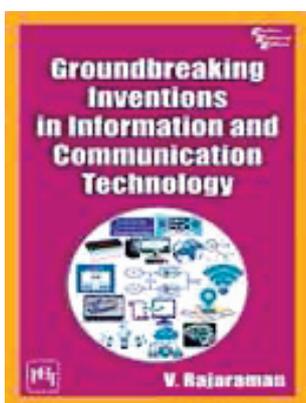# Let There be Computers and Virtual Computer Networks!*

Groundbreaking Inventions in Information and Communication Technology
Author: V Rajaraman
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I was very much excited when I received a copy of the book *Groundbreaking Inventions in Information and Communication Technology* by V Rajaraman from the publisher. Having had a preview of his description of the inventions in a three parts series in *Resonance: Journal of Science Education* published by the Indian Academy of Sciences, Bengaluru, I was looking forward to reading the book.

V Rajaraman, author of 23 books on computers, has chosen to list 15 groundbreaking inventions in this book (the numbers in parentheses indicate the year of the invention):

Fortran (1957)
Integrated Circuits (ICs) (1958)
Relational Database Management System (RDBMS) (1970)
Local Area Computer Networks (LAN) (1973)
Personal Computers (PCs) (1975)
Public Key Cryptography (1976)
Computer Graphics (1977)
The Internet (1983)
Global Positioning System (GPS) (1983)
World Wide Web (WWW) (1989)
Search Engines (1990)
Digitization and Compression of Multimedia (1993)
Mobile Computers (1999)
Cloud Computing (2006) and
Deep Learning (2011)

How did he choose these 15 from among hundreds of inventions that have been made in the last 60+ years in the field? As is characteristic of Rajaraman, he defines at the outset what constitutes a groundbreaking invention and goes about explaining each one of them in subsequent pages, in chronological order (in three periods: 1957–1974, 1975–1984 and 1985–2011). He explains the meaning of groundbreaking, "Introducing new ideas or methods" and lists the criteria that he

has adopted in choosing these inventions. The most important criterion, perhaps, is, "It should transform the way we live and thereby result in societal changes". As is typical of a professor, after discussing each invention, the author illustrates how the invention meets the criteria listed at the beginning of the book. What is remarkable about the book is that it is free of jargon. Each technical term needed to be understood is explained adequately by the author. He also narrates the story of the inventors in "boxes" and points out the successes and failures of strategies by the corporate world as each technology was unfolding. The narration is so gripping that the whole book (170+ pages) can be read in one sitting. The description of the inventions follows one after another as to how each invention followed the other (almost inexorably).

I remember vividly my mother telling me (in 1972) to send a telegram as soon as I reached the United States of America. My grandchildren today do not know what a telegram is. At the click of an icon or a swipe on the smartphone, I get to see my mother and talk to her face-to-face regardless of which country I am in. Our granddaughter (7 years old) teaches me and my wife Kannada language through online classes. Behind this transformation lie these 15 inventions!

I remember learning FORTRAN (FORmula TRANslation) language and punching cards and entering my computer program through a card reader and getting a printout of the results on a perforated sheet. While I could easily get X-Y plots using the computer, I had to view three-dimensional images using a Tektronix console before venturing to plot them. The computer used to be a BIG machine kept in the basement of an airconditioned building. Today, the laptop I carry around is smaller than the video terminal through which we used to monitor our jobs running on the mainframe. My laptop today has more memory and computing power than I could think of with the old computer. Somewhere along the line, the punching cards disappeared, interactive terminals appeared and disappeared, PCs appeared, graphic workstations appeared, and local area networks appeared. Today, with the wireless technology and access to the world wide web, all that has become history.

On the information and communication front, I do not have to explain to the young readers what has happened. They access almost everything on their cellphones. In my graduate days, we used to spend hours in the library searching for books and journals and making copious notes. Today, at the click of a button, we can access all those journals and books and download articles in a jiffy. The search engines do the job, and we get to access what we want instantly. While Walt Disney made his cartoons by drawing Micky Mouse and Donald Duck frame by frame, today's animation movies are made using computer graphics. Remember Jurassic Park? Some people make movies with their cellphones now.

