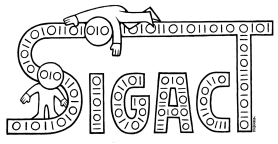

2020 SIGACT REPORT

SIGACT EC –
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SIGACT Mission Statement:

The primary mission of ACM SIGACT (Association for Computing Machinery Special Interest Group on Algorithms and Computation Theory) is to foster and promote the discovery and dissemination of high quality research in the domain of theoretical computer science. The field of theoretical computer science is the rigorous study of all computational phenomena - natural, artificial or man-made. This includes the diverse areas of algorithms, data structures, complexity theory, distributed computation, parallel computation, VLSI, machine learning, computational biology, computational geometry, information theory, cryptography, quantum computation, computational number theory and algebra, program semantics and verification, automata theory, and the study of randomness. Work in this field is often distinguished by its emphasis on mathematical technique and rigor.

1. Awards

- 2020 Gödel Prize: This was awarded to **Robin A. Moser and Gábor Tardos** for their paper "A constructive proof of the general Lovász Local Lemma", Journal of the ACM, Vol 57 (2), 2010. The Lovász Local Lemma (LLL) is a fundamental tool of the probabilistic method. It enables one to show the existence of certain objects even though they occur with exponentially small probability. The original proof was not algorithmic, and subsequent algorithmic versions had significant losses in parameters. This paper provides a simple, powerful algorithmic paradigm that converts almost all known applications of the LLL into randomized algorithms matching the bounds of the existence proof. The paper further gives a derandomized algorithm, a parallel algorithm, and an extension to the "lopsided" LLL. The new algorithmic paradigm involves resampling variables that cause bad events. Such resampling was subsequently used in numerous other papers, including ones that don't directly relate to the LLL. Moreover, the paper provides an elegant proof of correctness involving witness trees. Witness trees have been influential well beyond the LLL, inspiring the "entropy compression" method in combinatorics. Overall, the paper's power and simplicity make it a far-reaching achievement.

- 2020 Knuth Prize: The 2020 Donald E. Knuth Prize was awarded to **Cynthia Dwork** of Harvard University. Dwork is one of the most influential theoretical computer scientists of her generation. Her research has transformed several fields, most notably distributed systems, cryptography, and data privacy, and her current work promises to add fairness in algorithmic decision making to the list. She is widely known for the introduction and development of differential privacy, and for her work on nonmalleability, lattice-based encryption, concurrent composition, and proofs of work. She also did foundational work in many other areas including in distributed systems with her work on consensus, and in algorithmic fairness with her work on the formalization of the "treat like alike" principle. A striking feature of Dwork's work is her willingness and ability to tackle big, important problems. Two examples stand out: her work on cryptography in a network environment, and her work on privacy. Dwork and her collaborators recognized that the formalisms existing at the time could potentially fail spectacularly in the real world, where protocols run in a dynamic, asynchronous and widely spread network. They studied a number of abstract settings that, they felt, captured some important aspects of the large and daunting problem they had identified. Their work's significance was not fully understood at first, but Dwork and her collaborators persevered, and these basic settings have come to play a central role in modern cryptography. For example, nonmalleability (STOC 91, SICOMP 00, SIAM Review 03) and concurrent composition (STOC 98, JACM 04) of proof systems play a critical role in both the modeling and the construction of secure multiparty computation protocols. Dwork's identification of these models and concrete protocols that satisfy their requirements have led to a huge body of work on more general notions of composition and network security. The now gold-standard definition of security for public-key encryption (indistinguishability under adaptive chosen-ciphertext attacks) was first shown to be achievable in Dwork's seminal paper on nonmalleability (STOC 91). Lattice-based cryptography (STOC 97) forms the basis of recent progress in homomorphic encryption, functional encryption and program obfuscation. Lattice-based cryptosystems are also the main candidates for public-key encryption secure against attacks by quantum computers. Dwork's work provided the first public-key cryptosystem whose security was based on the worst-case hardness of a natural lattice problem. The second example of Dwork's ability to tackle big problems is her work on private data analysis. Consider a data curator that collects and stores sensitive data about individuals, the curator could be a government agency (such as the IRS), a clinical research group, a sociologist, or a company such as Google or Facebook. How can the curator publish (either publicly or internally) salient information about the data without compromising the privacy of individuals in the data set? This problem is critical for obvious ethical and legal reasons and, more subtly, because the curator requires participants' trust in order to collect accurate data. The problem has been studied in the statistics literature since the 1960s and in the database literature since the 1980s. However, in the early 2000s, there was still no coherent definition of what privacy should mean in this context, only intuitive requirements that individual information not be revealed. Inspired by a paper by Irit Dinur and Kobbi Nissim, Dwork began to investigate how one could precisely pin down privacy in statistical databases. Over the ensuing

