, where nodes correspond to atoms and edges to chemical bonds. In many real-world networks, the geometry is an important feature that is hard to treat mathematically. Typically, connections between nearby nodes are more abundant than connections between distant nodes, yet long-range connections play a crucial role in the small-world behavior these networks exhibit, i.e., all vertices are connected via short connecting chains. In addition, a high variability in the degrees of the nodes is observed. A key spatial stochastic model is percolation, while a well-known algorithmic problem where geometry plays a key role is the Euclidean traveling salesman problem.

HIGHLIGHTS

- In a joint project with Sandeep Juneja (TIFR, Mumbai) and Sarat Moka (University of Queensland), Michel Mandjes (UvA) developed an efficient importance sampling based rejection methodology to perfectly sample specific hard-sphere models. The analysis includes the assessment of the expected running time complexity of the proposed method in the regime that the intensity increases to infinity while the (expected) sphere radius decreases to zero at varying rates. The performance was compared analytically and numerically with a naive rejection algorithm and popular dominated Coupling-from-the-Past algorithms.

- In their project on spatial populations with seed-bank, Margriet Oomen (UL) and Frank den Hollander (UL/CWI), together with Andreas Greven (Erlangen), consider a system of interacting Fisher-Wright diffusions with seed-bank. Individuals live in colonies and are subject to resampling and migration as long as they are active. Each colony has a structured seed-bank into which individuals can retreat to become dormant, suspending their resampling and migration until they become active again. The geographic space labelling the colonies can be any countable Abelian group endowed with the discrete topology. The goal is to classify the long-time behavior of the system in terms of the underlying model parameters. The key challenge is to understand in what way the seed-bank enhances genetic diversity.

- Matteo Sfragara, Rajat Hazra, and den Hollander (UL), together with Arijit Chakrabarty (Indian Statistical Institute), consider the spectrum of Inhomogeneous Erdös-Rényi random graphs in the non-dense regime. Focus is on the empirical distribution of both the adjacency matrix and the Laplacian matrix associated with the graph in the limit as its size tends to infinity. They showed that the empirical spectral distributions, after appropriate scaling and centering, converge to deterministic limits weakly in probability. The results can be applied to constrained random graphs, Chung-Lu random graphs, and social networks.

- In joint work with Onur Gün and Marion Hesse (Weierstrass Institute Berlin), Luca Avena (UL) studied the solutions of the so-called Parabolic Anderson Model equation on a hypercube with random iid potential. This Stochastic Differential Equation describes the macroscopic evolution of a system of microscopic random walkers traveling in the hypercube, and branching with random rate described by the random spatial potential. The researchers in particular characterized the exponential growth of these solutions at the location of the largest potential in spectral terms.

- Together with Fabienne Castell, Alexandre Gaudillière and Clothilde Mélot (Aix Marseille Univ, CNRS), Avena also derived a new wavelets basis and a corresponding pyramidal algorithm to process arbitrary signals on arbitrary graphs. Here, processing means compressing, denoising, classifying, etc., while the signal is a real-valued function defined on the vertex set of the graph in question. The underlying algorithms are based on how random walkers explore the underlying network structure.

THEME 3: QUANTUM NETWORKS

Quantum computers are the next generation computing devices. They hold a tremendous promise to revolutionize the way we process and handle information throughout science, technology, and our rapidly evolving infor-

NEW PERSONNEL

Henk Alkema, MSc
PhD student, TU/e

Pierfrancesco Dionigi, MSc
PhD student, UL

Diego Goldsztajn, MSc
PhD student, TU/e

Rowel Gündlach, MSc
PhD student,TU/e

Dr. Mark Jones
Postdoc, CWI

Nikki Levering
PhD student, UvA

Maurizio Moreschi, MSc
PhD student, UvA

Tom Pijnappel, MsC
PhD student, TU/e

prof. dr. Frits Spieksma
Professor, TU/e

Michelle Sweering, MSc
PhD student, CWI

mation society. Quantum computers can be used to implement quantum algorithms, which in many instances are able to perform computations much faster than classical algorithms.

HIGHLIGHTS

- Tom Bannink, Jop Briët, Farrokh Labib (CWI), Harry Buhrman (CWI/UvA), and Troy Lee (University of Technology Sydney) studied a fundamental problem from multiparty communication complexity using links with quantum entanglement, nonlocal games, and Bell inequalities. They did so by considering the bias (which is the probability of winning minus the probability of losing) in the multiplayer game XOR, and the use of a shared entanglement protocol to increase it. They identified several general classes of games for which the classical bias cannot go to zero while the entangled bias stays above a constant threshold.

- Briët and Carlos Palazuelos (Universidad Complutense de Madrid) answered an old question of Pisier from operator space theory using techniques from additive combinatorics. Operationally, the result shows that tensor norms appearing quantum (query) algorithms and Bell inequalities can be arbitrarily far apart.

- Briët, Palazuelos, and Srinivasan Arunachalam (MIT/IBM Watson) completed a line of research started by Buhrman, de Wolf and others about two decades ago, giving a new characterization of quantum algorithms (in the query model of computations) in the terms of real multivariate polynomials.

DEVELOPMENTS OUTSIDE OF NETWORKS

- Gilles Brassard (University of Montreal), one of the pioneers of quantum computing, was a long-term visitor of CWI as a Turing Fellow.

- The 3rd general assembly of the Quantum Software Consortium (a parallel NWO-Gravitation consortium) was held in December at the Amsterdam Public Library. Aside from scientific talks it included a panel discussion on legal and ethical perspectives on quantum computing hosted by Joris van Hoboken (Vrije Universiteit Brussels & UvA).

- In a continued effort to maintain and strengthen links with industry, Ido Niesen joined QuSoft as postdoc, working for DisQover: a collaboration between QuSoft and ABN AMRO that explores the potential of quantum computers in finance.

NEW PERSONNEL

Rens Kamphuis, MSc
PhD student, UvA

Ellen Konijnenberg
Support Staff, TU/e

Daoyi Wang, MSc
PhD student, UL

Dr. Martín Zubeldía
Postdoc, TU/e

- Together with colleagues from UvA and TU Delft, Briët co-organized a week-long workshop at the Lorentz center on mathematical aspects of quantum information theory, which included roughly 25 experts from a diverse set of areas including geometric functional analysis, approximate representation theory, and quantum Markov processes.

