# The Ackermann Award 2023

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**Abstract**

Report on the 2023 Ackermann Award.

**2012 ACM Subject Classification** Theory of computation → Logic and verification; Theory of computation → Lambda calculus; Theory of computation → Equational logic and rewriting

**Keywords and phrases** lambda-calculus, computational complexity, geometry of interaction, abstract machines, intersection types

**Digital Object Identifier** 10.4230/LIPIcs.CSL.2024.1

**Category** Ackermann Award

## 1 The Ackermann Award

The Ackermann Award is the **EACSL Outstanding Dissertation Award for Logic in Computer Science**. It is presented at CSL, the annual conference of the EACSL (European Association for Computer Science Logic). This year, the 19th Ackermann Award is presented at CSL 2024 in Naples, Italy.

A call for nominations was issued in February 2023, open to any PhD dissertation (on any topic represented at the annual CSL and LICS conferences) formally accepted by a degree-granting institution in fulfilment of the PhD degree between 1 January 2022 and 31 December 2022. The Jury received ten nominations, which came from a number of different countries around the world: the nominees obtained their doctorates at institutions in Australia, Brazil, Germany, Italy, Spain and Sweden.

The topics covered a wide range of areas in Logic and Computer Science. All the nominated PhD theses were of a very high quality and contained significant contributions to their particular fields. On behalf of the Ackermann Jury, we extend our warmest congratulations to all the nominated candidates for their outstanding work.

All the submissions were evaluated by the Jury, and after two phases of reviewing and extensive discussion, the jury decided to grant the **2023 Ackermann Award** to **Gabriele Vanoni** for the PhD thesis entitled *On Reasonable Space and Time Cost Models for the λ-Calculus*, completed at the *University of Bologna*, Italy, in 2022.

## 2 Citation

Gabriele Vanoni receives the *2023 Ackermann Award* of the European Association of Computer Science Logic for the PhD thesis

*On Reasonable Space and Time Cost Models for the λ-Calculus*,

which provides the first reasonable space cost model for the λ-calculus, showing that the space complexity of functional programs is equivalent to that of Turing machines. To achieve this


ambitious goal, the thesis defines new abstract machines for call-by-name and call-by-value evaluation of $\lambda$-terms, as well as providing a characterisation of this new reasonable space measure by means of intersection types.

## 2.1 Background to the thesis

The thesis is in the domain of logical foundations of functional programming languages. More precisely, it studies space and time cost models for functional programs.

The use of resources (time and space consumption) during computation is typically measured on Turing machines (TMs), where time complexity refers to the number of steps the machine needs to perform until it stops, and space complexity is the number of tape cells used during the computation. However, TMs are a low-level model of computation, which does not provide an understanding of the time and space consumed on higher-level models of computation such as the ones that are at the core of modern programming languages.

The Slot and van Emde Boas Invariance Thesis states that a time (respectively, space) cost model is reasonable for a computation model $C$ if there are mutual simulations between Turing machines and $C$ such that the overhead is polynomial in time (respectively, linear in space). The rationale is that under the Invariance Thesis, complexity classes (such as LOGSPACE, P, PSPACE) are machine independent.

In his PhD thesis, Vanoni addresses the problem of finding out whether it is possible to define a reasonable space cost model for the $\lambda$-calculus, the paradigmatic computation model for functional programming languages.

## 2.2 Contributions of the thesis

In order to achieve the objective of the thesis, the work is organised in two stages. The first half of Vanoni's thesis is devoted to disproving a longstanding open conjecture in the field, originally stating that Girard's Geometry of Interaction is a reasonable space cost model for the $\lambda$-calculus. The second half of the thesis uses the intuitions gained with this first negative result to finally build a reasonable space cost model for the $\lambda$-calculus.

More precisely, the thesis starts by considering an evaluator for the $\lambda$-calculus, the $\lambda$IAM, which is based on Girard's Geometry of Interaction. The latter was conjectured to be a good candidate to obtain a reasonable cost model for space. Vanoni disproved this conjecture by a detailed complexity analysis using new variants of non-idempotent intersection types. As a consequence, he changed the target of his analysis and considered a variant of Krivine's abstract machine (a standard evaluation mechanism for the call-by-name $\lambda$-calculus), which he optimised for space complexity and implemented without any pointer. By analysing a refined version of the encoding of Turing machines into the $\lambda$-calculus, Vanoni concluded that the space consumed by this machine is indeed a reasonable space cost model. In particular, for the first time it was also possible to measure sub-linear space complexities. This result translates also to the call-by-value case.