decade, Dwork led the development of an entire scientific field at the intersection of computer science, statistics, economics, law and ethics. Her work produced a deep theory of private data analysis as well as techniques that have changed how companies, government agencies and hospitals collect and process data. Differential privacy has profoundly influenced the science of data privacy, providing a firm theoretical basis as well as a standard to which other approaches are compared. This influence extends beyond technical disciplines to legal and policy discussions, where differential privacy has been used to formulate a natural-language standard on which specific rules can be based. Differentially private algorithms are now implemented at the US Census Bureau, which plans to make the public releases from the 2020 decennial census differentially private. Google, Apple, and Microsoft already have deployed systems for collecting sensitive usage information while ensuring differential privacy, and a number of other companies (LinkedIn, Facebook, Uber) are testing systems for sharing aggregate information that is differentially private. Drawing on tools from learning theory, complexity and algorithms, Dwork developed techniques for differentially private analysis of data sets in a variety of domains. The ideas we highlight above are only a sample of Dwork's sustained record of contributions to theoretical computer science over the past four decades. The success of the ideas mentioned here is due to large, vibrant communities of scientists. Dwork has played a special role in these communities, leading both through her technical work and by creating opportunities for the communities to develop (for example, through advocacy efforts, organizing multi-disciplinary workshops, founding journals, and chairing conferences). Modern theoretical computer science would look very different without her involvement. Dwork has also played a remarkable role in mentoring young researchers and nurturing their talent. To name only a few: Shuchi Chawla, Katrina Ligett, Ilya Mironov, Kobbi Nissim, Omer Reingold, Aaron Roth, Guy Rothblum, Amit Sahai, Adam Smith, Kunal Talwar. Any one of these researchers can speak to the enormous influence Dwork's mentorship had on them and their careers. Overall, Dwork is an outstanding Computer Scientist who richly deserves the 2020 Knuth prize.

- 2019 ACM Paris Kanellakis Theory and Practice Award: **Noga Alon, Philip Gibbons, Yossi Matias** and **Mario Szegedy** have been awarded the Kanellakis Theory and Practice Award for 2019. Alon, Gibbons, Matias and Szegedy pioneered a framework for algorithmic treatment of streaming massive datasets. Today, their sketching and streaming algorithms remain the core approach for streaming big data and constitute an entire subarea of the field of algorithms. Additionally, the concepts of sketches and synopses that they introduced are now routinely used in a variety of data analysis tasks in databases, network monitoring, usage analytics in Internet products, natural language processing and machine learning. In their seminal paper, "The Space Complexity of Approximating the Frequency Moments," Alon, Matias and Szegedy laid the foundations of the analysis of data streams using limited memory. Follow-up papers, including "Tracking Join and Self-join Sizes in Limited Storage," by Alon, Gibbons, Matias, and Szegedy, and "New Sampling-Based Summary Statistics for Improving Approximate Query Answers," by Gibbons and Matias, expanded on the idea of

data synopses and were instrumental in the development of the burgeoning fields of streaming and sketching algorithms. This work has been applied to query planning and processing in databases and the design of small synopses to monitor vast quantities of data generated in networks.

- 2020 ACM-EATCS Edsger W. Dijkstra Prize in Distributed Computing: "Computation in networks of passively mobile finite-state sensors", by **Dana Angluin, James Aspnes, Zoe Diamadi, Michael J. Fischer, and Rene Peralta,** Distributed Computing 18(4): 235-253 (2006) was selected as the winner of the 2020 ACM-EATCS Dijkstra Prize in Distributed Computing. The Edsger W. Dijkstra Prize in Distributed Computing is named for Edsger Wybe Dijkstra (1930-2002), a pioneer in the area of distributed computing. His seminal works on concurrency primitives (such as semaphores), concurrency problems (such as mutual exclusion and deadlock), finding shortest paths in graphs, fault-tolerance, and self-stabilization are important foundations upon which the field of distributed computing is built.

- 2020 SIGACT Distinguished Service Award: The 2020 SIGACT Distinguished Service Award was presented to **Dieter van Melkebeek** for his leadership in creating the Computational Complexity Foundation (CCF) and transitioning the annual Computational Complexity Conference to be run under the auspices of the CCF. This new model benefits the research community in multiple ways, including open-access publication of the conference proceedings and reduced conference costs, while maintaining the prestige of this core theory conference. CCF has demonstrated financial stability and exemplary transparency. It enjoys broad support within the community and serves as a model that may be emulated in CS Theory and beyond. CCF has the potential to take up other issues of interest to the theory community; as an example, it has already taken over the guardianship of the popular Electronic Colloquium on Computational Complexity (ECCC) preprint service. The well-reasoned and smoothly executed transition realized a long-voiced desire of the community to become independent. In the face of the formidable legal, financial, and logistical challenges involved in the transition, it took an extraordinary leader to turn this desire into reality. Dieter's vision, determination, thoughtfulness, careful planning, attention to detail, and singular dedication made this transition an unqualified success.