THEME 4: DYNAMICS OF NETWORKS

Networks typically evolve over time. The way in which this happens is often closely related to their functionality. Random graphs are essential tools 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 behavior can be captured and analyzed.

HIGHLIGHTS

- Alessandro Garavaglia, under the supervision of Remco van der Hofstad and Nelly Litvak (TU/e), defended his thesis in January 2019. It contains a wealth of results on preferential attachment and related models, as well as on dynamical models for citation networks. Garavaglia investigated the local weak limit of preferential attachment models, their subgraph structure, as well as the diameter in the ultra-small regime. Further, he performed an extensive empirical analysis of various citation networks obtained through his collaboration with CWTS in Leiden. This analysis served as an input for suitable models that include ageing, preferential attachment and fitness. For the tree versions of this model, in work with van der Hofstad and Gerhard Woeginger (TU/e), Garavaglia identified the necessary ingredients that ensure that the model behaves similarly as the data.

- Matteo Sfragara (UL), together with Sem Borst (TU/e), Frank den Hollander (UL/CWI), and Francesca Nardi (TU/e), analyzed queue-based activation protocols in random-access networks, modeled as bipartite graphs. Each node represents a queue with a server that can be either active or inactive. Each node deactivates at unit rate, but activates at a rate that depends on the current queue length at the node. A node can turn active only when none of the neighboring nodes are active. In the limit as the queue lengths at the nodes become large, the transition time between the two states where one half of the network is active and the other half is inactive is identified. The transition decomposes into a succession of transitions on complete bipartite subgraphs, captured via a greedy algorithm that takes the graph as input and gives as output the set of transition paths the system is most likely to follow. It turns out that there are three scaling regimes depending on how the activation rate depends on the current queue length: subcritical, critical, and supercritical.

THEME 5: DYNAMICS ON NETWORKS

While random processes in static random structures are relatively well understood, their analysis in the dynamic setting is still in its infancy. In this theme, stochastic processes on randomly evolving networks are studied.

HIGHLIGHTS

- Birgit Sollie (VUA) and Michel Mandjes (UvA) have, with Sophie Hautphenne (University of Melbourne) and Mathisca de Gunst (VU),

considered inverse problems for general modulated infinite-server networks. When doing inference, the main complication is that the modulating process is not observed. A saddlepoint based technique has been developed for efficient and accurate evaluation of the likelihood.

- Mandjes and Liron Ravner (UvA) studied hypothesis testing for the input of a Lévy-driven storage system. In the setup considered, the storage level is sampled at Poisson epochs. As the likelihood is not explicit, tests are proposed that rely on specific transformations of the data. The tests are endowed with certain performance guarantees.

- Luca Avena, Hakan Güldas (UL), Remco van der Hofstad (TU/e) and Frank den Hollander (UL) analyzed the mixing time of a random walk on a dynamic version of the configuration model in which edges are rewired randomly. It turned out that there are three regimes, depending on the speed of the rewirings. Both global and local rewirings were considered. In April 2019, Güldas defended his PhD thesis.

- Diego Garlaschelli, Frank den Hollander and Janusz Meylahn (UL) studied synchronization of neurons forming a network, which plays a crucial role in understanding the human bio-clock. For the noisy Kuramoto model, synchronization was found for specific regimes of the interaction parameters. In September 2019, Meylahn defended his PhD thesis.

THEME 6: TRANSPORTATION AND TRAFFIC NETWORKS

Transportation and traffic networks are prominent examples of highly complex networks. Virtually all sectors of society are facing issues regarding their design, operations, performance and control. In this NETWORKS theme, in some projects the network structure is fixed and focus is on the effect of the randomness involved in user behavior, whereas in others the main objective concerns shaping of the network structure.

HIGHLIGHTS:

- Nikki Levering (UvA), in collaboration with Marko Boon (TU/e), Michel Mandjes (UvA), and Sindo Nunez Queija (UvA), started an extensive investigation of routing in a stochastic network model for road traffic. Her work is aimed at designing algorithms of acceptable complexity for graphs with random travel times on the edges. She assumes the travel times to be modulated by a common continuous-time Markovian random environment, thus creating a versatile model that overcomes unrealistic independence assumptions and can capture changing congestion and weather conditions. As a further extension, the probabilistic model will be allowed to include deterministic patterns in changing traffic and weather conditions as well. Levering will design computable heuristics that provide good performance for models of the Dutch road network. Different versions of a new backbone algorithm are currently investigated and compared in terms of complexity and performance. The models will next be fed with and tested against data obtained from the NDW (Nationale Databank Wegverkeersgegevens).

- For an intersection with fixed traffic signal settings, Boon, Guido Janssen, Johan van Leeuwaarden, and Rik Timmerman (TU/e) obtained the heavy-traffic limit of the queue length, when choosing a proper scaling. In a simulation study, using both discrete-event simulation and the microscopic traffic simulator SUMO, they show that a similar scaling exists for (more realistic) vehicle actuated controlled intersection access algorithms. This scaling results in an intersection operating under ideal conditions: as the congestion level increases towards one, the probability of an empty queue at the end of an access period converges to a constant strictly between 0 and 1.

- Mandjes and Jaap Storm (VUA) studied a stochastic model that describes how traffic, consisting of multiple vehicle types, propagates through a network. By deriving fluid and diffusion limits for the model, they developed explicit Gaussian approximations for the per-type vehicle densities, as a function of both the position in the network, and time. Using a similar approach, they found approximations for travel-times of vehicles, moving from one point in the network to another one. In a different project, Wouter Kager (VUA), Mandjes, and Storm studied a stochastic roundabout model. The roundabout model can be represented in terms of a multiclass queueing network, and by using fluid techniques, they proved a global stability theorem for this model.

