Chapter 1 Overview of Global Supercomputing

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ABSTRACT

In this chapter, a discussion is presented of what a supercomputer really is, as well as of both the top few of the world's fastest supercomputers and the overall top 500 in the world. Discussions are also of cognitive science research using supercomputers for artificial intelligence, architectural classes of supercomputers, and discussion and visualization using tables and graphs of global supercomputing comparisons across different countries. Discussion of supercomputing applications and overview of other book chapters of the entire book are all presented. This chapter serves as an introduction to the entire book and concludes with a summary of the topics of the remaining chapters of this book.

INTRODUCTION

Supercomputers are the fastest computers till date and hence the backbone of Computational Sciences. By processing and generating vast amounts of data with unparalleled speed, they make new developments and research possible. The hardware structure or the architecture of supercomputers determines to a larger extent the efficiency of supercomputing systems. Another important element that is considered is the ability of the compilers to generate efficient code to be executed on a given hardware platform. While the Supercomputers of the 1970s used only a few processors, supercomputers of the 21st century can use over 100,000 processors connected by fast connections.

In 1929, New York World newspaper coins the term "Super Computer" when talking about a giant tabulator custom-built by IBM for Columbia University (Gardner, 2014). In 1966, Seymour Cray developed the world's first "real" supercomputer, the CDC 6600: the first computer specifically designed for science and engineering calculations (Gardner, 2014).

A supercomputer is a computer at the frontlines of current processing capacity and speed of calculations. (Wikipedia, 2014) First introduced in

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the 1960s, the supercomputers of the 1970s used only few processors, and in the 1990s machines with thousands of processors began to appear.

By the end of the 20th century supercomputers were massively parallel computing systems composed of tens of thousands of processors. In contrast, supercomputers of the 21st century can use over 100,000 processors including those with graphic capabilities. For example, Sequoia, ranked as world's third system in 2103 (Top500, 2013) is a third-generation Blue Gene machine from IBM, and runs on 1.6 million processor cores. It can reach speeds of up to 20 petaflops. A petaflop, equals 1015 operations per second, which means that Sequoia can perform 20 x 1015 operations every second. Sequoia requires 3,000 gallons of water per minute to cool it down. It uses 6 or 7 megawatts on average with peak usage approaching 9 1/2 megawatts. (One megawatt equals 1 million watts), and that's \$6 or \$7 million a year in power. The 1.6 million cores of supercomputer Sequoia are located on 96 different racks, each of which weigh nearly 5,000 pounds and gives off an average of 100 kilowatts of energy, the amount needed to power about 50 single-family homes (Wagstaff, 2012).

Titan, a Cray XK7 system installed at the U.S. Department of Energy's (DOE) Oak Ridge National Laboratory and previously the No. 1 system, is now ranked No. 2 as of November 2013 (Top500, 2013). Titan achieved 17.59 petaflop/s on the Linpack benchmark using 261,632 of its NVIDIA K20x accelerator cores. Titan is one of the most energy efficient systems on the list, consuming a total of 8.21 MW and delivering 2,143 Mflops/W.

Tianhe-2, a supercomputer developed by China's National University of Defense Technology, is as of November 2013 the world's new No. 1 system (Top500, 2013) with a performance of 33.86 petaflop/s on the Linpack benchmark, according to the 42nd edition of the twice-yearly TOP500 list of the world's most powerful supercomputers. The list was announced November 18, 2013 during the opening session of the 2013 Supercomputing Conference (SC13) in Denver, Colorado USA.

Tianhe-2, or Milky Way-2, was deployed at the National Supercomputer Center in Guangzho, China in 2013. The surprise appearance of Tianhe-2, two years ahead of the expected deployment, marks China's first return to the No. 1 position since November 2010, when Tianhe-1A was the top system. Tianhe-2 has 16,000 nodes, each with two Intel Xeon Ivy Bridge processors and three Xeon Phi processors for a combined total of 3,120,000 computing cores.

The Indian government has stated that it has committed about \$940 million to develop what could become the world's fastest supercomputer by 2017, one that would have a performance of 1 exaflop, which is about 61 times faster than today's fastest computers (PTI, 2012).

Table 1 lists the top ten supercomputer sites in the world as of November 2013 along with number of cores and other performance measures. The Appendix of this book provides complete information for each of the Top500 supercomputer sites in the world as of November 2013. The authors gratefully acknowledge the permission granted to the co-editors of this book for reprinting this detailed information as one of the Appendices of this book. A more complete discussion of the Tianhe-2 or Milk Way-2, Titan, Sequoia, and other supercomputers are also presented in the following sections of this chapter.

APPLICATIONS OF SUPERCOMPUTERS

Supercomputers are used today for highly-intensive calculation tasks for projects ranging from quantum physics, weather forecasting, molecular modeling, and physical simulations. Supercomputers can be used for simulations of airplanes in wind tunnels, detonations of nuclear weapons, splitting electrons, and helping researchers study how drugs 30 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage: www.igi-global.com/chapter/overview-of-global-supercomputing/124335

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