Annual Report 2024

ICE-TCS

Icelandic Centre of Excellence
in Theoretical Computer Science

Contents

1 Introduction

The Icelandic Centre of Excellence in Theoretical Computer Science (ICE-TCS) has been active since its establishment on 29 April 2005. This nineteenth annual report provides an overview of the activities of the centre during 2024 and describes some of the upcoming events for 2025, which will mark the twentieth anniversary of the centre.

This annual report focuses on a selection of the main highlights of yet another busy year for ICE-TCS. We refer our readers to the data collected at the new centre's web page for further details.

2 Executive Summary and Highlights for the Reporting Period

The quality and impact of the research carried out by the members of the centre in 2024 is witnessed by the following main achievements.

- The algorithms group at ICE-TCS continued its explorations into probabilistic methods in constrained models of computing, focused on graph colouring. This past year, we have essentially completed the picture of what is possible under constraints of communication congestion (ergo, the CONGEST model) – see the papers at the 2024 editions of the SODA and DISC conferences. The group also made forays into memory constraints (i.e., streaming algorithms), with new ideas on combined distributed and streaming algorithms – in SODA 2024. Near the end of the year, we found ways to apply our toolbox to

dynamic algorithms, which is expected to result in multiple publications in 2025, broadening our reach. We also foresee "multi model" results on difficult colouring problems (using few colours), where the same underlying solution paradigm is mapped into effective algorithms in several disparate models (including the ones above, as well as others, such as communication complexity).

- The combinatorics group at ICE-TCS continued its work on applying algorithmic methods to address problems in enumerative combinatorics. A notable result was to show that each class of permutations defined by avoiding a partially ordered pattern with height at most two has a rational generating function. The group's Combinatorial Exploration method was then used to find combinatorial specifications and generating functions for hundreds of other permutation classes defined by avoiding a partially ordered pattern of size five, which led to the resolution of several conjectures put forward by other researchers. The group's article on Combinatorial Exploration has been accepted for [Memoirs of the American Mathematical Society](#).

- The concurrency and logic in computer science group at ICE-TCS continued its work on the theoretical foundations of, and tool development for, runtime monitoring, extending it to centralised and decentralised monitoring for hyperproperties, and studying algorithms for runtime instrumentation for reactive components. The work on those topics was presented at conferences such as [CONCUR](#) and [ECOOP](#), and received a Distinguished Artifact Award at ECOOP 2024 for "[Runtime Instrumentation for Reactive Components](#)". Moreover, members of the group published three journal articles in LMCS on complexity results for the mu-calculus and on Kleene algebras, as well as an ECOOP 2024 paper on type systems guaranteeing safety properties of smart contracts.

- The programming language theory group at ICE-TCS continued pursuing their research agenda in categorical foundations of programming language semantics. The highlights include the [paper](#) by Tarmo Uustalu with Exequiel Rivas on concurrent monads as a foundational mathematical structure for computational effects combined with concurrency and the whole series of articles by Dylan McDermott with Nathanael Arkor on the foundational theory of relative monads, in particular the [first (book-length!) article of this series](#) that appeared in Journal of Pure and Applied Algebra.

As in previous years, ICE-TCS researchers organised high-quality scientific meetings at Reykjavik University and elsewhere, increasing the international visibility of the centre and of Reykjavik University as a whole. To wit, we mention the following events (in reverse chronological order):

- In the period 10-21 June 2024, Antonis Achilleos organised the Reykjavik Summer of Cool Logic 2024 (SCooL 2024), which included the [Fifth Nordic Logic Summer School (NLS 2024)](#), [Twelfth Scandinavian Logic Symposium (SLSS 2024)](#) and the [Fifteenth International Symposium on Games, Automata, Logics, and Formal Verification (GandALF 2024)](#). The three events included twelve invited talks and courses by high-profile speakers in logic and computer science. By way of example, we mention that the invited talks at GandALF 2024 were delivered by Bernd Finkbeiner (CISPA

Helmholtz Center for Information Security), Kim Guldstrand Larsen (Aalborg University), Brigitte Pientka (McGill University) and Azalea Raad (Imperial College London).

- In the period 4-7 March 2024, Tarmo Uustalu organised the [26th Estonian Winter School in Computer Science, EWSCS 2024](#), in Viinistu, Estonia. ICE-TCS adjoint member Szabolcs Horvát taught the course "Random graphs and methods for constructing them" at that school.
- Together with Amirouche Moktefi and Niccolò Veltri, Tarmo Uustalu co-organised the [2024 Logic in Estonia workshop](#), which was held at the Estonian Academy of Sciences, Tallinn, on 15 January 2024. The invited speakers were Valentin Goranko (Stockholm University), Margus Veanes (Microsoft Research) and Jan von Plato (University of Helsinki).

