



2019 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 interpreted broadly so as to include 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

- 2019 Gödel Prize: This was awarded to **Irit Dinur** for her paper “The PCP theorem by gap amplification”, Journal of the ACM, Vol 54 (3), Article 12, 2007 (preliminary version in the proceedings of the 38th Symposium on Theory of Computing, STOC 2006). The PCP theorem is one of the most influential and impressive results of the theory of computation, having fundamental implications both to the study of the inherent difficulty of approximation problems and to the study of probabilistic proof systems. This paper provides an alternative proof of the PCP theorem, which is fundamentally different from the original proof. The new proof is significantly simpler than the original, making its presentation in complexity courses a feasible task. In addition, it significantly improves on important parameters of the resulting PCP, yields the same improvements for locally testable codes, and has inspired much research including practical applications. Providing an alternative proof for a result of such importance is an achievement to celebrate, especially for a proof addressing issues that have been puzzling many researchers and resolving a central open problem in the area. Dinur's proof diverges from the original proof which relied on the arithmetization of NP. In this sense, the new proof is more direct and reveals new insights into the PCP Theorem and into NP. The proof is pivoted at the “amplification” of PCP systems, via a gradual process (of logarithmically many steps), while maintaining a direct connection with what is happening in terms of natural NP-complete problems. In

fact, the amplification process is often described in terms of a natural Constraint Satisfaction Problem.

- **2019 Knuth Prize:** The 2019 Donald E. Knuth Prize was awarded to **Avi Wigderson** of the Institute for Advanced Study for fundamental and lasting contributions to the foundations of computer science in areas including randomized computation, cryptography, circuit complexity, proof complexity, parallel computation, and our understanding of fundamental graph properties. Wigderson has also trained many generations of theoretical computer scientists through his visitor and postdoc program at the Institute for Advanced Study. Wigderson's work revolutionized our understanding of randomness in computation. In a series of results, he showed under widely-believed computational assumptions that every probabilistic polynomial time algorithm can be fully derandomized. In other words, randomness is not necessary for polynomial-time computation. This was achieved by a sequence of papers of his: "Hardness vs. Randomness" with Nisan, "BPP Has Subexponential Time Simulations Unless EXPTIME has Publishable Proofs" with Babai, Fortnow, and Nisan, and "P=BPP if E Requires Exponential Circuits: Derandomizing the XOR Lemma" with Impagliazzo. This last result showed that $P=BPP$ is implied by the assumption that there exist functions that can be computed by exponential-time Turing machines that cannot be computed by subexponential-size circuits in the worst case. To this day, the Impagliazzo-Wigderson paper is one of the strongest pieces of evidence we have that $P = BPP$. In cryptography, in two landmark papers, one with Goldreich and Micali and one with Ben-Or and Goldwasser, Wigderson showed how one could compute any function securely in the presence of dishonest parties. Wigderson also with Goldreich and Micali showed that all problems with short proofs (i.e., all problems in NP) in fact have zero-knowledge proofs: that is, proofs that yield nothing but their validity, a central cryptographic construct. Additionally, originating from cryptography but with applications to many areas in theoretical computer science, Wigderson with Ben-Or, Goldwasser, and Kilian defined the model of multi-prover interactive proofs. This model for the first time showed how it would be possible for a polynomial-time machine to verify an exponentially-long proof. This idea had substantial impact, and among other things it led to the celebrated PCP theorem and the flow of follow-up works on hardness of approximation. In the area of parallel computation, Wigderson provided a series of foundational results about parallel computing models. This includes the first RNC algorithm for constructing a perfect matching in a graph with Karp and Upfal, the first NC algorithm for finding a maximal independent set in a graph with Karp, and a number of fundamental lower bound results. With Reingold, Vadhan and Capalbo, Wigderson gave the first efficient combinatorial constructions of expander graphs, an important class of highly connected sparse graphs. Before this work, only algebraic constructions had been known. Wigderson's development of combinatorial expander constructions enabled a series of important subsequent results including Reingold's deterministic logspace algorithm for st-connectivity.

- 2018 Paris Kanellakis Theory and Practice Award: **Pavel Pevzner** has been named the 2018 ACM Paris Kanellakis Theory and Practice Award recipient for pioneering contributions to the theory, design, and implementation of algorithms for string reconstruction and to their applications in the assembly of genomes. He made fundamental contributions to the theoretical study of string algorithms and to their application to scalable reconstruction of genomes and other biological sequences such as antibodies and antibiotics.
- 2019 Edsger W. Dijkstra Prize in Distributed Computing: "Randomized Distributed Edge Coloring via an Extension of the Chernoff–Hoeffding Bounds" by **Alessandro Panconesi** and **Aravind Srinivasan** (originally published in PODC 1992).
- 2019 SIGACT Distinguished Service Award: The award this year was given to **Rebecca Wright** for her 11-year leadership of DIMACS, particularly in continuing and expanding the research and educational missions of DIMACS, for promoting diversity in computer science, and for using her expertise in privacy and security to help shape public policy on a national level.