- Rens Kamphuis (UvA), Mandjes and Paulo Serra (TU/e) looked into statistical issues concerning travel time estimation. Traditional route selection systems such as in-vehicle navigation systems select the route that minimizes the expected travel time between origin and destination. However, this selection criterion does not take the reliability of the routes into account. Drivers are likely to have an aversion to routes with a high travel time variance, as a higher variance implies a lower probability of arriving on time at the destination. This ongoing project concentrates on developing novel statistical techniques to estimate travel time distributions in road traffic networks. The resulting procedures are then used in producing routing algorithms, that have the specific feature that they allow drivers to indicate their risk aversion.

DEVELOPMENTS OUTSIDE OF NETWORKS:

- There is much collaboration between NETWORKS and the NWO Sustainable Logistics project Dynafloat. The latter project addresses the dynamic control of urban traffic using floating car, planning, and infrastructure data. It comprises three PhD projects: of Anna Oblakova (UT), who defended her thesis end of 2019; of Sara Ghazanfari (CWI), who is supervised by Sindo Nunez Queija (UvA) and Rob van der Mei (VUA/CWI), with involvement of Liron Ravner (TU/e); and of Rik Timmerman (TU/e), who is supervised by Marko Boon, Ivo Adan, Onno Boxma, and Johan van Leeuwaarden (TU/e).

- Bo Klaasse (TU/e), Timmerman, and Boon, together with Tessel van Ballegooijen and Gerard Eijkelenboom (De Verkeersonderneming, Rotterdam) developed an algorithm to identify ‘high-performance days’: days that exhibit the seemingly paradoxical behavior of high traffic flow and, simultaneously, a striking absence of traffic jams; for such days we introduce the notion of. The algorithm relies on a novel approach to estimate the critical speed, exploiting the roughly linear relation between traffic flow and traffic density in case of no congestion using robust regression as a tool for labelling. Identifying high-performance days could be a building block in the quest for traffic jam reduction; using more

detailed data one might be able to identify specific characteristics of high-performance days. The algorithm is applied to a case study featuring the highly congested A15 motorway in the Netherlands.

THEME 7: COMMUNICATION AND ENERGY NETWORKS

Communication and energy networks are both prominent instances of highly complex large-scale networked systems which are of critical importance to society. Because of their vital interest, these systems need to be designed to achieve consistently high levels of performance and reliability, and yet be cost-effective to operate. This involves huge challenges, especially since both communication and energy networks are subject to inherent uncertainty and random variation in demand as well as supply.

HIGHLIGHTS

- The research of Fiona Sloothaak (TU/e), with her supervisors Bert Zwart (CWI & TU/e) and Sem Borst (TU/e), focused on macroscopic models that provide fundamental insights of how small disturbances in energy grids can lead to heavy-tailed behavior in blackout sizes. Together with Lorenzo Federico (TU/e) she studied non-local failure propagation in complex networks where the failure rate dynamically depends on the global structure. Together with Tommaso Nesti (CWI) and Zwart, she developed an entirely novel model that identified heavy-tailed city sizes as a key mechanism in the emergence of scale-free blackout sizes. Besides failure dynamics in networks, she also finished a project on the topic of battery-swapping infrastructure for Electric Vehicles, in collaboration with James Cruise and Seva Shneer (Heriot-Watt University), Maria Vlasiou (TU/e), and Zwart.

- Bart Post (TU/e), with his supervisors Ton Koonen and Sem Borst (TU/e), analyzed and designed algorithms for load-driven self-organization of Radio-over-Fiber enabled dense cellular networks. Having previously explored problems of dynamic user association (which users should be associated with which access points) and dynamic frequency assignment (which frequencies and optical wavelengths should be allocated to the various access points) separately, Post investigated in 2019 the problem of joint user association and frequency allocation. In addition, he added energy consumption (which access points should be powered off and when)

HIGHLIGHT

Souvik Dhara, Photo Martijn Anthonissen

SOUVIK DHARA WINS STIELTJES PRIZE

Souvik Dhara, who was awarded his PhD with distinction at the TU/e last year, has been awarded the Stieltjes Prize for the best mathematics PhD thesis of 2018 in the Netherlands. Dhara, now a Schramm postdoctoral fellow at MIT Mathematics and Microsoft Research Lab New England, defended his thesis entitled "Critical percolation on random networks with prescribed degrees" under the supervision of Remco van der Hofstad and Johan van Leeuwaarden (TU/e).

as a third dimension, and examined the optimal trade-off with user-experienced performance in terms of throughput levels and response times.

- A thread that continued to be highly active in 2019 revolves around performance evaluation and algorithm design for large-scale data center networks and cloud systems. Mark van der Boor (TU/e), together with his supervisors Sem Borst and Johan van Leeuwaarden (TU/e), worked on a novel class of load balancing algorithms where the various servers provide occasional queue updates to guide the load assignment. He demonstrated that the proposed schemes strongly outperform existing strategies, and can achieve a vanishing waiting time in the many-server limit with just one message per job. Together with Martín Zubeldía (who started as a post-doc with a joint position at TU/e and UvA) and Borst, van der Boor also worked on zero-wait load balancing with sparse messaging. He introduced a novel scheme which relies on absence of messages at predefined time instants, and is the first to provably achieve vanishing queueing delays while using strictly less than one message per job.

- The research of Youri Raaijmakers (TU/e) focuses on the performance and stability of server selection and task replication algorithms in parallel-server systems, in particular so-called redundancy scheduling policies and stochastic learning approaches. Redundancy scheduling provides a popular mechanism for improving the delay performance, but also raises challenging stability issues due to possibly concurrent execution of several job replicas. Together with his supervisors Boxma and Borst (TU/e), Raaijmakers used fluid limits to establish the stability conditions for Processor-Sharing systems with redundancy scheduling and general service requirement distributions with either identical or independent and identically distributed job replicas. In addition, Raaijmakers analyzed stability conditions for threshold-based redundancy scheduling in systems with heterogeneous job types and server pools, with only partial knowledge of the job types.

