

Dexter Kozen

Complexity, logic and rock 'n' roll

Luca Aceto

ICE-TCS, School of Computer Science, Reykjavik University

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“No way could I do theory that would even come *close* to what Dexter was able to produce in his seemingly effortless way, out of his sleeve. So I quit. Not to become a taxi driver, but to do different things, which require far less of the qualities that Dexter had in such amazing abundance.” (David Harel)



Dexter Kozen

Selected awards and honours

- Outstanding Innovation Award, IBM Corporation (1980)
- Fellow, John Simon Guggenheim Foundation (1991)
- ACM Fellow (2003)
- Fellow of the AAAS (2008)
- LICS Test-of-Time Award (2011)
- Fellow of the EATCS (2015)
- EATCS Award (2016)
- W. Wallace McDowell Award, IEEE Computer Society (2016)

Dexter Kozen's research work: through the prize citations

The Dexter Kozen trivia quiz

Can you name some of Dexter's contributions?

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EATCS Fellow (2015) and EATCS Award (2016)

For "pioneering and seminal work in fields as diverse as complexity theory, logics of programs, algebra, computer algebra and probabilistic semantics".

"Dexter Kozen is . . . perhaps **the** theoretical computer scientist, who has excelled across the entire spectrum of our field and crashed through the so-called Volume A/Volume B barrier."

W. Wallace McDowell Award, IEEE Computer Society (2016)

For "groundbreaking contributions to topics ranging from computational complexity, to the analysis of algebraic computations, to logics of programs and verification."

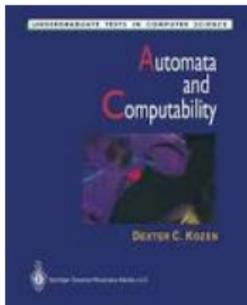
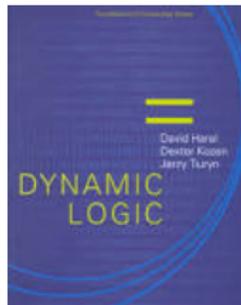
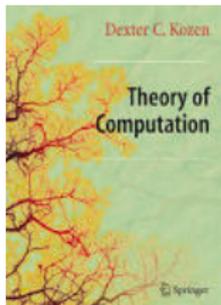
Dexter Kozen: The teacher



- Faculty of the Year, Association of Computer Science Undergraduates, Cornell (1994 and 2013)
- Stephen and Margery Russell Distinguished Teaching Award, College of Arts and Sciences, Cornell (2001)
- Michael Tien '72 Excellence in Teaching Award, College of Engineering, Cornell (2008)
- Daniel M. Lazar '29 Excellence in Teaching Award, College of Engineering, Cornell (2013)

"Dexter is a true department stalwart at Cornell. He is well known to be an outstanding teacher at every level. Many graduate students say that he is the best teacher they have ever had, undergraduates nominate him for awards."

Dexter Kozen: The books



Dexter Kozen: Career Summary

- Born on December 20, 1951.
- 6/74 BA summa cum laude, Mathematics, Dartmouth College (received the John G. Kemeny Prize in Computing)
- 5/77 MS, PhD, Computer Science, Cornell University
- Postdoc at UC Berkeley 1977–1978
- IBM Research, Yorktown Heights, NY, 1978–1985 (Research Staff Member; Manager, Theory of Computation Project)
- Cornell University (Professor since 1989 and Joseph Newton Pew, Jr. Professor in Engineering since November 1994)

Nordic connections (sample):

- Visiting Professor at Aarhus University in 1981–1982 and 1991–1992.
- Supervised Kjartan Stefánsson's PhD thesis "Newtonian Graphs, Riemann Surfaces, and Computation" (Cornell University, May 1995).

Dexter's first contribution to complexity theory

- NP: **existential acceptance condition.**
- coNP: **universal acceptance condition.**
- **Alternation (Chandra, Kozen and Stockmeyer, FOCS 1976 and JACM 1981):** existential and universal branches alternate in computations.

"... a deep contribution to complexity theory that made it possible to connect time and space complexity."

"... the deterministic complexity hierarchy $LOGSPACE \subseteq PTIME \subseteq PSPACE \subseteq EXPTIME \subseteq \dots$ shifts by exactly one level when alternation is introduced." (JACM, 1981)

The FOCS 1976 article was Dexter's first published paper.