In addition, SIGACT has standardized the deadlines for nominations of awards.

2. Significant papers on new areas published in proceedings

Below we highlight some of the "Best Paper" award winners from two SIGACT sponsored conferences.

STOC 2020
The ACM Symposium on Theory of Computing covers much of computer science theory.

Ryan Alweiss, Shachar Lovett, Kewen Wu, and Jiapeng Zhang, in their paper "Improved Bounds for the Sunflower Lemma," which won the Best Paper Award, made progress

toward resolving one of the most famous remaining open problems posed by the great Hungarian mathematician Paul Erdös. In combinatorics, a *sunflower* is a collection of sets whose pairwise intersections are all equal. Erdös and Rado in 1960 pioneered the study of upper bounds on the size of sunflower-free set systems, a topic whose applications include lower bounds for monotone circuits. They famously conjectured an exponential upper bound on the number of sets in a sunflower-free collection of *k*-element sets. The paper of Alweiss et al. takes a giant step toward resolving this conjecture.

The Danny Lewin Best Student Paper award at STOC 2020 was given to Siddharth Bhandari and Sayantan Chakraborty for their paper entitled "Improved bounds for perfect sampling of *k*-colorings in graphs." The paper presents a new algorithm for generating a uniformly-random sample from the set of proper *k*-colorings of a finite graph in (expected) polynomial time, provided that the number of colors is greater than three times the maximum degree of the graph. Previously, polynomial-time perfect sampling algorithms were only known to exist when the number of colors was much larger — roughly the square of the maximum degree.

SODA 2020
ACM-SIAM Symposium on Discrete Algorithms is a major conference that focuses on algorithms and combinatorics.

The Best Paper Award at SODA 2020 was given jointly to "Chasing Convex Bodies Optimally", by Mark Sellke, and "Chasing Convex Bodies with Linear Competitive Ratio" by C.J. Argue, Anupam Gupta, Guru Guruganesh, and Ziye Tang. Sellke's paper also won the Best Student Paper Award at the conference. The two papers resolved a long-standing open question in the theory of online algorithms posed by Friedman and Linial in 1991, involving the design of algorithms that select a sequence in points in high-dimensional space in response to queries that require each point new point in the sequence of belong to a specific convex body. The closely related problem of "convex function chasing" (also solved in Sellke's paper) has been shown to have applications to efficiently powering datacenters.

3. Significant programs that provided a springboard for further technical efforts

SIGACT sponsored or co-sponsored a number of important conferences including the Symposium on Theory of Computing (STOC), Symposium on Principles of Distributed Computing (PODC), Symposium on Parallel Algorithms and Architectures (SPAA), and Symposium on Discrete Algorithms (SODA).

SIGACT also supports several conferences in-cooperation including Symposium on Principles of Database Systems (PODS), Symposium on Foundations of Computer Science (FOCS), and Symposium on Principles of Programming Languages (POPL).

SIGACT helped support the creation of Algorithmic Principles of Computer Systems (APOCS) a conference co-located with the ACM-SIAM SODA Conference in Jan 2020 and also supported "Papa Fest" a celebration of Christos Papadimitriou's 70th birthday at Columbia University in New York, to celebrate his many contributions to TCS.

SIGACT is planning on launching a test of time award like FOCS has done recently. We expect this to be announced shortly, with the first award being given in 2021.

4. Innovative programs which provide service to our technical community

The Committee for the Advancement of Theoretical Computer Science (CATCS), sponsored by SIGACT, continues to be very active. The committee meets by conference call every month and has developed and executed action plans to increase the visibility of theoretical computer science and to increase the funding base for theory of computation at the NSF. The Committee has helped advise the NSF CCF Director and other NSF officers on several matters including recruiting for positions within. The committee has also been working to obtain a more detailed and complete picture of the state of academic employment in theoretical computer science within the broad range of US research universities. Having Shuchi Chawla be the chair of CATCS, and be on the SIGACT EC has resulted in a close co-operation between the two groups.

SIGACT continues to support student attendance at SODA and STOC by funding Best Student Paper Awards, travel, lunches, and reduced registration fees. SIGACT has also provided additional student support for all of its other sponsored and co-sponsored conferences this year. This helps ensure that the maximum number of students can attend these conferences.