GRANTS AND AWARDS

GRANTS

NWA-ORC grant for project PrimaVera
Stella Kapodistria (PI)

NWO VENI Grant
Georgios Amanatidis

EuroTech Grant
Frits Spieksma

AWARDS

Teaching Award TU/e
Bart Jansen

Stieltjesprijs for best PhD thesis
Souvik Dhara

Knight of the Order of the Netherlands Lion
Onno Boxma

Best Paper Award QTNA
Onno Boxma

Best Paper Award ISAAC 2019
Mark de Berg, Sandor Kisfaludi Bak

PORTFOLIOS

NETWORK PAGES

The Network Pages are an interactive web portal aimed at a broad audience interested in network science. The slogan 'The math and algorithms that keep us connected. Network science for students, teachers and researchers' describes the content as well target audiences of the site. The goal is to publish an article bi-weekly and a blog-post in between. In 2019, we have approached people to start their own blogs on the Network Pages, which has been embraced positively.

We have started professionalizing the writing of content through 'Analytic Storytelling' workshops, which teach participants to write articles, helping them to bridge the gap between their usual academic writing and the more outreach-focused style that is preferred for the Network Pages. Three workshops have been held thus far and the articles written by their participants are online. The effect of the workshop is evident, as the articles have become more accessible and the feedback from the participants is positive. We intend to continue organizing the workshop. In addition, the editorial guidelines for authors have been revised and simplified.

One of our priorities was to advertise the articles through social media and other scientific magazines or platforms. We created a Twitter account for the Network Pages (@PagesNetwork) where we post news about articles that appear. We started a collaboration with two other initiatives: Pythagoras, a Dutch magazine for youth and mathematics teachers, and Quantum Universe, an online platform of the University of Amsterdam similar to the Network Pages with the goal to promote physics. Our plan is to publish two or three articles in Pythagoras on a yearly basis, with a clear reference to the Network Pages. The first such article will appear in the June 2020 issue. With Quantum Universe we will collaborate on a case-by-case basis; whenever we have an article that might be interesting for their target group we will try to publish a shorter version on their website as well.

VALORIZATION

The research activities in NETWORKS are not only driven by intriguing scientific quests, but also strongly inspired by urgent challenges involving complex dynamic networks that industry and society are increasingly being confronted with. Several paths are pursued to accomplish the transfer of novel insights and results and translate fundamental concepts into actual implementations.

Specifically, the main vehicles for knowledge transfer and utilization are:

(i) A long-term flux of young talented professionals who have been and will continue to be trained in the various groups in NETWORKS. Several NETWORKS alumni have accepted jobs in industry.
(ii) Active engagement in broader efforts to promote the application of advanced knowledge in mathematics and computer science to solve problems of industrial and societal relevance.
(iii) Close ties with various companies and societal organizations, and involvement in application-oriented multi-disciplinary projects.
(iv) Open and highly visible channels towards companies and societal organizations that face challenges relating to complex dynamic networks and seek innovative solution approaches.

As in previous years, in 2019 there were successful interactions with TNO, which is a semi-public organization in technology research with an active interest in the various application areas pursued by NETWORKS,

and in particular societal infrastructure networks.
Besides an existing interaction in the field of traffic and transport, Tom Pijnappel (TU/e) started his PhD project, partly funded by TNO, focusing on highly complex resource management and optimization problems in future wireless communication networks which exceed the scope of current (mostly model-based) approaches. Data-driven approaches, learning algorithms, and emerging artificial intelligence concepts provide powerful alternative techniques, but their use in mobile networks raises formidable challenges, for example in terms of the massive amounts of data needed to ensure satisfactory performance and possibly slow convergence. The objective is to explore the potential benefits of combining data-driven and model-based approaches (e.g. expert-knowledge-aided deep learning), provide benchmarks of achievable gains in various scenarios, and develop concrete algorithms for specific use-cases in Beyond 5G mobile networks.

A new collaboration is with Transtrend, a Rotterdam based company that focuses on active investment management through the development and application of systematic trading strategies. In the processes studied at Transtrend, an important role is played by the dynamics of the opinions of the economic agents involved. PhD student Danny Chang (UvA/Transtrend) studies network models for opinion spreading. His work fits in a broader effort, in which NETWORKS seeks interaction with researchers from the social sciences. A workshop with involvement of both members of NETWORKS and colleagues from the social sciences has been held in January 2020.

In addition, a joint research line with CBS (the Dutch Bureau for Statistics) and ING Bank is being set up. This research focuses on models that describe networks of companies, with the main objective to get a handle on the underlying 'vulnerability' due to the companies' connectedness. More concretely, in case a specific company goes bankrupt, which set of other companies does it affect as well? For evident reasons, stakeholders such as the Dutch National Bank are highly interested in such insights. NETWORKS' affiliated member Diego Garlaschelli (UL) is an internationally leading expert in this field. On the methodological level, techniques from network theory and statistical mechanics ('econophysics') are intensively relied upon.

Several principal investigators of NETWORKS are engaged in application-oriented projects

HIGHLIGHT

Photo Bart van Overbeke

ONNO BOXMA RECEIVES ROYAL DECORATION AS A BINDING FORCE IN DUTCH MATHEMATICS

Onno Boxma (TU/e) was appointed Knight of the Order of the Netherlands Lion. Boxma was presented with the royal decoration at his home in Nuenen on April 26th in the presence of his family and some close colleagues. In his speech, mayor Maarten Houben described Boxma as an excellent and very dedicated scientist. His two honorary doctorates (one from the University of Haifa in Israel and one from the University of Edinburgh in Scotland) and his many important administrative initiatives testify to this. Boxma has distinguished himself in particular as the first chairman of the mathematics cluster STAR between 2009 and 2013 and as scientific director of Eurandom between 2005 and 2011. He served as vice-dean of the Department of Mathematics and Computer Science at TU/e from 2009 until 2013.

which are typically carried out in the framework of the 'Topsector' themes of the Dutch government, special industrial partnerships or various local initiatives. There are in particular long-standing collaboration efforts between TU/e and Philips (e.g. Data Science and Flagship programs) and between TU/e and UvA with SURFnet.
NETWORKS also continues to explore connections with various routes of the National Research Agenda (NWA) and forge novel links with non-traditional application domains such as the social sciences.

