SIGACT News Complexity Theory Column 108

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Introduction to Complexity Theory Column 108

Current and Future Columns

Warmest thanks to Rafael Pass and Muthu Venkitasubramaniam for this issue's guest column, "Average-Case Complexity Through the Lens of Interactive Puzzles." When I mentioned to them that my introduction would have a section on Alan Selman's passing, they immediately wrote back that they were very sorry to hear of Alan's passing, and mentioned (as you will see discussed in the second page of their article), "The main problem that we are addressing actually goes back to a paper of Even, Selman, and Yacobi from 1984: 'The Complexity of Promise Problems with Applications to Public-Key Cryptography'." It is beautiful, and a tribute to the lasting influence of Alan's research, that in the 2020s his work from many decades earlier is helping shape the field's dialogue.

Coming in the complexity theory column of future *SIGACT News* issues will be articles by Alexander Knop, Shachar Lovett, Sam McGuire, and Weiqiang Yuan (tentative topic: Intermediate Models Between Query Complexity and Communication Complexity), Carlo Mereghetti and Beatrice Palano (tentative topic: Quantum Finite Automata), Ben Lee Volk (tentative topic: Algebraic Natural Proofs), and Susanna F. de Rezende, Mika Göös, and Robert Robere (tentative topic: Proofs, Circuits, and Communication).

Alan L. Selman, 1941-2021

Alan L. Selman passed away on January 22, 2021, at the age of 79. And with that passing, one fewer giant of the field walks among us.

Alan's obituary, written by his wife Sharon, can be found at `https://www.plattmemorial.com/single-post/alan-l-selman`. A posting by Ken Regan on Alan will appear in the "Gödel's Lost Letter and P = NP" blog (whose homepage is

https://rjlipton.wordpress.com. A tribute to Alan by Mitsu Ogihara, Ken Regan, and Atri Rudra is planned for the journal that Alan was for many years the editor-in-chief of, *Theory of Computing Systems*. And remembrances of Alan, possibly gathered in a collective article, are being planned for *SIGACT News*, but at the moment this introduction is being written it is not known whether those will appear in the March issue or in the June issue.

Alan's research and service contributions to computational complexity theory were tremendous. I won't cover them here—they are too many and too deep to do justice to here—but rather I point the reader to a 17-page *SIGACT News* article, "Beautiful Structures: An Appreciation of the Contributions of Alan Selman" [15], on Alan, from seven years ago on the occasion of Alan's retirement, and which can be found online at https://arxiv.org/abs/1406.4106.[1]

In a moment, I'll include here the preface of that article (a section that is not a summary of Alan's research and service contributions, but is trying to give some sense of Alan's big-picture approach to theory research). But first—though I of course did not know him as closely and deeply as his many long-term colleagues, much less his family—let me comment very briefly on what I know of Alan himself, whose life was not at all just theoretical computer science. Alan's funeral was live-streamed, and at it, Alan's son, touching on five generations, movingly described how Alan's love of his family came to Alan through the generations before Alan, and flowed to the generations after Alan. Through Alan's generosity, I myself was lucky enough to know Alan across decades: we co-edited a book, wrote two research papers together, even wrote—Alan had a real love of writing and language—a note on writing in theoretical computer science, and had a long tradition of research seminars and theory days that brought together the University at Buffalo, RIT, and University of Rochester theory groups; Alan was also my wife's wonderful postdoctoral advisor. And always, coexisting with Alan's technical artistry and amazing taste in theory research, Alan's love of and expertise in the "real" world was quiet yet luminous. Alan loved the theater, and spoke warmly of his beloved Shaw Festival at Niagara-on-the-Lake. He loved and knew food; any restaurant commended by Alan was going to be an experience. His conversations with restaurants' staff had their own type of expertise and artistry. Alan's love of music was deep, and in emails to me he commented that he envied the opera opportunities I'd have on sabbatical in Germany, and when my wife and I lucked into a stunning production at the Canadian Opera Company in Toronto, Alan was the person we wrote to about it. Theoreticians are often suspected of not living in the real world; Alan loved theory, but he also saw, appreciated, and loved the varied beauty of the broad world.

