

# 超級電腦的前世今生

文／林一平 講座教授

「超級電腦能為社會做許多事。有一年超級電腦預測美國佛羅里達州將會有大雪霜，這個訊息提早在 2 週前傳達給佛州果農，預先準備，救了那一整年的橘子收成。當年台灣氣象局要進口 Cray 電腦，美國有軍事科技管制的顧慮，批准有困難。經陳世卿博士斡旋，得以圓滿進口。」

克雷研究公司於 1976 年開發第一部超級電腦 CRAY-1，銷售至羅斯阿拉摩斯 (Los Alamos) 國家實驗室時，造價 880 萬美元。超級電腦之父克雷再接再厲，於 1981 年發表 Cray-2 超級電腦，採用水冷技術運作。

在發展 Cray-2 時，公司有另一個團隊發展 Cray X-MP，主要設計者為陳世卿 (Steve Chen)。這位台灣來的年輕小夥子於 1979 年加入克雷研究公司。當時克雷給陳世卿 2 個選擇，一是加入 Cray-2 的研發團隊，有許多研發資源可用；其二是構思一個新計畫，但僅提供有限的資源。

事過境遷的 30 年後，陳世卿很優閒的告訴我：「經過思考，我選擇冒險性高、比較辛苦，但較創新的後者。」他採用多處理器的設計，以較便宜的處理器來製作出 Cray X-MP 超級電腦，每秒可執行 10 億個指令，速度較 Cray-2 稍差，而成本則大大降低。陳世卿一炮而紅，於 1983 年舉行記者發表會。他回憶道：「我第一次在那麼大的場面講話，英文說得結結巴巴。」

陳世卿於 2009 年 7 月訪問交通大學，我有幸與他共處一段時間，受益良多。他提到，超級電腦能為社會做許多事。有一年超級電腦預測美國佛羅里達州將會有大雪霜，這個訊息提早在 2

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近年來陳世卿博士仍然十分投入研發，但更深入偏遠地區。某日我和他在新竹共進晚餐，幫他點了羊肉，問他菜還可以嗎？他僅是客氣回答還可以。後來他說了實話。他在甘肅吃過哈薩克人招待的羊肉後，其他地方的羊肉都不覺得好吃。他談起在偏遠的平原，現代哈薩克人騎摩托車牧羊的情景，相當有趣。

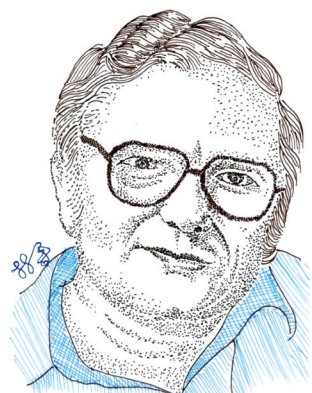
1986 年德國曼漢大學 (University of Mannheim) 的 Hans Meuer 開始追蹤高速計算的發展趨勢，而一群專家們更在 1993 年成立 TOP500 超級電腦系統排名，來評估現有的超級電腦系統。這個排名，不是比賽處理器 (CPU) 或硬碟數目的多寡，而是比運算量。

超級電腦主要用於科學應用，需要執行大量浮點運算 (Floating-point Operations; FLO)，於是超級電腦的能力以每秒能執行的 FLOPS 來評量。浮點運算最早的標準 (IEEE 754-1985) 由卡亨 (William Kahan) 所主導完成。卡亨持續對浮點運算的研究有重大貢獻，被稱為浮點運算之父 (The Father of Floating Point)。

我於 2014~2016 年間在科技部擔任政務次長，督導超級電腦的建置，了解其技術的複雜度，更能體會過去計算機先驅者的貢獻。



林一平與陳世卿博士合影。林一平提供



林一平手繪之卡亨 (William Kahan)。林一平提供

# Supercomputers : The Past and Present

"Supercomputers can be hugely beneficial to society. In one example, supercomputers accurately predicted a heavy snowstorm and widespread frost in Florida, USA, allowing fruit farmers to take preventative measures two weeks before the storm hit, ultimately saving their orange crop for the year. However, there have been challenges in acquiring supercomputers. For instance, when Taiwan's Central Meteorological Administration attempted to purchase a Cray weather forecasting supercomputer from the United States, concerns over the US military's science and technology strategy threatened to impede the process. Fortunately, with the help of Dr. Steve Chen, the import of the Cray supercomputer was successfully completed."

