Acceptance speech

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I am honored to receive the BBVA Foundation Frontiers of Knowledge Award for my contributions to the automation of semiconductor chip design.

It is a process that took over thirty years of work of many people which, together with manufacturing technology, has made it possible to go from chips that contained only a few hundreds of transistors in the 1970s to today's devices featuring tens of billions of transistors, a nine orders of magnitude increase.

The strategic importance of semiconductor design and manufacturing cannot be overestimated. Chips are pervasive. Everyday objects are powered by chips, from cars to airplanes, from medical devices to smart phones. Perhaps most importantly, these chips drive computing systems that make it possible to store and manipulate an enormous quantity of data. Artificial intelligence would be simply impossible without semiconductors. The multibillion Chips Acts intended to sustain semiconductor design and production have formed a fundamental part of the industrial strategy of countries stretching from the United States to Europe, attesting to the vital importance of this sector to the economy and defense at large.

The design of semiconductors with billions of transistors is unfeasible without the help of sophisticated algorithms and software tools that automate, at least in part, the design process. My research journey started in the 1970s when I joined the University of California, Berkeley from Politecnico di Milano, my alma mater.

At that time, I was a theoretician at heart. I was interested in algorithms for the solution of large-scale systems of equations. My first contribution was indeed in speeding up the simulation process, that is, the analysis of physical systems

by computer modeling. The key to this acceleration was in relaxation-based algorithms – techniques that I developed together with my great friend and partner in crime Richard Newton, who should have been with me today sharing this award. Richard left us in 2007 after a short illness, and his departure left a huge void in our field and in our hearts.

In the 1980s, I became interested in other areas of semiconductor design such as the optimal layout of transistors and wires on a plane, and the optimal realization of designs expressed in high-level languages with logic gates, called logic synthesis. While simulation was essential in verifying the correctness of designs without the need for prototypes, automatic layout and logic synthesis made it possible to speed up chip design by orders of magnitude, at the same time eliminating errors in the process. My interest in these fields came in 1980 during my visit to the IBM Watson research center where I collaborated with extraordinary individuals such as Bob Brayton, who should be credited for fundamental contributions to logic synthesis.

We always placed our algorithms and computer programs in the open domain. We felt strongly that allowing others to leverage our work freely and to verify our theories with their implementation was essential to advance the field. In 1983, Pat Gelsinger, now Intel CEO, asked me to help design the Intel 386 microprocessor using the tools I developed. This was an important milestone in the wide use of electronic design automation or EDA. In 1983, Richard Newton and I co-founded SDA, which later became Cadence, and in 1987, Synopsys, both with the financial help of semiconductor companies. They are now each worth more than 60 Billion dollars on NASDAQ. I believe that the staying power of these companies, which are still growing at a fast pace after almost 40 years, is due to fundamental results in research.

Design is the process of bringing to life abstract ideas and concepts via their successive refinement towards a physical realization. It is a science in its own right. Automating the mundane parts of design, as we did for electronic design, empowers engineers in all fields to explore a much larger solution space in a much shorter time. Since 1989, I have been extending this paradigm to other fields such as vehicle design, building design and even synthetic biology and drug discovery. Once you have a hammer everything looks like a nail.

Applications were essential in my research. The inspiration came from identifying difficult problems that engineers in industry faced, finding a way of formalizing them and developing algorithms for their solution. Finding the right formulation is a most important step, whereby limiting the freedom of designers has been fundamental to the development of electronic design automation allowing to frame a design problem into a solvable mathematical problem. A design methodology is about freedom from choice!

While physicists unveil the laws of nature, engineers create their own world that in the end has to come to terms with physical reality. We are limited in our inventions by the laws of nature. In conceiving ideas and bringing them to life we need to take into consideration ethics: ensuring that our creations do not bring harm to humans or the environment.

In this refinement process, I was always fascinated by the role of time, which brings me to the influence that philosophy has had on my scientific work. At the beginning of the design process, physical time is often not part of the equation. We use causality to determine the dependency of various processes that take place in our inventions. Then, this order refines until it is embedded in physical reality, and it becomes physical time. As Kant wrote, time and space are categories of man, they do not exist in the abstract. I am convinced that a solid scientific and technical education cannot forget the humanities. Many mistakes made in the development of technological systems could have been avoided if we had paused to think about their broader implications.

Finally, I would like to acknowledge the wonderful environment that the University of California, the companies I worked with, my colleagues and PhD students have created, and recognize with enormous gratitude the love and support that my family, who are in the audience today, have given me over the years. And I mean "support" also in the Italian term "sopportare," which means they had to bear with me for all these years...