The following invited talks, courses and seminars, listed in reverse chronological order, were delivered by members of the centre in 2024:
- Luca Aceto delivered invited courses on "Writing Scientific Papers and Reports, and Making Technical Presentations" to PhD students at the School of Advanced Studies, University of Camerino, on 10-11 December 2024 and at the Italian National Cybersecurity Doctoral Programme, IMT Lucca, on 25 January 2024.
- On 23 October 2024, Tarmo Uustalu delivered an [invited talk](#) at the [Day of Logic](#) at the Department of Computer Science, University of Verona. The theme of the event was "Categorical Logic and Constructive Mathematics". During his stay in Verona, Tarmo also gave an invited course on "[Substructural Logics à la Lambek: Proof Theory and Categorical Semantics](#)". The course was held in the period 21-30 October 2024.
- Tarmo Uustalu was also one of the two invited speakers of the [Structure Meets Power](#) satellite workshop of ICALP/LICS/FSCD 2024 held in Tallinn, 7 July 2024.

Regarding new funding from competitive sources, Tarmo Uustalu together with Anders Claesson from the University of Iceland won a [Collaboration Fund grant](#) for the project "[Icelandic advantage in computer-assisted proof](#)". The award amount for the two-year project is 51.84 M ISK (roughly 359,731 €). Moreover, ICE-TCS PhD students Vasiliki Kyriakou, Yasuaki Morita and Jasmine Xuereb were awarded PhD grants from the Reykjavik University Research Fund. On the other hand, none of the project grant applications submitted by members of the centre to the Icelandic Research Fund were successful.

According to our records, in 2024, ICE-TCS hosted [14 unique guests](#) for stays ranging from a few days to four weeks. (We remark that the centre also hosted 12 invited speakers who contributed to the [First Reykjavik Summer of Cool Logic 2024](#). So we actually had 26 visitors from outside Iceland in 2024.) Most of the guests delivered a seminar in the [ICE-TCS seminar series](#), which consisted of nine seminars in the reporting period. At the time of writing, the ICE-TCS seminar series has hosted over 420 talks since the establishment of the centre.

However, we note that the number of talks in the ICE-TCS seminar series has been lower than usual in 2024.

ICE-TCS researchers have also continued to serve the community in a variety of leading roles. By way of example, we limit ourselves to mentioning the following highlights.

- Antonis Achilleos is a member of the [Executive Committee of the Scandinavian Logic Society](#). He was PC co-chair of GandALF 2024 and of the Twelfth Scandinavian Logic Symposium (SLSS 2024). He was also a PC member for VORTEX 2024.
- Henning Úlfarsson has chaired the Department of Computer Science at Reykjavik University since 1 July 2023.
- Luca Aceto is currently a member of the steering committees for CONCUR, GandALF and ICALP, of the editorial and advisory boards for Electronic Proceedings in Theoretical Computer Science, of the executive board of Logical Methods in Computer Science, and of the editorial board of the Journal of Logical and Algebraic Methods in Programming. Since 1 November 2024, he is the director of the PhD programme at the Department of Computer Science at Reykjavik University. He chaired the EATCS Fellows Selection Committee 2024 and will serve as a member of that committee in 2025-2026. Luca is also a member of the editorial board of LIPIcs, after having chaired it. In 2024, he also served as PC member for the 18th International Conference on Reachability Problems (RP 2024).
- Tarmo Uustalu served on the PCs of CMCS 2024, TyDe 2024 and ICTAC 2024 and on the steering committees of FICS, ICTAC, MPC, MSFP.
- Magnús Halldórsson was a member of the award committee for the Doctoral Dissertation Award given by the PODC (ACM Principles of Distributed Computing) conference. He is a member of the steering committees of PODC, ALGOSENSORS, DCOSS, WADS, and SWAT.

2.1 Research Output in 2024

During the reporting period, ICE-TCS researchers based at Reykjavik University published or had accepted 31 refereed scientific papers in 2024, as opposed to 19 published in 2023. In addition, Antonis Achilleos co-edited the [Proceedings of the Fifteenth International Symposium on Games, Automata, Logics, and Formal Verification](#) with Adrian Francalanza. We are pleased to see that most of the research output of the centre is still published in high-quality venues, including conferences such as PODC, SODA, DISC, CONCUR, and ECOOP, and journals such as Algorithmica, Electronic Journal of Combinatorics, Journal of Algebra, and Logical Methods in Computer Science, to name but a few. Moreover, several articles were authored by PhD students and postdocs without senior co-authors from the centre, which is a welcome sign of the research independence of the junior members of the centre.