Cray Research designed and manufactured its first supercomputer, the Cray-1, in 1976. The initial Cray-1 system, which was delivered to Los Alamos National Laboratory, had a price tag of 8.8 million US dollars. Building on the success of the Cray-1, Seymour Cray, widely regarded as the father of supercomputing, unveiled the Cray-2 in 1981, which featured liquid immersion cooling technology.

During the development of the Cray-2, Cray Research launched a parallel project to create the Cray X-MP, led by Dr. Steve Chen, who served as the principal designer of the system. Chen, who had joined the company in 1979, was presented with two options at the time: to join the well-resourced Cray-2 team or to spearhead a new project with limited support from the company. Chen opted for the latter, leading the development of the Cray X-MP alongside a dedicated team of engineers.

Over 30 years later, Dr. Steve Chen spoke to me in a relaxed manner, explaining that he had chosen to pursue the riskier and more innovative option presented to him when he joined Cray Research in 1979. This choice led him to develop the CRAY X-MP supercomputer, utilizing a multiprocessor design with cheaper processors. Despite slightly lower performance compared to the Cray-2, the Cray X-MP boasted an impressive overall instruction issue rate of 1 billion instructions per second (1000 MIPS), while greatly reducing the total cost. All eyes were on Dr. Chen, who recalled the 1983 press conference as his first public speaking event in English, which had made him feel nervous and caused him to stammer.

During Dr. Chen's visit to the National Chiao Tung University in July 2009, I had the honor of spending time with him and gaining invaluable insights. He emphasized that supercomputers can greatly benefit society, citing an instance where a supercomputer accurately predicted heavy snow and frost in Florida, USA, allowing fruit farmers to

take preventative measures two weeks prior to the storm and save their crops. Dr. Chen also played a crucial role in overcoming an obstacle encountered by the Taiwan Central Meteorological Administration during the purchase of a Cray weather forecasting supercomputer from the United States, helping to ensure a successful import. In 1985, while Dr. Chi-Fu Den was directing the Engineering Division of the National Science Council and working on plans to establish a high-speed computer center, he sent staff to seek advice from Dr. Chen, underscoring the latter's reputation as a leading expert in the field.

In recent years, Dr. Chen has dedicated himself to research and development that extends to rural and ethnic minority regions. During a dinner I had with him in Hsinchu, I ordered lamb chops and asked him how the food was. Initially, he replied politely that it was fine. However, a few moments later, he revealed the truth - ever since he tasted lamb dishes served by the Kazakhs in Gansu, he had never been satisfied with lamb from other places. He went on to describe a fascinating scene he had witnessed of modern Kazakh herders on motorcycles herding sheep and goats in rural plains.

For the development of supercomputers, Hans Meuer from the University of Mannheim in Germany began tracking significant trends and developments in High-Performance Computing (HPC) back in 1986. In 1993, a group of experts initiated the TOP500 project to evaluate and rank supercomputer systems based on their computing capacity. The Top 500 list does not focus on the number of processors (CPUs) or hard disks, but rather on the amount of computation that a system can perform.

Supercomputers play a critical role in the field of computational science by performing massive and complex calculations, such as Floating-point Operations (FLO). The performance of a supercomputer is commonly measured in floating-point operations per second (FLOPS). The first standard for floating-point arithmetic, IEEE 754-1985, was established under the leadership of William Kahan in 1985. William Kahan is widely recognized as "The Father of Floating Point" due to his significant contribution to the advancement of IEEE standards for floating-point computation.

During my tenure as the Deputy Minister for the Ministry of Science and Technology from 2014 to 2016, I oversaw the establishment of supercomputers. This experience helped me appreciate the complexity of the technology and deepened my recognition of the significant contributions made by past computing pioneers.