One should note that the challenges are rather formidable. For one, the various abstract machines need to implement computations in the $\lambda$-calculus with a fine control over garbage collection. The $\lambda$IAM was promising precisely because it did not need any garbage collection. Vanoni's modified Krivine abstract machine instead resorts to eager garbage collection. Another subtle point is that, in order to obtain meaningful notions of sub-linear space complexity, one needs to separate the amount of work space from the size of the input, since the latter must not be counted, as in Turing machine models; and the usual abstract machines for the $\lambda$-calculus do not allow one to distinguish between input and non-input data.

Finally, Vanoni provided a characterisation of this new reasonable space measure by means of intersection types. This was instrumental in characterising the space complexity of each of the abstract machines considered, and was done through a minimal, yet non-trivial, modification of the original type system proposed by de Carvalho. Eventually, this leads Vanoni to obtain characterisations of reasonable space complexity that are modular and independent of the machine model.

### 2.3 Biographical sketch

Gabriele Vanoni carried out his PhD under the supervision of Ugo Dal Lago at the University of Bologna, Italy. He is the winner of the E.W. Beth Dissertation Prize 2023 and Best Italian PhD thesis in theoretical computer science 2023 (awarded by the Italian Chapter of EATCS). He won a Distinguished Paper Award at ICFP 2022, and his LICS 2022 paper was selected for the LMCS special issue. He was invited speaker at DCM 2023 and TLLA 2023. After a year as a postdoctoral researcher at Inria in Sophia Antipolis, he is now a postdoctoral researcher at IRIF in Paris.

## 3 Jury

The jury for the **Ackermann Award 2023** consisted of eight members, two of them *ex officio*, namely, the president and the vice-president of EACSL. In addition, the jury also included a representative of SIGLOG (the ACM Special Interest Group on Logic and Computation).

The members of the jury were:

- Christel Baier (Technical University Dresden);
- Maribel Fernández (King's College London), president of EACSL;
- Joost-Pieter Katoen (RWTH Aachen University), ACM SIGLOG representative;
- Delia Kesner (IRIF, Université Paris Cité);
- Slawomir Lasota (University of Warsaw);
- Jean Goubault-Larrecq (ENS Paris-Saclay);
- Florin Manea (University of Göttingen), vice-president of EACSL;
- James Worrell (University of Oxford).

## 4 Previous winners

Previous winners of the Ackermann Award were

**2005, Oxford:**
Mikołaj Bojańczyk from Poland,
Konstantin Korovin from Russia, and
Nathan Segerlind from the USA.

**2006, Szeged:**
Balder ten Cate from the Netherlands, and
Stefan Milius from Germany.

**2007, Lausanne:**
Dietmar Berwanger from Germany and Romania,
Stéphane Lengrand from France, and
Ting Zhang from the People's Republic of China.

**2008, Bertinoro:**
Krishnendu Chatterjee from India.

**2009, Coimbra:**
Jakob Nordström from Sweden.
**2010, Brno:**
no award given.
**2011, Bergen:**
Benjamin Rossman from USA.
**2012, Fontainebleau:**
Andrew Polonsky from Ukraine, and
Szymon Toruńczyk from Poland.
**2013, Turin:**
Matteo Mio from Italy.
**2014, Vienna:**
Michael Elberfeld from Germany.
**2015, Berlin:**
Hugo Férée from France, and
Mickael Randour from Belgium.
**2016, Marseille:**
Nicolai Kraus from Germany
**2017, Stockholm:**
Amaury Pouly from France.
**2018, Birmingham:**
Amina Doumane from France.
**2019, Barcelona (conference in 2020):**
Antoine Mottet from France.
**2020, Ljubljana (conference online in 2021)**
Benjamin Kaminski from Germany.
**2021, Göttingen (conference online in 2022)**
Marie Fortin from France, and
Sandra Kiefer from Germany
**2022, Warsaw (conference in 2023)**
Alexander Bentkamp from The Netherlands.

Detailed reports on their work appeared in the CSL proceedings and are also available on the EACSL homepage.