Science, Technology, and the Indian Society

Vishwani D. Agrawal
AT&T Bell Laboratories
Murray Hill, NJ 07974, USA
va@research.att.com

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Traditionally, keynote talks are delivered by individuals with significant influence on the society. Ministers or secretaries of governments, or presidents of large commercial corporations usually qualify. You also listen to the same people through the *media*. You want them to tell you what should be done. They quote from the ancient scriptures, which they interpret for you. They quote from management experts like Tom Peters and C.K. Prahalad. They read *Business Week* and interpret electronics news for you. You have been listening to these people for so long that you have forgotten how anyone else, including yourself, sounds like. In contrast, I happen to be a plain engineer like most of you. I have no more knowledge of things than you have. So, this talk is going to be like a conversation between us. If I manage to touch a chord in your heart, you may even recognize your own voice in my speech.

I have chosen to speak on *Science, Technology, and the Indian Society*. Let me begin with science. Science is the understanding of Nature. This understanding begins with observation. Some examples are the falling of an apple, behavior of animals or humans, and genetic variations in plants. The observation provides input to our brain which derives models and derives principles or laws of nature. So, science is a product of the natural phenomena and the human brain.

I cannot go on without sharing with you my thoughts about the human brain, which is at the root of both science and technology. The brain has two attributes. They are curiosity and creativity. Both try to change things. Curiosity changes our level of knowledge, while creativity changes physical objects. The brain senses the environment using inputs from eyes and ears, and then tries to change the environment. If things are good, brain wants to make them bad. If they are bad, it tries to make them good. If it is cold, we want heat. If it is hot, we want cold. That is why the entire world must go through ups and downs. Civilizations rise and fall. So much so that change is called a law of nature. In fact, nature may have just created the brain and the brain did the rest. If science grew out of curiosity, then technology is the outgrowth of creativity.

Technology is the application of scientific knowledge. Some people call it applied science. I think differently. I think the purpose of technology is to improve the quality of life, increase happiness, and improve health and welfare. Unlike science, technology is a creation of humans alone. The only part nature takes in technology is through the creation of the human brain.

Technology's sole purpose is progress. Although, temporarily it may seem to be doing just the opposite. Examples are war, pollution, stress, etc. In the long run, however, even these things lead to progress – the second world war introduced the nuclear technology.

You all know that the United States of America had a tremendous industrial progress during the first half of this century. Industrial progress is measured in terms of productivity. Inputs are capital and labor, and the output is the total industrial output of the nation. Robert Solow, who won the Nobel prize in economics, conducted a study of the industrial output of America. He found that growth could not be explained on the basis of increases in labor and capital alone. He determined that the industrial output grew at twice the rate of increase in labor and capital. He attributed this to technology. Thus, a *technology factor* is normally included in the equation of the industrial output.

New engineering designs that are cheaper to manufacture, more efficient production methods, and new management concepts are responsible for a greater than unity technology factor. By implementing the concept of assembly line, Henry Ford was able to produce many more cars than before, still using the same amount of material and labor. Inventions like the airplane, the telephone and the computer completely changed the way we travel, communicate and even think. All of these have contributed to increased productivity.

VLSI is a key technology that has been responsible for progress on this planet in recent times. Not everyone understands VLSI. An example will prove the point. Those of you who have seen a personal computer, will be familiar with the "Intel inside" campaign of the Intel Corporation. VLSI is like the microprocessor in a computer. To the outside world, a computer is I/O and software. I

say software because the users can see floppys lying around their PC. But, really it is the VLSI chips that make everything possible. Since the early 70s, it is VLSI technology that has been responsible for most of the progress in computers, communications and software technology. So, if we decided on a label "VLSI inside", there will hardly be anything without it. In VLSI, we are dealing with a *core technology*.

Before I turn to the Indian society, let me say a few words about the meaning of *society*. If we assume that the human animal started out as an *individual*, then formation of a society was the most important step in its development. Society represents an organization that makes collective thought and action possible. Though not always obvious, society is the most powerful organization. Its sole purpose is to guarantee the well-being of its member, the individual. To serve that purpose, it will make or break governments, and preserve or destroy businesses. Thus, all governments and businesses, including the so-called giant multinationals, work for the society. It is not the other way round as some of you may think.

Indian society has an old tradition of original thinking. We developed the *Arabic* numerals that led to tremendous progress in mathematics and science. There are other examples of old times. But, what happened in the recent times? We find ourselves technologically backward, financially poor, and intellectually unscientific. Ask why? I say, we ceased to be *original*. Today, you want your government to tell you what is right and what is wrong. A technocrat, who is not in touch with science, makes decisions for you. Even in research, a foreign professor has to tell you what to do. Ask yourself – have you written a radically new scientific paper – a *landmark* paper? Have you even thought of doing such research? Coming to VLSI, are you working on a new way of synthesizing logic? Are you going to invent a new simulator, or a new fault simulator, or a new router? Is there something beyond the CMOS technology? Could there be another technology, invented by you, that will replace CMOS in the future?