Here is the preface of the 2014 *SIGACT News* article on Alan. The rest of the article is

[1] But, very briefly put, Alan's research handiwork and vision is ingrained in the shape of the field. As just a few literature pointers to a minute fraction of the concepts, directions, and results where Alan's contributions were *essential* (and, again, I'm leaving out many whole research streams, and often am citing just a sample one or few among many relevant papers by Alan): the richness of reductions [20]; promise problems [6, 32, 19, 22]; the importance of studying function classes, including nondeterministic ones [3, 34, 35, 7, 23]; separating NP-completeness notions [26, 25]; semi-feasible computation (aka P- and NP-selectivity) [29, 27, 30, 28, 14, 16, 24]; relativized separations at the second level of the polynomial-hierarchy [1]; the structure of relativization [4, 3]; tally and sparse sets, and exploring cases (known as positive relativizations) where relativized results imply absolute results [5, 2, 21, 36, 11]; self- and autoreducibility [31, 9, 10]; the Berman-Hartmanis Conjecture [18, 5]; the fact that $\mathrm{P}^{\mathrm{NP}\cap\mathrm{coNP}} = \mathrm{NP}\cap\mathrm{coNP}$ [27]; unique solutions collapse the polynomial hierarchy [17]; one-way functions [13, 33]; and disjoint NP-pairs [12, 8].

Alan's service contributions were also essential to the field. From co-founding the annual Conference on Computational Complexity (for its first ten years called the Structure in Complexity Theory Conference), to being an important part of efforts to secure greater funding for theory, to serving as Editor-in-Chief of *Theory of Computing Systems*, to so much more, Alan throughout his career, while a giant in research, was also a giant in service, as was for example recognized when he was awarded the ACM SIGACT Service Prize.

about Alan's service, human infrastructure (and every student, postdoc, and coauthor who came in contact with Alan was a very fortunate person, as Alan's brilliance, kindness, and generosity were extraordinary), and research contributions. But the preface was trying to convey some hint of what Alan's work and actions revealed about his big-picture view of doing theory research.

Preface

As I write these words in June 2014, it has been just over a month since the retirement celebration for Alan Selman at the University at Buffalo's Center for Tomorrow. I can't think of a more fitting location for the celebration, given that Alan's technical contributions to the field are of such beauty and insight that they are as important to the field's future as they have been to its past and present.

Any retirement is bittersweet, but as I mentioned in the previous column's introduction, Alan will be keeping his hand in the field in retirement. That happy fact helped all of us at the celebration focus on the sweet side of the bittersweet event. Warm talks and memories were shared by everyone from the university's president, the department chair, and Alan's faculty colleagues all the way up to the people who are dearest of all to Alan—his postdocs and students.

The warmth was no surprise. Alan is not just respected by but also is adored by those who have worked with him. Anyone who knows Alan knows why. Alan is truly kind, shockingly wise, and simply by his nature devoted to helping younger researchers better themselves and the field. But in fact, I think there is more to say—something far rarer than those all too rare characteristics. What one finds in Alan is a true belief in—an absolute, unshakable belief in—the importance of understanding of the foundations of the field.

Now, one might think that Alan holds that belief as an article of faith. But my sense is that he holds the belief as an article of understanding. Like all the very, very best theoreticians, Alan has a terrific intuition about what is in the tapestry of coherent beauty that binds together the structure of computation. He doesn't see it

all or even most of it—no one ever has. But he knows it is there. And in these days when many nontheory people throw experiments and heuristics at hard problems, often without much of a framework for understanding behaviors or evaluating outcomes, not everyone can be said to even know that there is an organized, beautiful whole to be seen. Further, Alan has such a strong sense for what is part of the tapestry that—far more than most people—he has revealed the tapestry's parts and has guided his collaborators and students in learning the art of discovering pieces of the tapestry.

And that brings us to the present article and its theme of the beauty of the structures and the structure that Alan has revealed—the notions, the directions, and the theorems. For all of us whose understanding isn't as deep as Alan's, the beauty of Alan's work has helped us to gain understanding, and to know that that tapestry really is out there, waiting to be increasingly discovered by the field, square inch by square inch, in a process that if it stretches beyond individual lifetimes nonetheless enriches the lifetimes of those involved in the pursuit of something truly important. To summarize Alan's career in a sentence that is a very high although utterly deserved compliment: Alan is a true structural complexity theorist.

However, looking at the ending of that Preface now, I realize with regret that it shortchanged Alan and missed the obvious. The final sentence should have read, "To summarize Alan's career in a sentence that is a very high although utterly deserved compliment: Alan is the quintessential structural complexity theorist." Alan, in his gentle, dignified way, was in his work, his service, and his mentoring of the next generations the most passionate advocate that structural complexity has ever had; I do not think we will see his like again.

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