Turing Award Nomination: John Hennessy and David Patterson for pioneering the science of computer architecture through the quantitative approach, and for massive industrial impact

Nominators: Forest Baskett and Krishna V. Palem

Starting with their respective leadership through the Stanford MIPS and the Berkeley RISC projects leading to the absolutely seminal co-authored textbook ‘Computer Architecture: A Quantitative Approach’, John Hennessy and David Patterson enabled the science of computer architecture and its practice universally. By building on the pioneering work of Backus, Brooks, Cocke and Allen as a representative sample—pioneering efforts recognized by the Turing award—Hennessy and Patterson jointly catalyzed the phenomenal growth of RISC based systems, in the high-performance, as well as in the embedded computing domains. In our view, the credit rests with them for transforming computer architecture into a systematic and pedagogically well-founded field with computer science roots—science being identified with clean reductionist models and methods as opposed to an ad-hoc collection of inventions.

Many view the IBM-801 project as having shifted the ‘balance of power’ from a (hardware) microarchitecture, to (software based) compiler-centric techniques. Traditionally—and this includes the lessons learned from the IBM 801 project—computer architecture is a field identified with great innovation of the engineering kind, and therefore studied as a catalog of disparate ideas. This poses a great challenge in understanding and evaluating the complex interactions between different parts of the system. In contrast, computer science has been extremely successful in creating foundational frameworks through which innovation can evolve, be understood, and most significantly be repeated and verified. Turing machines and the associated complexity theories, the foundations of concurrency at the heart of modern operating systems, seminal ideas underlying databases and networking protocols, are but a few of the historically prominent examples of such frameworks. Building on the IBM-801 legacy and moving RISC into the VLSI era cultivating in their co-authored textbook—among the most widely used books in the field of computing—Hennessy and Paterson virtually created the ‘foundations’ of modern computer architecture in these finest traditions of computer science.

A level of abstraction and the ability to parameterize the space of possible designs are key elements of creating a scientific foundation in any branch of computer science. In this context, Hennessy and Patterson’s DLX is an absolute bedrock of an idea, which allowed the framing of new architectural concepts, but perhaps more significantly enabled the repeatable quantitative evaluation of the resulting complex interactions in the design. Much as the IBM-801 shifted the focus from increasing hardware ’machismo’ to a more balanced partnership between hardware and software, DLX essentially reversed the trend to where modeling and analysis—again, key elements of a scientific enterprise—drove the design, and not the other way around. This was possible since DLX provided clean and easy to understand behaviors and thus, well-characterized relationships between cause and effect. Starting with the core processor that DLX helped capture, the quantitative approach went on to embrace instruction level parallelism, the memory hierarchy and I/O with amazing ease. In our view, this ability to model and analyze the entire architecture of a planned machine conceptually and accurately, was absolutely the key element behind the success of the quantitative approach, and its use by generations of computer architects.

In addition to the scientific and intellectual impact and the numerous microprocessor architectures they influenced, the MIPS and Berkeley RISC projects directly impacted the industrial landscape massively over the decade since their innovation. The commercial processors they inspired, namely MIPS and SUN Microsystems’s SPARC, and by their own acknowledgment ARM processors that the Berkeley and Stanford projects inspired and influenced, were major players in the marketplace with respectively 50% of the stand-alone embedded processors (1999), and 34% of the microprocessors used in workstations (1994)—between them, they had cumulative sales of over 16.6 billion processors over the two decades since their inception, by 2010!

John Cocke in his Turing Award lecture said ‘‘Comparison of various machine architectures is not done well today, perhaps because of its intrinsic difficulty or perhaps because of commercial implications. I hope this can be done more carefully in the future; maybe we could look to academia for help.’’ John and Dave have jointly overcome this challenge with their quantitative framework and the commercial successes that have derived from it. For these contributions, John Hennessy and Dave Patterson have already been widely been recognized through unique distinctions such as the ACM-IEEE Eckert Mauchly award, the IEEE John von Neumann Medal (joint), the Japan Prize for Computing and
Communication (joint), and by election, membership in the American Academy of Arts and Sciences, the US National Academies of Science, and of Engineering.

We therefore nominate John Hennessy and David Patterson to be recognized by ACM’s highest honor, the Turing award in the strongest terms possible, for pioneering the science of computer architecture.