INTERNATIONALIZATION

Exchange between NETWORKS and the Indian Statistical Institute (ISI) continued in 2019, with a 1-month visit by Matteo Sfragara (UL) to ISI Kolkata in February. Rajat Hazra from ISI Kolkata received an offer for a tenured position at Leiden University, which he accepted. He will move to Leiden in August 2020.

Exchange between NETWORKS and ACEMS in Australia also continued in 2019, through an extended visit to the University of Queensland and the University of Melbourne by Michel Mandjes (UvA). Peter Braunsteins, formerly at the University of Melbourne, was offered a 2-year postdoc position within NETWORKS, shared between Mandjes and Frank den Hollander (UL). Former NETWORKS postdoc Marijn Jansen joined the University of Queensland, where he works on a project on population modelling.

A new partnership has been formed with the PhD training network SAMBa, hosted by the University of Bath in the United Kingdom. PhD students from SAMBa and NETWORKS are given the opportunity to attend each other's activities.

EDUCATION

Two main components of the NETWORKS educational program are the Training Weeks and the internships.

In the Training Weeks, researchers from NETWORKS gather to learn more about the research topics studied within the entirety of the NETWORKS project. The morning sessions of the Training Weeks are dedicated to two mini-courses on topics studied within the projects, while the afternoon is used for presentations by NETWORKS researchers and Open Problem Sessions. In 2019, the Spring Training Week was held from 6 to 10 May with mini-courses by Frits Spieksma (TU/e) on practical combinatorial optimization, and Tobias Müller (University of Groningen) on hyperbolic stochastic geometry. The 2019 Fall Training Week was held from 28 October to 2 November with a mini-course by Jesper Nederlof (TU/e) on algebraic graph algorithms, and by Stella Kapodistria (TU/e) entitled "Exact and approximate solutions for decision making under uncertainty". During this Training Week, another element was brought into the program, namely a discussion session on machine learning and artificial intelligence

The NETWORKS internships are short (2 to 3 months) research projects. Many PhD students do their internship with another research group in NETWORKS, but they can also visit a research group abroad or an applied research institution. The internships not only serve to broaden the knowledge of the PhD students, but also to foster collaborations between researchers from different research areas. They already led to several new results on the interface between algorithmics and stochastics.

OUTREACH

In 2019, the Masterclass "Networks goes to school" was organized in a slightly different set-up than in 2018. In 2018, the masterclass was organized in two parts for the same group of students. However, for some of the secondary school students, it was difficult to get two days of dispensation from their regular classes. Therefore, in 2019 we organized a one-day edition of the Masterclass, but in 2 different regions: on 14 March in Eindhoven and on 21 March in Leiden. In total about 65 students from mainly international schools participated in the events.

The main topics covered in this masterclass were queueing theory and mathematical genetics. Mark van der Boor (TU/e) talked about his research on how to mathematically model a queue. Margriet Oomen (UL) talked about her research on mathematical genetics. She discussed the Wright-Fischer model which describes the evolution of genes within a population. Before every lecture there was a crash course providing all the necessary background knowledge needed to follow the lectures.

On 18 February 2019, the KNAW Symposium "The Era of Mathematics" was organized in Amsterdam. In this symposium, scientists from different disciplines shared their view on the importance of mathematics in society. The event attracted over 200 people to the Public Library in Amsterdam. Frank den Hollander (UL) acted as the moderator of the discussion, Nicos Starreveld (UvA)

"VERY stimulating for students to see how mathematics is being applied at university; important to challenge them to think more critically and outside their school curriculum; meet other maths students from other schools and share experiences; encourage students to study mathematics at university."

– School teacher

participated as well. Philip Bond, professor of Engineering Mathematics at University of Oxford gave a lecture entitled "Making mathematics impactful – why it matters and how to achieve it", and Ionica Smeets, professor of Science Communication at UL talked about mathematics in society.

WORKSHOPS

WORKSHOP	PERIOD	LOCATION	INVOLVED FROM NETWORKS
Queues and Games	February 5, 2019	Eurandom, Eindhoven	Onno Boxma
Workshop YEP XV	March 25–29, 2019	Eurandom, Eindhoven	Nelly Litvak, Clara Stegehuis
Models and Algorithms for Planning and Scheduling Problems (MAPSP) 2019	June 3–7, 2019	Conference Hotel Zeeuwse Stromen, Renesse	Nikhil Bansal, Leen Stougie
Random Cluster Model	June 11–14, 2019	Lorentz Center, Leiden	Frank den Hollander
Random Graphs, Counting and Sampling	September 11, 2019	CWI, Amsterdam	Viresh Patel, Leen Stougie
YEQT XIII: "Data-Driven Analytics and Optimization for Stochastic Systems"	October 16–18,2019	Eurandom, Eindhoven	Mark van der Boor, Liron Ravner
Heavy Tails	December 9–13, 2019	Eurandom, Eindhoven	Remco van der Hofstad

HIGHLIGHT

DISTINCTIONS

In 2019, three NETWORKS PhD students were awarded their doctorates with distinction (cum laude).

Sándor Kisfaludi-Bak (TU/e)

ETH-Tight Algorithms for Geometric Network Problems

The major contribution in the thesis by Sándor Kisfaludi-Bak is a general framework to develop sub-exponential algorithms for certain types of geometric intersection graphs, which encompass graphs that model sensor networks. The framework applies to many different problems and leads to algorithms that are both faster and more general than what was known. A second contribution concerns the Traveling Salesman Problem, one of the most widely studied problems in all of computer science. Kisfaludi-Bak improved the best-known running time for the Euclidean version of the problem, which constitutes the first progress on the complexity of this famous problem since many years. He also proved that the running times of his algorithms are best possible, assuming the widely accepted Exponential Time Hypothesis. Kisfaludi-Bak is now a postdoc at the Algorithms and Complexity Group of the Max-Planck-Institut für Informatik, in Saarbrücken, Germany.