The second TCS Visioning workshop was organized by the SIGACT Committee for the Advancement of Theoretical Computer Science and took place during the week of July 20, 2020. The workshop was held online and involved over 75 participants from the United States, Europe, and Asia. The main goal of the workshop was to identify broad research themes within theoretical computer science that have potential for a major impact in the future. These themes were then packaged into research nuggets in a way that can be consumed by the general public. A workshop report in the form of a white paper accompanied with graphics/posters produced by a professional graphic designer will be released publicly within a few months. These will then be delivered primarily to the Computing Community Consortium (CCC) and funding agencies such as the National Science Foundation (NSF) to help them advocate for TCS.

SIGACT has co-sponsored the SIGACT CRA-W Grad Cohort Workshop, the Women in Theory Workshop as well as the TCS women's spotlight workshop at STOC, featuring both an inspiring senior researcher as well as post-docs and senior graduate students.

5. Significant new initiatives

The major conference run through SIGACT is the Symposium on Theory of Computing (STOC). Due to the situation with COVID-19, STOC in Chicago was basically converted into a fully online conference. We wanted to thank the local arrangements team – Madhur Tulsiani (local arrangements chair), Yury and Kostya Makarychev and Gautam Kamath – for putting the online conference together. Julia Chuzhoy was the PC chair for STOC, and Tim Roughgarden was the Theory Fest Chair - and they all worked tirelessly to ensure that attendees had a great experience. The full length talk videos were made available before the conference, and each paper was given a 10 minute slot during the conference to summarize their work. This enabled a late morning start and a finish by late afternoon to attempt to cater to people from the US West coast to Europe. We were not sure how to best cater to attendees from the Far East and Australia. A post survey of STOC attendees definitely suggests that with some frequency the conference needs to be held virtually increasing participation – we had participants from many countries this time. The attendance at STOC doubled and was over 700. In addition, to the conference talks, there were workshops as well as a reception held on gather.town. From the post-STOC survey it does appear that there is significant support for an online conference.

Challenges to this approach are that it requires a great deal more volunteer effort and organization. We have aimed to keep registration fees low, but in future years this may require increases in registrations costs for the conference to maintain financial stability.

6. Summary of key issues that the membership of the SIGACT will have to deal with in the next 2-3 years

Funding and articulating the importance of theoretical computer science are perennial issues that are being addressed by the Committee for the Advancement of Theoretical Computer Science (CATCS) in conjunction with SIGACT. We have effectively fundraised to increase the Knuth prize from $5,000 to $10,000 thanks to a private donor (for three years). We might have to fund raise additional funds for future years. The SIGACT Service Award was increased from $1,000 to $3,000.

Membership in SIGACT has been flat. Since generally there are minimal specific benefits for SIGACT membership after joining the ACM, this is perhaps not surprising. We also need to think about ways to simply offer a lifetime membership.

SIGACT needs to do more to support programs and events to have a broader reach to historically under-represented groups. We strongly suggest that the next SIGACT EC prioritize this issue.

Another key issue relates to open access. By and large, the community is deeply supportive of open access and is encouraged by recent efforts by the ACM to make conference papers more readily and freely accessible. A natural consequence of this may

be decreased funding for SIGACT through the ACM Digital Library program, which provides the bulk of our discretionary budget. At this stage we are making SIGACT News freely available on the SIGACT website.

7. Volunteer Development Process

SIGACT now has a number of sub committees working to improve diversity in TCS, by running the STOC Theory Women Workshop (Barna Saha, Sofya Raskhodnikova and Virginia Vassilevska Williams) and as well as a sub-committee to identify top new papers for coverage in CACM (Research Highlights) consisting of Aleksander Madry (chair), Irit Dinur, Boaz Barak and Jelani Nelson. We hope to recruit more volunteers for other activities. Amit Sahai has kindly taken on the role of co-ordinating awards. We do need a sub-committee to solicit for conference locations for STOC. Right now this is handled by the SIGACT EC.

Award committees for the Knuth prize, Gödel prize and SIGACT Distinguished Service Award also evolve and change every year with new members being added and members rotating out. This year the award committees for the SIGACT Distinguished Service Award were Laszlo Babai (chair), Alistair Sinclair and Rebecca Wright. The Knuth prize award committee was Alan Frieze (chair), Hal Gabow, Noam Nisan, Ronitt Rubinfeld, Eva Tardos and Andrew Yao. The Gödel prize committee was Samson Abramsky, Anuj Dawar (chair), Joan Feigenbaum, Robert Krauthgamer, Dan Spielman and David Zuckerman.

The PC chair for 2021 STOC will be Virginia Vassilevska Williams and the PC chair for 2022 STOC will be Anupam Gupta.