A Brief History of Supercomputing

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**ABSTRACT**

Supercomputing is the dynamic field of problem solving that attempts to push the boundaries of size, power, and performance of modern systems in order to solve extremely complex and advanced technical problems via incredible performance standards. Since their creation in the 1960s, engineers have continued to challenge the present standards of computing, evolving beyond current metrics.

**INTRODUCTION**

Since standard computers lie at the backbone of supercomputing, it is extremely necessary to explore the history of traditional computing and how it lead to the supercomputer. Widespread observance of computing began in the late 1940s in response to the rising challenges of World War II. However, British scientist Charles Babbage is credited as inventing the computer as it is understood and implemented today. Babbage designed the analytic engine, a proposed device featuring a “mill” for conducting arithmetic operations, a “store” for saving information, and programmable punch cards [Hal70]. While Babbage’s machine was not physically built in his lifetime, his accomplishments have become increasingly prevalent.

Computer scientist Alan Turing is often credited with sparking the age of computation, through his numerous contributions to computer science. Famously, Turing created an electromechanical device known as the *Bombe* which he used to crack the German Enigma encryption code. President Eisenhower credited his contributions, adding that it could have shortened the war by nearly two years. This incredible feat began to show the true power of such devices, with the 1950s beginning a new era in computation, based on Turing’s Universal Machine [CD11]. Turing’s contributions would therefore catapult engineering efforts to create super machines, capable of performing record-setting calculations and solving new problems.

**HISTORY**

Often characterized as the first supercomputer, the Control Data Corporation 6600 was designed in 1964. It was a single processor design capable of 10 million instruction per second [Cer03]. This machine sparked an era of supercomputing defined by Seymour Cray and Cray-derivative architectures. These machines boasted

Researchers have been able to solve unique problems, including the birth of starts, the human genome, and

IMPLEMENTATION

**MODERN SUPERCOMPUTING**

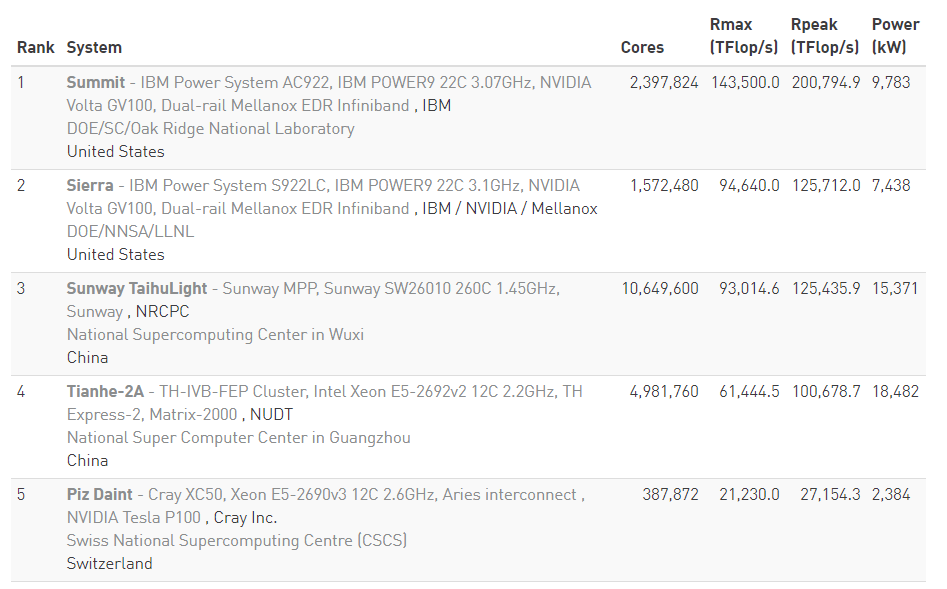


Figure 1 – Top 5 Supercomputers (Nov. 2018) [TOP18]

A couple of important characteristics can be observed from the very top supercomputers in the world from Figure 1. While *Summit* is capable of over 1.5 times the number of operations as *Sunway TaijuLight*, it only has approximately 1/4 the number of cores and consumes 2/3 the power. Very strong conclusions can be drawn from this figure, most notably how the implementation of these vast systems can lead to strikingly different performances. From a naïve perspective, one might assume that a computer with 4 times as many cores would be capable of greater performance, *Summit* proves that just throwing more hardware at a problem will not yield the top performance possible. Additionally, even with this massive underlying architecture, *Summit* is able to operate at a frequency of 3 GHz, twice the frequency of *Sunway TaijuLight*. The distinction between these two systems yields a snapshot into the complexity of the supercomputing.

Just here in Pittsburgh, there are two major supercomputing centers: the Center for Research Computing (CRC) and the Pittsburgh Supercomputing Center (PSC). A major facet of large-scale computing implementations is in the ease of programmability from a user’s perspective. If a machine is incredibly difficult or complex to use, it may be completely counterproductive to develop and utilize this machine due to the offset of complexity versus performance. Specifically, students at the University of Pittsburgh have the opportunity to utilize the resources of the CRC center and can see their code be computing and carried out on this incredibly advanced hardware. A major shift in the supercomputing paradigm can be accomplished by providing this kind of access to everyday people, similarly to how the very first computers worked. While once just used by governments and large businesses, emerging technology brought this computing availability to the everyday man.