The full list of accepted and published papers authored by members of the centre from Reykjavik University in 2024-2025 is available at https://icetcs.github.io/publ/publ24.html and https://icetcs.github.io/publ/ — lists of earlier publications are accessible from the latter link.

3 Current Members

During the reporting period, ICE-TCS had seven core permanent members at Reykjavik University, namely Luca Aceto, Antonis Achilleos, Eyjólfur Ingi Ásgeirsson (Department of Engineering at Reykjavik University; Scientific Co-director), Magnús M. Halldórsson (Scientific Director), Anna Ingólfsdóttir (Scientific Co-director), Henning Úlfarsson and Tarmo Uustalu. In addition, the centre had several adjoint members at Reykjavik University (Yngvi Björnsson, Szabolcs Horvát and Jacky Mallett), one at deCODE Genetics and Reykjavik University (Bjarni V. Halldórsson) and one with a joint affiliation at the University of Iceland and deCODE Genetics (Páll Melsted).

In 2024, the centre hosted the following five postdoctoral researchers supported by research grants from the Icelandic Research Fund:
- Aggeliki Chalki (complexity and logic),
- Nicolaos Matsakis (algorithms, from October 2024),
- Dylan McDermott (semantics of programming languages, until September 2024),
- Joseph Tooby-Smith (theorem proving, from September 2024)
- Jana Wagemaker (concurrency theory, until June 2024).

During the reporting period, members of the centre supervised seven PhD students affiliated with ICE-TCS, namely
- Reed Acton (supervised by Henning Úlfarsson),
- Maxime Flin (supervised by Magnús M. Halldórsson),
- Vasiliki Kyriakou (supervised by Antonis Achilleos and Karoliina Lehtinen),
- Calvin Lee (supervised by Tarmo Uustalu),
- Stian Lybech (supervised by Luca Aceto and Mohammad Hamdaqa),
- Yasuaki Morita (supervised by Tarmo Uustalu and Dylan McDermott), and
- Jasmine Xuereb (supervised by Antonis Achilleos and Adrian Francalanza).

All those PhD students are supported by research grants from the Cooperation Fund of the Icelandic Ministry for Education, the Icelandic Research Fund or the Reykjavik University Research Fund. Jasmine Xuereb is enrolled in a joint Reykjavik University/University of Malta doctorate.

Judging from the success its PhD students and postdocs have in securing academic positions at high-profile institutions, ICE-TCS seems to provide an environment where young researchers can develop their careers and take steps in achieving their potential. For example, among the centre's (former) postdocs, Jana Wagemaker took up a tenure-track assistant professorship at Radboud University Nijmegen in July 2024, Joseph Tooby-Smith will be a lecturer at the University of Bath from September 2025 and Dylan McDermott is now a senior research associate at the University of Oxford. Last, but by no means least, we remark that Maxime Flin,

who will finish his PhD at some point in the second half of 2025, has already been hired as a postdoctoral researcher by Jukka Suomela at Aalto University.

During the reporting period, ICE-TCS members supervised two MSc students, Eva Ósk Gunnarsdóttir and Calvin Lee. who defended their theses in the reporting period. Calvin is now a PhD student at ICE-TCS. Eva Ósk worked as a research assistant at ICE-TCS supervised by Anna Ingólfsdóttir and Maria Oskarsdottir (data science) until August 2024 and is now a data analyst at Islandsbanki.

The complete list of the PhD theses supervised by members of the centre is available at https://icetcs.github.io/theses/phdtheses.html and that of the MSc theses completed at ICE-TCS is at https://icetcs.github.io/theses/msctheses.html.

4 A first look at 2025

The coming year will mark the 20th anniversary of ICE-TCS. As part of the celebrations for that occasion, ICE-TCS will revive its annual Theory Day, which has been dormant over the last couple of years, and will invite some distinguished guests for that event. Moreover, Tarmo Uustalu will host three theorem-proving conferences, viz. FroCoS, ITP and TABLEAUX, at Reykjavik University in the period 27 September-3 October 2025. These events continue the centre's tradition of bringing high-quality international conferences to Reykjavik University. (See the centre's web page for past such events since 2005.) Tarmo will also co-organise the World Logic Day 2025 Estonia event that will be held at the Estonian Academy of Sciences on 11 January 2025 and the 27the Estonian Winter School in Computer Science, EWSCS 2025, that will be held at Viinistu 3-6 March 2025. Moreover, three ICE-TCS PhD students (Stian Lybech, Yasuaki Morita and Jasmine Xuereb) will defend their theses in 2025.