Clara Stegehuis (TU/e)

Networks with Communities and Clustering

Clara Stegehuis received the cum laude distinction for her contributions to the area of large complex networks, in particular the probabilistic analysis of such networks through random graphs. Her thesis deals with the structural properties of so-called scale-free networks that have hubs (nodes of extremely large degree), which makes it challenging to establish mathematically rigorous results. Stegehuis obtained new results for correlations between nodes, subgraph structures, and the influence of community structure on the spreading of an epidemic. While the research is mathematical in nature, it also led to a range of new insights into network behavior. Stegehuis has since been appointed as assistant professor at the University of Twente.

Pieter Kleer, Photo Isabella Pozzi

Pieter Kleer (VUA)

When Nash met Markov: Novel results for pure Nash equilibria and the switch Markov chain

Pieter Kleer received the cum laude distinction for his research on the quantifying effect of safety margins in route planning. When drivers avoid certain highways to escape the risk of usual traffic jams, for instance caused by accidents, they can significantly increase the average travel time for everyone in the road network. In order to model this type of risk-aversion, Kleer studied game-theoretical traffic models. Among other results, he developed unifying models to analyze the deterioration of the average travel time in road networks, as a result of drivers incorporating safety margins in their route choices. After graduating, Kleer obtained a postdoc position at the Algorithms and Complexity Group of the Max-Planck-Institut für Informatik in Saarbrücken, Germany.

ORGANIZATIONAL ASPECTS

ORGANIZATIONAL DEVELOPMENTS

In 2019, 10 PhD students and 3 postdocs have been appointed within the NETWORKS program. Leen Stougie (CWI) joined the Management Team, succeeding Lex Schrijver (CWI), who retired early 2019. Frits Spieksma (TU/e) succeded Nikhil Bansal in the project-eam. In the support staff, Ellen Konijnenberg (TU/e) succeeded Petra Rozema (TU/e) as the secretary of NETWORKS.
By the end of 2019, NETWORKS counted 48 members and 47 affiliated members (who are not paid by the grant yet strongly connected to the NETWORKS program).

NETWORKS members and affiliated members convene two times a year during the so-called NETWORKS days.

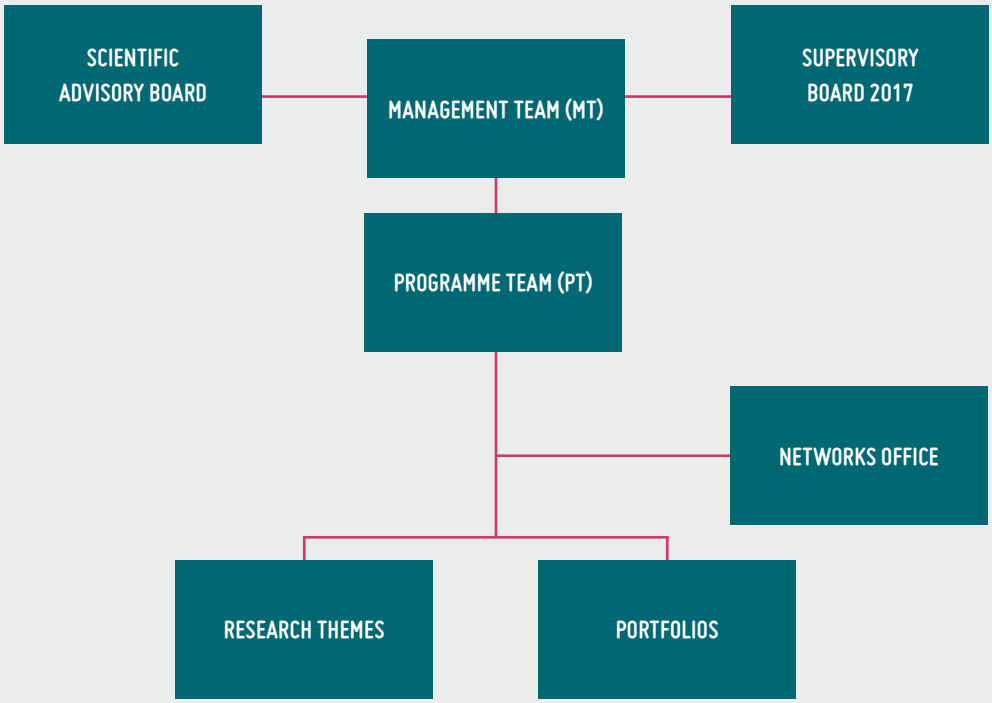
- On 15 March, the first NETWORKS day of 2019 took place in Eindhoven. Keynote lectures were given by Ivo Adan (TU/e) and Maris Ozols (UvA). The day ended with a goodbye ceremony for Lex Schrijver.

- In September 2019, the second NET-WORKS day was organized in Utrecht. Keynote lectures were given by Ines Lindner (VUA), Bert Zwart (CWI and TU/e) and Monique Laurent (CWI and Tilburg University)

PHD DEFENCES

PHD STUDENT	DEFENSE DATE	UNIV.	THESIS TITLE	PROMOTORES
Murtuza Ali Abidini	2019-01-24	TU/e	Performance analysis of optical switches	Onno Boxma, Ton Koonen
Abhishek	2019-01-22	UvA	Stochastic models for unsignalized road traffic intersections	Sindo Núñez-Queija, Michel Mandjes
Alessandro Garavaglia	2019-01-29	TU/e	Preferential attachment models for dynamic networks	Remco van der Hofstad, Nelly Litvak
Hakan Güldas	2019-07-03	UL	Exploration on and of Networks	Frank den Hollander, Remco van der Hofstad
Sándor Kisfaludi-Bak	2019-06-27	TU/e	ETH-Tight Algorithms for Geometric Network Problems	Mark de Berg, Hans Bodlaender
Pieter Kleer	2019-09-09	CWI & VUA	When Nash met Markov: Novel results for pure Nash equilibira and the switch Markov Chain	Guido Schäfer, Lex Schrijver
David Koops	2019-02-22	UvA	Queueing Systems with Nonstandard Input Processes	Michel Mandjes, Onno Boxma
Aleksandar Markovic	2019-02-05	TU/e	Dynamic range and frequency assignment problems	Mark de Berg, Gerhard Woeginger
Janusz Meylahn	2019-09-24	UL	Stochastic resetting and hierarchical synchronization	Frank den Hollander, Diego Garlaschelli
Brendan Patch	2019-02-11	UvA	Modelling complex stochastic systems: approaches to management and stability	Michel Mandjes, Thomas Taimre
Astrid Pieterse	2019-09-04	TU/e	Tight Parameterized Preprocessing Bounds: Sparsification via Low-Degree Polynomials	Mark de Berg, Bart Jansen
Nicos Starreveld	2019-02-28	UvA	Queues, random graphs, and queues on random graphs	Michel Mandjes, René Bekker
Clara Stegehuis	2019-01-31	TU/e	Networks with Communities and Clustering	Johan van Leeuwaarden, Remco van der Hofstad