Complexity of algebraic structures

- Complexity of finitely presented algebras (STOC 1977): Many results. For example, the isomorphism problem is equivalent to the graph isomorphism problem.
- First-order theory of Boolean Algebras (BA): Tarski showed decidability of BA in 1949 with non-elementary complexity. Dexter showed that BA is complete for the Berman complexity class $\bigcup \text{STA}(*, 2^{cn}, n)$.
- Theory of the real numbers with $+$, \times and $=$: Tarski showed decidability in 1948 with non-elementary complexity. Together with Ben-Or and Reif, Dexter gave an EXPSPACE algorithm and conjectured EXPSPACE-completeness.

Kozen-Landau Theorem

There is an $O(n^2)$ algorithm for deciding whether a polynomial with coefficients in a commutative ring has a nontrivial functional decomposition.

Consequences

“In 1985 a cryptosystem was proposed based on polynomials. ... The Kozen-Landau theorem shows that polynomial composition is not a good candidate for such public-key systems. Recently I [Susan Landau] was told that in the main Maple command `solve` for solving polynomial systems (and pretty much everything else), the algorithm begins by attempting to decompose any polynomials passed as input. This is because even while few polynomials are decomposable, the decomposition method is sufficiently fast that it provides a big win when it succeeds. The implementation is the Kozen-Landau technique.”

- “The most succinct and beautiful proof imaginable of completeness for PDL”. PDL is a logic for reasoning about program behaviour introduced by Vaughan Pratt in 1974. Example of a PDL equivalence:

$$[a^*]p \equiv p \wedge [a][a^*]p.$$

- Dexter's work on the μ -calculus, a logic with fixed-point operators.

ALWAYS(good) = good \wedge $[-]$ ALWAYS(good) **largest solution!**

POSSIBLY(win) = win \vee $\langle - \rangle$ POSSIBLY(win) **least solution!**

Crucial age-old question (posed by Kleene)

What are the “laws” characterizing equivalence of regular expressions?

- No finite set of equational laws suffices (Redko, 1964). Infinitary equational axiomatizations by Conway, Krob and Bloom.
- Two implicational axiomatizations by Salomaa in 1966, but involving one **non-algebraic** proof rule.
- **Dexter gave an elegant, algebraic implicational axiomatization and developed the theory of Kleene Algebras and its variants.**

Applications: compiler and protocol verification, static analysis of programs, bytecode verification, reasoning about local variable scoping (Kleene Algebra with tests) and **verification of software-defined networks (netKAT)** to name a few.

Partial types (Thatte, 1988)

They allow one to type objects that are not typable with simple types, such as heterogeneous lists and persistent data.

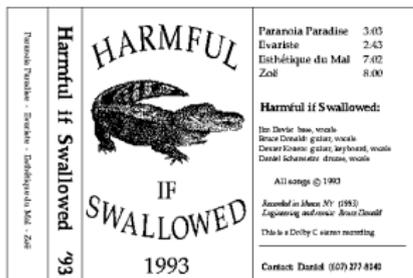
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Results on the decidability of type inference

- 1 Semidecidable (Thatte)
- 2 Decidable in exponential time (O'Keefe and Wand)
- 3 Decidable in $O(n^3)$, where n is the size of the λ -term (Dexter Kozen, Jens Palsberg and Michael Schwartzbach, 1992)!
Their algorithm constructs a finite automaton that represents a canonical solution to a given set of type constraints.

Automata-theoretic techniques are now widely used in program analysis and type checking.



Dexter was a guitarist, singer and songwriter in the band “Harmful if Swallowed”. [Sample: Evariste]



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First time I saw Dexter: LICS 1989, musical performance at the Monterey Aquarium

Dexter and colleagues played “academic renditions” of punk rock classics and some originals written by Dexter.

Why don't we VLSI like we used to do (oh yeah)

Dexter: The departmental stalwart

Joe Halpern

When one of our faculty members had a sudden emergency the night before the final exam in his core undergraduate course (a course with over 60 students), with the final exam only partially completed (yes, it was the night before the final...), he called on Dexter. Dexter stayed up to the wee hours of the morning preparing the final, and helped grade it. I think this incident really gives a sense of Dexter, both the way he came through for someone else in an emergency, and that he was the one that was turned to in the first place.

John Hopcroft

I feel that, over time, Dexter's values have become absorbed by the department and are reflected in quality work, respect for others and a sincere collegiality. He is the professor you hope for, whether as a student or a colleague.

Thank you!



Presentation of the EATCS Award, Rome, 13 July 2016. Compare with the W. Wallace McDowell Award presentation.