In order to celebrate its 20th anniversary, ICE-TCS will nominate at least one of its members for international awards such as ACM Distinguished Scientist or ACM Fellow.

In keeping with its activities since 2005, ICE-TCS will endeavour to maintain a regular seminar series and a vibrant guest programme. At the time of writing, confirmed guests are
- Nicola Del Giudice, postdoc at the University of Camerino, who will visit ICE-TCS in the period 6-20 February 2025,
- Jana Wagemaker, assistant professor at Radboud University, Nijmegen, who will visit ICE-TCS in the period 17-21 February 2025, and
- Pierre-Louis Curien, professor at Université Paris Cité, who will visit ICE-TCS in the period 12-30 March 2025.

In January 2025, Luca Aceto will deliver a six-hour course on research skills to the PhD students in the Italian National PhD Programme in Cybersecurity. Moreover, he will keep holding similar sessions with the PhD students at the Department of Computer Science at Reykjavik University.

For the first time in a few years, the [recent call for faculty positions](#) issued by the Department of Computer Science at Reykjavik University explicitly mentions theoretical computer science as one of the focus areas. It will be interesting to see what the quality and quantity of applicants from our fields of computer science will be. To our mind, it is high time to hire scientifically strong and motivated future members of the centre. Indeed, the core faculty at ICE-TCS has not changed for many years and one of the centre's founding members and scientific co-directors, Anna Ingólfsdóttir, will be employed 50% in 2025 and might be retiring in 2026.

On 16 January 2025, we received encouraging [news on the funding front from the Icelandic Research Fund](#) to which several core members of the centre as well as postdocs and PhD students had submitted grant applications in June 2024. Magnús Halldórsson's project grant application was selected for funding, as were two PhD grant applications submitted by Reed Acton and Vasiliki Kyriakou. All the grants are for three years. This means that ICE-TCS received three of the four grants awarded to the Department of Computer Science at Reykjavik University. Researchers from the centre whose applications did not receive funding, despite having high scores from their reviewers, will submit applications to the Reykjavik University Research Fund to support some of their PhD students. We shall see what our success rate will be.

In summary, this promises to be another busy year for ICE-TCS. We encourage our readers to follow the centre's activities on its [web page](#), which will be kept up to date regularly.

5 Summary and Self-Evaluation

It is hard to maintain the level of activity ICE-TCS kept for nearly 20 years. However, despite some initial signs of tiredness within our small community, we think that, as witnessed by the highlights we mentioned in this annual report, during 2024 the centre has remained visible within the international research community in theoretical computer science. We can be proud of the centre's research, the service and leadership roles that its members continue having and the events organised by the members of ICE-TCS. It is probably fair to say, however, that the local impact of ICE-TCS doesn't match its international one.

Research at ICE-TCS during the reporting period has been published in high-quality venues, and the quality of the publication venues may be viewed as a proxy for the scientific value of our research. There is always room to improve on the percentage of the centre's research output that appears in the proceedings of A* conferences, but that's something that is only partially under our control. The best we can do is to keep carrying out the best research of which we are capable, write good articles and submit them to the most appropriate outlet.

We are very pleased with the success that ICE-TCS alumni continue to have in their careers. On the one hand, this is due to the fact that we seem to be hiring strong young academics as

PhD students and postdocs. At the same time, we like to think that the research environment at the centre helps them to develop as scientists and to achieve their potential. (At least, the time they spend at ICE-TCS does not appear to cause any harm to their careers!) We will endeavour to continue to provide a stimulating research environment for our junior collaborators and for all of us. As part of this effort, we will strengthen our career-development efforts, and strive to revamp the ICE-TCS seminar series and to entice more students and members of other research centres at the department to attend the talks we will offer.

In order to increase the centre's local impact, it might be worth exploring ways to foster inter-group collaborations within the centre, leading to future grant applications spanning several groups, and to build active research cooperation with the new [research centre in cybersecurity at the department](#) and with researchers working on data and network science. Moreover, we should strive to advertise nationally some of the international successes that ICE-TCS has and to actively nominate its members for national and international honours.

In summary, we can be pleased with what ICE-TCS has managed to achieve in 2024 and with its contributions over nearly 20 years. We will continue to exploit all available means to maximise our impact and research collaborations, as well as the quality of our research output. At the end of the day, the most important asset of the centre is its people and we should try to grow as well, and as much, as we can.

Despite the passage of time, the level of ambition at the centre is still high. We look forward to yet another year of activities in theoretical computer science at Reykjavik University. Bring it on!

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