The first invention mentioned above, the FORTRAN language was developed for scientific computing. Its obituary has been written several times. But it continues to thrive (the lat-

est being Fortran 2018) by adapting itself to changes in the industry.

Computers, in the beginning, were vacuum tube-based power guzzlers and could not run at a stretch for more than 5–6 hours. The Discovery of transistors and inventions of ICs changed all that. Today, computers can go on (almost nonstop) for 5–6 years. The author points out that the latest IC chip could pack 1.2 trillion transistors in it. The ICs found their way into all kinds of applications one could not even think of in the earlier years. The ICs were singularly responsible for the miniaturization of computers, their mass production, and their dependability. As a result, computers became smaller and smaller and more and more powerful to the extent that Personal Computers (PCs) and laptops hit the market. Somewhere along the line, computers (number crunching) receded to the background (disappeared into the cloud, so to say) and gave way to 'Information Technology' (IT) and to 'Information and Communication Technology' (ICT). The author illustrates this transformation that he has been a witness to, from day one, through the 15 inventions discussed in the book.

With the increased use of computers, more and more data was generated, and the databases grew larger and larger. Managing them became a formidable task. The answer came in the way of Relational Database Management Systems (RDBMS). You can imagine their power and versatility in managing the Aadhaar card database or the Indian Railways reservation system. Privacy of personal information and financial transactions has to be protected. The error tolerance is ZERO! The author describes nicely the role of cryptography in all these transactions. He also explains how cryptography evolved from Caesar's time to what is practiced today. As I mentioned earlier, every time there is a new term that needs to be understood, the author explains it in simple terms. That is not easy. Not everybody can do that. What is remarkable is that he achieves it without interrupting the flow of the book.

Single point entry (in my graduate student days) to the computer was replaced by access from various points through a local area network (LAN). "Going" to the computer center stopped with the setting up of wide-area networks. Remote access to a computer from anywhere in the world became possible. The connecting cables disappeared, and today, almost everything is possible through 'Wi-Fi'.

We take Computer Graphics (CG) for granted today. But it had its painful beginnings. Rajaraman describes elsewhere the initial bottlenecks he faced in linking computers and graphics terminals. I remember how, as a graduate student, I had to write my own computer programs to draw the lines and curves and three-dimensional images on a plotter by "instructing" the pen to move from place to place on a sheet of paper. Computer graphics changed the way we retrieve and represent information and communicate with the masses. That means massive information (megabytes and gigabytes) to be transmitted (again and again). Compressing the data and transmitting them (without error) was the need of the hour.

The inventions in these areas have made it possible for us to perform many tasks routinely today. My granddaughter (sitting in some other part of town) conducts tests online for us and asks us to send the answer sheets back as .jpg files. She corrects them and sends them back in a minute or two. Without all these inventions (computers, internet, GPS, search engines, etc.), online classes and webinars during these pandemic days would have been impossible. Thanks to Professor Rajaraman for bringing out this right book at the right time.

I do not want to rob the readers of the pleasure of reading the book and learning about the 15 inventions described therein by themselves. After reading it, if you thought that we have reached the heights of technology, hold your breath. The era of deep learning has just started. Face recognition and speech recognition in your cellphone are some of the simplest examples that go beyond the traditional algorithm-based artificial intelligence (AI). Rajaraman has not written the last word on the subject yet. For some reason, he has not mentioned 'quantum computing' in his list of inventions. Maybe, he thinks that the time has not come to write about it. Maybe, it does not meet the criteria listed by him yet.

While the book is well produced in terms of its print and its look, the distraction within are the blue colored images of the inventors and their inventions. For a popular book of its kind, it is priced slightly on the higher side. In this era of discounts and sales, the publisher may consider offering the book on a discount to reach out to a large number of intended readers (young and not so young) out there.

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