**FUTURE OF HPC**

In order to predict the future of supercomputing, it is equally important to understand the past. Figure 2, from 2010, shows some important events in supercomputing, highlighting the year coupled with the performance in FLOPS. This graph shows a prediction of the exaFLOP by the year 2019, as previous jumps of 3 order of magnitude took approximately 10-15 years. As previously shown, the current top Supercomputer is still an entire order of magnitude away from reaching this benchmark.

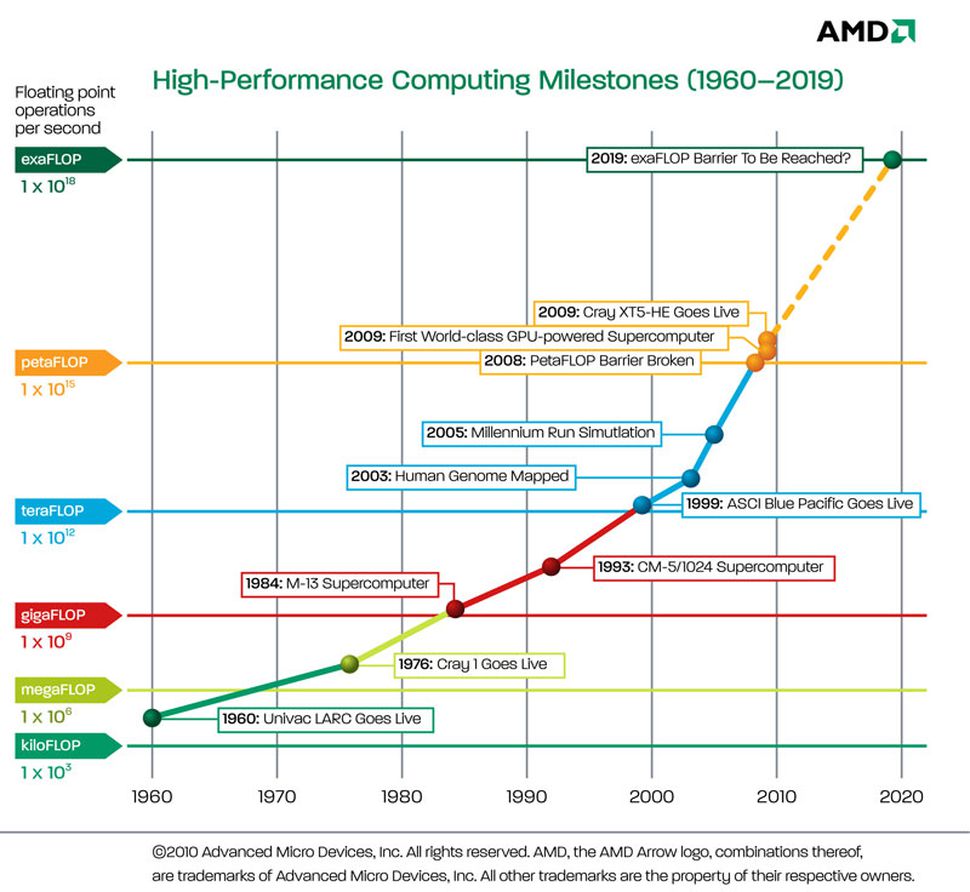


Figure 2 – High-Performance Computing Barriers [AMD]

This inaccuracy in predication can be attributed to a few factors, including slowing clock speed of microprocessors in regard to the number of transistors, as illustrated in Figure 3. Additionally, Moore’s law is beginning to reach its limit, but not necessarily due to the laws of physics. While it may be possible to create new fabrications of increasingly smaller size from a technical standpoint, it will soon be too economically infeasible as the fabrication technology to create such devices will soon outweigh the value of production [Wal16].

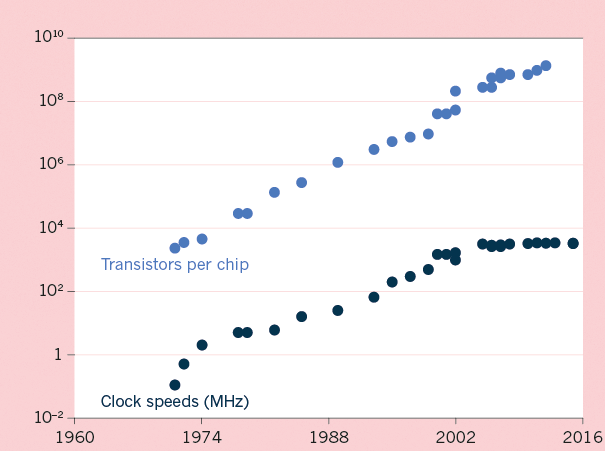


Figure 3 – Transistor / Clock Speed Ratio [Wal16]

**AI**

From my current understanding of both legacy and modern computing, I strongly believe that Artificial Intelligence will be the major focus of the generations to come and will have revolutionary impact in all areas of life. The invention of a truly conscious AI will completely overthrow modern understandings of computing and push rapidly shifting way of life not seen since the Industrial Revolution. This type of technology will produce dynamic economic paradigms shifts, as modern careers will quickly become obsolete. Additionally, such a technology could produce massive emotional impacts as we begin to interact with incredibly vast intelligence.

This computing shift can already be seen today as the top high-performance computing system, *Summit,* was specifically designed and architectured from the ground up for AI applications, including machine learning and neural networks.

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