

Preface

Everyone loves to talk about big data, of course for various reasons. We got into that discussion when it seemed that there is a serious problem that big data is throwing down to the system, architecture, circuit and even device specialists. The problem is of scale, of which everyday computing experts were not really aware of. The last big wave of computing is driven by embedded systems and all the infotainment riding on top of that. Suddenly, it seemed that people loved to push the envelope of data and it does not stop growing at all.

According to a recent estimate done by Cisco[®] Visual Networking Index (VNI), global IP traffic crossed the zettabyte threshold in 2016 and grows at a compound annual growth rate of 22%. Now, zettabyte is 10^{18} bytes, which is something that might not be easily appreciated. To give an everyday comparison, take this estimate. The amount of data that is created and stored somewhere in the Internet is 70 times that of the world's largest library—Library of Congress in Washington DC, USA. Big data is, therefore, an inevitable outcome of the technological progress of human civilization. What lies beneath that humongous amount of information is, of course, knowledge that could very much make or break business houses. No wonder that we are now rolling out course curriculum to train data scientists, who are gearing more than ever to look for a needle in the haystack, literally. The task is difficult, and here enters the new breed of system designers, who might help to downsize the problem.

The designers' perspectives that are trickling down from the big data received considerable attention from top researchers across the world. Upfront, it is the storage problem that had to be taken care of. Denser and faster memories are very much needed, as ever. However, big data analytics cannot work on idle data. Naturally, the next vision is to reexamine the existing hardware platform that can support intensive data-oriented computing. At the same time, the analysis of such a huge volume of data needs a scalable hardware solution for both big data storage and processing, which is beyond the capability of pure software-based data analytic solutions. The main bottleneck that appeared here is the same one, known in computer architecture community for a while—memory wall. There is a growing mismatch between the access speed and processing speed for data. This disparity no doubt will affect the big data analytics the hardest. As such, one

needs to redesign an energy-efficient hardware platform for future big data-driven computing. Fortunately, there are novel and promising researches that appeared in this direction.

A big data-driven application also requires high bandwidth with maintained low-power density. For example, Web-searching application involves crawling, comparing, ranking, and paging of billions of Web pages or images with extensive memory access. The microprocessor needs to process the stored data with intensive memory access. The present data storage and processing hardware have well-known bandwidth wall due to limited accessing bandwidth at I/Os, but also power wall due to large leakage power in advanced CMOS technology when holding data by charge. As such, a design of scalable energy-efficient big data analytic hardware is a highly challenging problem. It reinforces well-known issues, like memory and power wall that affects the smooth downscaling of current technology nodes. As a result, big data analytics will have to look beyond the current solutions—across architectures, circuits, and technologies—to address all the issues satisfactorily.

In this book, we attempt to give a glimpse of the things to come. A range of solutions are appearing that will help a scalable hardware solution based on the emerging technology (such as nonvolatile memory device) and architecture (such as in-memory computing) with the correspondingly well-tuned data analytics algorithm (such as machine learning). To provide a comprehensive overview in this book, we divided the contents into three main parts as follows:

Part I: State-of-the-Art Architectures and Automation for Data Analytics

Part II: New Approaches and Applications for Data Analytics

Part III: Emerging Technology, Circuits, and Systems for Data Analytics

As such, this book aims to provide an insight of hardware designs that capture the most advanced technological solutions to keep pace with the growing data and support the major developments of big data analytics in the real world. Through this book, we tried our best to justify different perspectives in the growing research domain. Naturally, it would not be possible without the hard work from our excellent contributors, who are well-established researchers in their respective domains. Their chapters, containing state-of-the-art research, provide a wonderful perspective of how the research is evolving and what practical results are to be expected in future.

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Emerging Technology and Architecture for Big-data
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