Indian engineers and scientists should be looking for answers to the above questions. They should inform the policy-makers about these. Instead, the policy-makers are either listening to journalists, or listening to television reports, or reading religious scriptures, and telling researchers what to do. There is confusion about India's role in technology. Take the case of software. We are pushed into quickly acquiring software skills and earning revenues. We can write as good a program as anyone else. But, does that make us a technology leader in software? I will return to this point a little later.

Starting from the state of technology we have in India today, some things may look impossible. Let me quote from Dr. A. Prabhakar's speech at the inauguration of this conference. He stated that NEC of Japan was going to start production of 256 megabit memory chips at a cost of one billion US dollars. You all got the picture – that was not a job for a poor country like India. Let us examine why NEC wants to spend 1 billion dollars. Perhaps they expect to earn 100 billion dollars from this investment. NEC's solution involves deployment and management of a new technology, financing, production and marketing. With that kind of expected return on investment, I am sure, any banking corporation, having confidence in NEC's competence, will gladly loan the money. So, it is the technical leadership that the company must have, and not necessarily the money, to put a new product in the market. I emphasize that technical leadership is more important than capital. What then is *technical leadership?*

As I said, technology is application of science. Technical leadership is scientific innovation. We can learn science, but we must create technology. We can also learn the *current* technology, which I will call as *skills*. However, these will be obsolete soon. To be a technology leader, we must be involved in a process of continuous innovation.

So, if we can write software, do we have the software technology, or merely the current skills? Current trends point to a future with distributed computing and high-speed communication between computers. Can we expect that a new distributed operating system of the future may be invented in India? Or, a computer scientist in India will invent a new parallel programming language. If the answers are yes, or even maybe, we can say we have the software technology. However, unless something changes, the answer to these questions is "no". That is because none of you is even thinking of doing such things.

In conclusion, let me grade ourselves. First, our performance in science. We have great traditions of producing scientists like Bose and Raman, and mathematicians like Ramanujan. We get an A. Nation's investment in science must grow at least at the rate of growth of the gross national product (GNP).

With all the scientific knowledge and 900 million brains, we fail to make any technological breakthroughs. We learn and practice some current skills, but do not innovate. Indian engineer is yet to earn the kind of respect that the Indian society gives to the foreign technologist. In technology, we get a C grade. This is where improvement is urgently needed. I suggest committed investment both in short-term technology of design and applications, and in long-term research. Remember the technology factor I talked about. Investment in technology is the single most important investment that a society can make for rapid self-improvement.

I have great admiration for the Indian Society. It has the richest of traditions and great diversity. The only

society that comes close in diversity is perhaps the American society. We have a solid foundation of the ‘‘ancient wisdom.’’ I think the only problem has been with our interpretation of this wisdom. Neither wisdom nor knowledge must be regarded as absolute or stationary. There is only one law of the ancient wisdom and that is, *old wisdom should give rise to new wisdom which should be superior to the old wisdom.*

As India strives to become a modern technological society, I have a two-part prescription for the Indian engineer. First, take leadership in inventing new ideas, concepts and designs that others will use. Second, make your voice heard by your national policy-makers.

I thank you for listening and for your questions. Hope to meet you again, if not before, next year at the VLSI Design Conference in Bangalore.

Vishwani D. Agrawal *is a Distinguished Member of Technical Staff at AT&T Bell Laboratories, Murray Hill, New Jersey, and an honorary Visiting Professor at Rutgers University, New Brunswick, New Jersey. He received a BSc from Allahabad University in 1960, BE from Roorkee University in 1964, ME from the Indian Institute of Science in 1966, and PhD from the University of Illinois at Urbana-Champaign in USA in 1971. During 1972-74, he was an Assistant Professor at the Indian Institute of Technology, New Delhi. His research career spans over 25 years during which he significantly contributed to the fields of radar antennas and computer testing. He has published over 200 papers and four books, and has received five best paper awards. He holds seven US patents on digital testing and design for testability. In 1986, the IEEE elected him a Fellow for his contributions to probabilistic testing of integrated circuits. In 1993, University of Illinois honored him with their Distinguished Alumnus Award. In 1985, with Prof. H.N. Mahabala of IIT, Madras, Dr. Agrawal founded the VLSI Design Conference. He was the General Co-Chair of the Conference in 1991, and has chaired its Steering Committee since the start. From 1985 to 1987 he was the Editor-in-Chief of the IEEE Design & Test of Computers magazine. In 1990, he founded the Journal of Electronic Testing: Theory and Applications, which is the first and currently the only archival journal in its area. He is the Editor-in-Chief of the journal. During 1989 and 1990, he served on the Board of Governors of the IEEE Computer Society which, with its over 100,000 members, is the largest society of computer professionals in the world today. In 1994, he chaired the IEEE Computer Society’s Fellow Selection Committee. Most recently, he served as the Program Chairman for the Fourth Asian Test Symposium, held at Bangalore in November 1995.*