ORGANOGRAM



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Patty Koorn, workshop officer
Ellen Konijnenberg, secretary
Tiny Dekker, webmaster
Bart Groeneveld, outreach
Nicos Starreveld, outreach

PORTFOLIOS
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RESEARCH THEMES
Approximate and exact network methods
Spatial networks
Quantum networks
Dynamics of networks
Dynamics on networks
Transportation and traffic networks
Communication and energy networks

NETWORKS MEMBERS

FULL NAME WITH TITLE	FUNCTION PROFILE	AFFILIATION ABBREVIATED
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Mark van der Boor, MSc	PhD student	TU/e
prof.dr.ir. Sem Borst	Professor	TU/e
prof.dr.ir. Onno Boxma	Professor	TU/e
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dr. René Bekker	Assistant professor	VUA
prof.dr. Sandjai Bhulai	Professor	VUA
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dr Celine Comte	Postdoc	TU/e
dr. Daniel Dadush	Tenure Track	CWI
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dr. Dion Gijswijt	Assistant professor	TU Delft
prof.dr. Mathisca de Gunst	Professor	VUA
prof.dr. Markus Heydenreich	Professor	LMÜ Munchen
dr. Pim van der Hoorn	Tenure Track	TU/e
dr. Stacey Jeffery	Tenure Track	CWI
Joost Jorritsma, MSc	PhD student	TU/e
dr. Wouter Kager	Assistant professor	VUA
dr. Júlia Komjáthy	Tenure Track	TU/e
Roel Lambers, MSc	PhD student	TU/e
prof.dr. Monique Laurent	Professor	CWI, Tilburg University
prof.dr. Nelly Litvak	Professor	UT, TU/e

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dr. Francesca Nardi	Associate professor	University of Florence
dr. Jesper Nederlof	Assistant professor	University Utrecht
dr. Neil Olver	Associate professor	London school of Economics
Dr. Rudi Pendavingh	Associate professor	TU/e
Prof. dr. Frank Redig	Professor	TU Delft
dr. Guus Regts	Assistant professor	UvA
dr. Jacques Resing	Assistant professor	TU/e
dr. Jaron Sanders	Tenure Track	TU/e
prof.dr. Guido Schäfer	Professor	CWI, UvA
prof.dr. Bettina Speckmann	Professor	TU/e
dr. Floske Spieksma	Associate professor	UL
dr. Clara Stegehuis	Assistant professor	UT
Fabian Stroh, MSc	PhD student	UvA
ir. Céline Swennenhuis	PhD student	TU/e
Viktória Vadon, MSc	PhD student	TU/e
prof.dr. Evgeni Verbitskiy	Professor	UL
dr. Maria Vlasiou	Associate professor	TU/e
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dr. Tom van der Zanden	Assistant professor	Maastricht University
Qi Zhang, MSc	PhD student	UL
prof.dr. Bert Zwart	Professor	CWI, TU/e

PHD PROJECTS

PHD STUDENT	PROJECT TITLE	AFFILIATION	SUPERVISORS
Murtuza Ali Abidini	Optical Networks	TU/e	Onno Boxma, Ton Koonen, Jacques Resing
Henk Alkema	TSP and other problems on point sets in thin subspaces	TU/e	Mark de Berg, Remco van der Hofstad
Tom Bannink	Quantum Walks and Quantum Algorithms	CWI	Harry Buhrman, Frank den Hollander
Abhishek	Optimisation of polling networks with limited service disciplines	UvA	Sindo Núñez Queija, Marko Boon
Mark van der Boor	Load Balancing Algorithms in Networked Systems	TU/e	Sem Borst, Johan van Leeuwaarden
Ruben Brokkelkamp	Network Optimization under Strategic Behaviour and Data Uncertainties	CWI	Guido Schäfer
Souvik Dhara	Information diffusion and epidemics on random graphs	TU/e	Remco van der Hofstad, Johan van Leeuwaarden
Pierfrancesco Dionigi	Spectra of Random Networks	UL	Diego Garlaschelli, Frank den Hollander
Lorenzo Federico	Invasion percolation and minimal spanning trees on spatial graphs	TU/e	Remco van der Hofstad, Frank den Hollander
Hans de Ferrante	Machine Learning for Organ Allocation at EuroTransplant	TU/e	Frits Spieksma, Bart Smeulders
Alessandro Garavaglia	Citation networks and performance measures	TU/e	Remco van der Hofstad, Gerhard Woeginger
Diego Goldsztajn	Load Balancing and Robust Dimensioning in Heterogeneous Networks	TU/e	Sem Borst
Martijn Gösgens	Analysis of community detection algorithms in real-world and random graphs	TU/e	Remco van der Hofstad, Nelly Litvak
Hakan Güldas	Random processes on dynamic random graphs	UL	Frank den Hollander, Remco van der Hofstad, Luca Avena
Rowel Gündlach	Decision making under uncertainty	TU/e	Remco van der Hofstad, Stella Kapodistria
Mariska Heemskerk	Correlated sources in networks	UvA	Michel Mandjes, Johan van Leeuwaarden
Oliver Jovanovski	Metastable behaviour of random graphs	UL	Frank den Hollander, Francesca Nardi
Rens Kamphuis	Estimation-based routing in road networks.	UvA	Michel Mandjes, Paulo de Andrade Serra
Madelon de Kemp	Optimized Appointment Scheduling	UvA	Michel Mandjes, Neil Olver
Sándor Kisfaludi-Bak	FPT algorithms for geometric network problems	TU/e	Mark de Berg, Hans Bodlaender
Pieter Kleer	Refined Models and Coordination Mechanisms for Network Games	CWI	Guido Schäfer, Lex Schrijver
David Koops	Scaling limits of random walks	UvA	Michel Mandjes, Onno Boxma

