2009 Fulkerson Prizes

The 2009 Delbert Ray Fulkerson Prizes were presented at the 20th International Symposium on Mathematical Programming, held August 23 to August 28, 2009, in Chicago. Listed below are the names of the authors who received the Fulkerson Prizes, the titles of their prizewinning papers, and the prize citations.

Maria Chudnovsky, Neil Robertson, Paul Seymour, and Robin Thomas, "The strong perfect graph theorem", *Annals of Mathematics*, volume 164, issue 1, 2006, pages 51–229.

Claude Berge introduced the class of perfect graphs in 1960, together with a possible characterization in terms of forbidden subgraphs. The resolution of Berge's strong perfect graph conjecture quickly became one of the most sought-after goals in graph theory. The pursuit of the conjecture brought together four important elements: vertex colorings, stable sets, cliques, and clique covers. Moreover, D. R. Fulkerson established connections between perfect graphs and integer programming through his theory of antiblocking polyhedra. A graph is called perfect if for every induced subgraph H the clique-covering number of H is equal to the cardinality of its largest stable set. The strong perfect graph conjecture states that a graph is perfect if and only if neither it nor its complement contains, as an induced subgraph, an odd circuit having at least five edges. The elegance and simplicity of this possible characterization led to a great body of work in the literature, culminating in the proof by Chudnovsky, Robertson, Seymour, and Thomas, which was announced in May 2002, just one month before Berge passed away. The long, difficult, and creative proof by Chudnovsky and her colleagues is one of the great achievements in discrete mathematics.

Maria Chudnovsky is in the Department of Mathematics at Princeton University. Neil Robertson is in the Department of Mathematics at the Ohio State University. Paul Seymour is in the Department of Mathematics and the Program in Applied and Computational Mathematics at Princeton University. Robin Thomas is in the School of Mathematics at the Georgia Institute of Technology.

Daniel A. Spielman and Shang-Hua Teng, "Smoothed analysis of algorithms: Why the simplex algorithm usually takes polynomial time", *Journal of the ACM*, volume 51, issue 3, 2004, pages 385–463.

George Dantzig's simplex algorithm for linear programming is a fundamental tool in applied mathematics. The work of Spielman and Teng is an important step toward providing a theoretical understanding of the algorithm's great success in practice, despite its known exponential worst-case behavior. The smoothed analysis introduced by the authors fits nicely between overly pessimistic worst-case results and the average-case theory developed in the 1980s. In smoothed analysis, the performance of an algorithm is measured under small perturbations of arbitrary real inputs. The Spielman-Teng proof that the simplex algorithm runs in polynomial time under this measure combines beautiful technical results that intersect multiple areas of discrete mathematics. Moreover, the general smoothed-analysis framework is one that can be applied in many algorithmic settings, and it is now established as an important technique in theoretical computer science. The LP-specific techniques used by Spielman and Teng have interesting interpretations regarding the Hirsch conjecture, and they provide new insights into the good behavior of the simplex algorithm.

Daniel Spielman is in the Department of Computer Science at Yale University. Shang-Hua Teng is in the Department of Computer Science at Boston University.

Thomas C. Hales, "A proof of the Kepler conjecture", *Annals of Mathematics*, volume 162, issue 3, 2005, pages 1063–1183, and Samuel P. Ferguson, "Sphere Packings, V. Pentahedral Prisms", *Discrete and Computational Geometry*, volume 36, issue 1, 2006, 167–204.

In 1611 Johannes Kepler asserted that the densest packing of equal-radius spheres is obtained by the familiar cannonball arrangement. This statement is known as the Kepler conjecture, and it is a component of Hilbert's eighteenth problem. After four centuries, Ferguson and Hales have now proven Kepler's assertion. The Ferguson-Hales proof develops deep connections between sphere packings and mathematical programming, making heavy use of linear programming duality and branch and bound to establish results on the density of candidate configurations of spheres. The beautiful geometric arguments and innovative use of computational tools make this a landmark result in both geometry and discrete mathematics.

Hales and Ferguson received the AMS David P. Robbins Prize in 2007 for this work. Hales presented a special lecture on the proof at ISMP 2000 in Atlanta. Ferguson's paper provides a difficult step in the Kepler proof. This award is given to both researchers to appropriately acknowledge their individual contributions to this remarkable result and also to have the full proof of the Kepler theorem.

Thomas Hales is in the Department of Mathematics at the University of Pittsburgh. Samuel P. Ferguson is at the National Security Agency.

About the Prize

The Delbert Ray Fulkerson Prize recognizes outstanding papers in the area of discrete mathematics. Established in 1979, the prize is sponsored jointly by the Mathematical Programming Society (MPS) and the AMS. Up to three awards of US$1,500 each are presented at each (triennial) international symposium of the MPS. Originally, the prizes were paid out of a memorial fund administered by the AMS that was established by friends of the late Delbert Ray Fulkerson to encourage mathematical excellence in the fields of research exemplified by his work. The prizes are now funded by an endowment administered by MPS.

The prize is presented for papers published during the six calendar years preceding the year in which the prize is given. The prize is given for single papers, not series of papers or books, and in the event of joint authorship, the prize is divided. The topics of papers considered for the prize include graph theory, networks, mathematical programming, applied combinatorics, and related subjects.

—Announcement of the Fulkerson Prize Committee