



A. Pincus

AMIR PNUELI

1941–2009

Elected in 1999

“For the invention of temporal logic and other tools for designing and verifying software and systems.”

BY DAVID HAREL AND MOSHE VARDI

AMIR PNUELI, a pioneer in the fields of specification, verification, and analysis of computer systems, and a Turing Award winner, died after suffering a brain hemorrhage on November 2, 2009. His sudden death shocked the international computing community.

A brilliant man who was shy, modest, and graceful, Pnueli, or simply Amir as he was called by anyone who knew him, was born in Nahalal, in what is now Israel, on April 22, 1941. He spent the bulk of his career at Tel Aviv University and at the Weizmann Institute of Science in Israel and in recent years also at New York University.

Amir did his doctoral work at Weizmann in applied mathematics under the late Chaim L. Pekeris, writing a thesis in 1967 on the calculation of ocean tides. Immediately thereafter he made a transition to computer science, working as a postdoctoral fellow at Stanford University and at IBM’s research center in Yorktown Heights, New York, for two years. He returned to Israel in 1968 as a faculty member in the Department of Applied Mathematics at the Weizmann Institute and in 1973 moved to Tel Aviv University, where he founded the Department of Computer Science and was its first chair. In 1980, Pnueli returned to the Weizmann Institute as a professor, together with three younger computer scientists—

Adi Shamir, Shimon Ullman, and David Harel. Together, they invigorated the computer science group there, which has grown steadily since.

Amir's modest demeanor belied groundbreaking technical achievements. His 1977 paper, "The Temporal Logic of Programs," marked a crucial turning point in the verification of concurrent and reactive systems. Incidentally, the paper was published in the proceedings of the Institute of Electrical and Electronics Engineers Symposium on Foundations of Computer Science but never in a journal; it apparently did not have to appear in an archival journal to become so influential. Temporal logic was developed by philosophers in the late 1950s to reason about the use of time in natural language. By introducing it to the field of formal methods, Pnueli gave researchers a set of tools that enabled them to specify and reason about the ongoing behavior of programs. His 1977 paper opened up a new world for computer scientists, and its impact is crucially felt in both the theory and the practice of the continuously growing field of program verification and analysis. At the time of its writing, program verification was widely considered a hopeless challenge, but Pnueli's paper quietly established a framework for advanced techniques and gave new life to the domain. For this contribution, Pnueli received the Association for Computing Machinery's A. M. Turing Award in 1996, considered the "Nobel Prize" of computing. The citation reads: "For his seminal work introducing temporal logic into computing science and for outstanding contributions to program and system verification."

Throughout the rest of his career, Pnueli continued to extend and strengthen his ideas and to contribute to the development of other verification methods. In a joint paper with David Harel in 1986, they coined the term "reactive system" to describe systems that maintain an ongoing interaction with their environment and argued for its significance; the term has since become deeply ingrained in the literature. Working with a variety of collaborators—including current and former students—Pnueli made numerous additional contributions to a number of related topics, from algorithmic verification to

automated synthesis of reactive modules. Noteworthy was his extremely fruitful longtime collaboration with Zohar Manna from Stanford University, with whom he coauthored books on temporal logic and its use in the specification and verification of concurrent and reactive systems.

He had boundless curiosity and was deeply interested in developing techniques that could be used in industrial applications, not only research settings. Over the years he cofounded a number of companies, designing and supervising systems that included message switching, operating systems, software development tools, and compilers.

Pnueli's graciousness and humility endeared him to colleagues and students alike. He listened attentively to all who sought him out, and he had a knack for finding the best in what they said. "People loved working with him because he made them feel smart," said Lenore Zuck, a former doctoral student who is currently at the University of Illinois in Chicago. At work, Pnueli was laid-back and informal, alternating between research and conversation and indulging in long digressions about politics, food, music, and literature. "It never felt tiring to work with him," said Zuck. Beneath his casual comportment lay deep insight and intuition, and collaborations often happened inadvertently. One could start a new piece of work in a discussion with Amir while standing in line for lunch at the cafeteria or during a coffee break at a conference in some remote part of the world.

Amir's accomplishments were also honored in 2000 by the Israel Prize, the state's highest honor, and in 2007 by the ACM Software System Award, given to him jointly with a team of colleagues for their work on Statemate, a software engineering tool that evolved from the Statecharts language and that supports visual graphical specifications that represent the intended functions and behavior of a system. He also received honorary doctorates from the University of Uppsala, the Université Joseph Fourier in Grenoble, and the Carl von Ossietzky Universität in Oldenburg.

At Pnueli's funeral the first-listed author of this tribute challenged himself to identify Amir's vices but found it very

difficult. He ended up finding two. The first: in all his letters of recommendation, about anyone at all, Amir wrote only good things. But in his defense, he really believed that everyone was very good, and this was simply part of the way he considered others, out of his unusual measure of modesty. The second problem: he was often late—late in delivering a paper on time, late with a letter of recommendation, late with a report, late with the response to some request, and so forth. But here too, in his defense, the issue was always taken care of eventually and was always done in depth and in detail and combined with the great grace of his personality and his deep wisdom.

Amir Pnueli died at the scientifically young age of 68, when he was in the process of doing some of his best work. We will never know what else he would have achieved, nor what other ideas and directions he would have brought to computer science, if he had lived another 15 or 20 years, as he so very well deserved. For us—his direct scientific beneficiaries—we followed him not just for his intelligence, his wisdom, and his universally acknowledged greatness as a scientist but also for his personality, for his ability to share with everyone his wisdom and ideas—everyone small and large—with his hallmark unlimited generosity.

Amir is survived by his wife, Ariela; his three children, Shira, Ishai, and Noga; and his grandchildren, Noam, Romy, Gaya, and Ella.