More PhD projects on the next page »

PHD PROJECTS (CONTINUATION)

PHD STUDENT	PROJECT TITLE	AFFILIATION	SUPERVISORS
Twan Koperberg	Exploration of sparse networks through random rooted forests	UL	Luca Avena, Alex Gaudilliere
Lucas van Kreveld	Resource allocation in stochastic networks	UvA	Michel Mandjes, Jan-Pieter Dorsman
Farrokh Labib	Structure and randomness in quantum networks	CWI	Jop Briët, Harry Buhrman
Nikki Levering	Data-based routing in road traffic networks	UvA	Sindo Núñez Queija, Marko Boon
Aleksandar Markovic	Algorithms for Range- and Frequency-Assignment Problems in Wireless Networks	TU/e	Gerhard Woeginger, Mark de Berg
Janusz Meylahn	Spontanenous synchronization in complex networks	UL	Frank den Hollander, Diego Garlaschell, Joke Meijer
Maurizio Moreschi	Algorithmic and combinatorial aspects of partition functions	UvA	Viresh Patel, Guus Regts
Oliver Nagy	Random walks on dynamic random graphs	UL	Frank den Hollander, Luca Avena, Remco van der Hofstad
Daniel Olah	Robust Spanner Networks in the Face of Uncertainty	TU/e	Mark de Berg, Remco van der Hofstad, Tim Hulshof
Margriet Oomen	Spatial populations with seed-bank	UL	Frank den Hollander, Andreas Greven
Brendan Patch	Stability and control of transportation and communication networks	UvA	Michel Mandjes, Thomas Taimre
Astrid Pieterse	Parameterized Preprocessing for Network Analysis Problems	TU/e	Bart Jansen, Mark de Berg
Tom Pijnappel	Combined Data-Driven and Model Based Algorithms for Mobile Network Design and Operations	TU/e	Sem Borst
Bart Post	Dynamic resource allocation and user association in pico-cell networks	TU/e	Sem Borst, Ton Koonen, Gerhard Woeginger
Youri Raaijmakers	Speed Scaling	TU/e	Sem Borst, Onno Boxma
Andrea Roccaverde	Breaking of ensemble equivalence for complex networks	UL	Frank den Hollander, Diego Garlaschelli
Matteo Sfragara	Dynamic behavior of interacting-particle systems with hard-core interaction	UL	Frank den Hollander, Sem Borst, Francesca Nardi
Fiona Sloothaak	Dynamic interaction and volatility in future energy networks	TU/e	Sem Borst, Bert Zwart
Birgit Sollie	Statistical inverse problems for network dynamics	VUA	Michel Mandjes, Mathisca de Gunst, Bartek Knapik
Nicos Starreveld	Interpretation of measurements for distributed control	UvA	Michel Mandjes, René Bekker
Jaap Storm	Stochastic models for road traffic	VUA	Michel Mandjes, Sandjai Bhulai, Wouter Kager
Fabian Stroh	Hamilton cycles in sparse graphs	UvA	Viresh Patel
Michelle Sweering	Combinatorial Algorithms on Strings and Graphs	CWI	Leen Stougie
Daoyi Wang	Parabolic Anderson Model on sparse random graphs	UL	Frank den Hollander, Wolfgang König, Renato Dos Santos

PUBLICATION HIGHLIGHTS

- Congestion analysis of unsignalized intersections: The impact of impatience and Markov platooning.
  Abhishek, A., Boon, M.A.A., Mandjes, M., & Núñez-Queija, R., *European Journal of Operational Research* 273(3), pp 1026–1035.

- Heavy traffic analysis of a polling model with retrials and glue periods.
  Abidini, M.A., Dorsman, J.-L., & Resing, J., *Stochastic Models* 34(4), pp 464–503.

- Random walks on dynamic configuration models: a trichotomy.
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- Expansion of percolation critical points for Hamming graphs.
  Federico, L., van der Hofstad, R.W., den Hollander, F. & Hulshof, T., *Combinatorics, Probability and Computing* 29(1), pp 68–100.

- Switch chain mixing times and triangle counts in simple random graphs with given degrees.
  Bannink, T., van der Hofstad, R., Stegehuis, C. & Mateos, J. (ed.), *Journal of Complex Networks* 7(2), pp 210–225.

- Parameter estimation for a discretely observed population process under Markov-modulation.
  de Gunst, M., Knapik, B., Mandjes, M., Sollie, B., *Computational Statistics and Data Analysis* 140, pp 88–103.

- Outlaw distributions and locally decodable codes
  Briët, J., Dvir, Z., & Gopi, S., *Theory of Computing* 15(12), pp 1—24

- A deterministic polynomial kernel for Odd Cycle Transversal and Vertex Multiway Cut in planar graphs.
  Jansen, B.M.P., Pilipczuk, M. & van Leeuwen, E.J., In: 36th *International Symposium on Theoretical Aspects of Computer Science – TU Berlin*, Berlin, Germany, 1 Mar 2019, pp 39:1–39:18.

- Computing the Number of Induced Copies of a Fixed Graph in a Bounded Degree Graph
  Patel, V. & Regts, G., *Algorithmica* 81(5), pp 1844—1858

- Synchronization of phase oscillators on the hierarchical lattice.
  Garlaschelli, D., den Hollander, F., Meylahn, J.M. & Zeegers, B.P., *Journal of Statistical Physics* 174(1), pp 188–218.

- Diameter in ultra-small scale-free random graphs.
  Caravenna, F., Garavaglia, A. & van der Hofstad, R., *Random Structures and Algorithms* 54(3), pp 444–498.

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NETWORKS is a project of University of Amsterdam, Eindhoven University of Technology, Leiden University and Center for Mathematics and Computer Science (CWI) and receives funding from OC&W through NWO

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TU/e Technische Universiteit Eindhoven University of Technology

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