A successful researcher in privacy and security, Wright joined DIMACS as Deputy Director in 2007 and served as Director from 2011 to 2018. DIMACS started as an NSF Science and Technology Center during the period 1989-2000. Since then DIMACS has had to rely on a series of individual grants and gifts to sponsor its programs, including its special foci, curriculum development projects and postdoctoral research program. Wright has worked closely with NSF program directors and other sponsors to ensure continued support of these programs.

Wright established two new education programs that engage women in computer science. The Douglass-SAS-DIMACS Computer Science Living-Learning Community for Women brings first-year undergraduate women at Rutgers who have strong interest in computer science into an immersive education environment, including a shared living space and academic experiences. The Douglass-DIMACS Computing Corps, now largely led by its membership of Rutgers undergraduate women, carries out computing activities with local middle schools and Girl Scout troops. Wright has expanded DIMACS programs that work with K-12 educators in the region.

Wright has helped harness theoretical computer science for the public good. She has worked extensively on privacy and security issues in voter registration databases, through the National Research Council's Committee on State Voter Registration Databases, the ACM's US Public Policy Council, and the Privacy and Technology Advisory Board of the Electronic Registration Information Center.

Wright serves on the CRA-W and the Simons Foundation Mathematical and Physical Sciences Advisory Board. She briefed the US Senate's Diversity in Tech Caucus in 2016 as a representative of CRA-W and leads the CRA-W's efforts in cosponsoring the SWSIS Scholarships for Women Studying Information Security program.

- SIGACT made 40 student travel awards to allow students to attend the 2019 STOC conference. In addition, we provided financial assistance to several other conferences for student travel support as well.

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 2019

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

Wojciech Czerwinski, Slawomir Lasota, Ranko Lazic, Jerome Leroux and Filip Mazowiecki, in their paper “The Reachability Problem for Petri Nets is Not Elementary,” which won a Best Paper Award.

Nima Anari, Kuikui Liu, Shayan Oveis Gharan, and Cynthia Vinzant, in their paper “Log-concave polynomials II: High dimensional walks and an FPRAS for counting bases” which won a Best Paper Award.

Ran Raz and Avishay Tal, in their paper “Oracle separation of BPQ and PH” which won a Best Paper Award.

The Danny Lewin Best Student Paper award at STOC 2019 was given to Lijie Chen and Roei Tell for their paper entitled “Bootstrapping Results for Threshold Circuits Just Beyond Known Lower Bounds”. This paper shows that seemingly-slight improvements in currently-known lower bounds on the size of depth- d threshold circuits would suffice, in order to answer some longstanding questions in circuit complexity.

SODA 2019

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

Sepehr Assadi, Yu Chen, and Sanjeev Khanna, in their paper “Sublinear Algorithms for $(\Delta+1)$ Vertex Coloring,” which won a Best Paper Award, designed algorithms for graph coloring in several canonical classes of sublinear algorithms including graph streaming, sublinear time, and massively parallel computation algorithms.

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 Computation (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 “Symposium on 50 Years of Complexity Theory: A Celebration of the Work of Stephen Cook” in Toronto in May 2019.

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 Student Best 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.

SIGACT has co-sponsored the SIGACT CRA-W Grad Cohort Workshop and the Women in Theory Workshop.

5. Significant new initiatives

The major conference run through SIGACT is the Symposium on Theory of Computation (STOC). For the second year, we attempted a major expansion of STOC, under the label “TheoryFest”. The change lengthened the program to 5 days. While it remained 3 days of paper presentations, we increased to three parallel sessions to allow a modest increase in accepted papers. There was a day of tutorials and workshops; a panel session on directions

in theory; poster sessions in some evenings; and a large number of invited speakers across a number of areas. Again the event seemed successful, in that there was strong feedback that the event was well enjoyed by the participants. We did see an increase in the number of attendees, but it was less than we had desired. We are planning to keep this format in future years, and will have to evaluate as we continue how the new format is working. In particular, we may have to raise conference rates in order to balance the budget for the conference under the new framework. As the current conference fees are very low, this should not be problematic.

Challenges to this approach are that it requires a great deal more volunteer effort and organization, and is significantly more expensive. 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 the next 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.

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.

6. 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), Boaz Barak, Mary Wooters and Omer Reingold. 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.

