



## Industry Developments and Models

# 10 Things CIOs Need to Know About High-Performance Computing

Steve Conway

### IDC OPINION

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High-performance computing (HPC), once a niche market serving government- and university-based researchers, began moving into tier 1 commercial firms in the late 1970s. HPC quickly established itself as a game changer for accelerating innovation and competitiveness in public- and private-sector organizations. The arrival of commercial-grade clusters in 2001-2002 made HPC affordable even for most SMEs and start-ups, with HPC system prices now starting at under \$10,000. During the past two decades, HPC has been one of the fastest-growing IT markets, expanding from \$2 billion in 1990 to \$21.0 billion in 2015. Few people would have imagined at the dawn of the supercomputer era that HPC systems would be used to help design products ranging from cars and airplanes to golf clubs, Pringles potato chips, and Pampers diapers – much less to enable a company such as PayPal to detect online consumer fraud in near real time. IDC forecasts that:

- Commercial HPC adoption will continue to ramp up, helping to propel the HPC market to \$31 billion in 2019.
- As more companies of all sizes in more markets learn to exploit HPC to speed and improve innovation, competitors lacking this advantage will fall behind.
- Successful CIOs will need to gain a basic understanding of HPC and ensure that their organizations carefully consider whether to adopt this technology.

## IN THIS STUDY

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This study provides market data and analysis aimed at ensuring that CIOs in commercial, government, and other settings have essential information about the contemporary realities and potential value to their organizations of HPC. IDC hopes that this information will prove useful to CIOs in deciding whether to exploit HPC and in working with HPC staff if they do adopt this proven game-changing technology.

The study includes first-hand perspectives on HPC from two very different adopters, which graciously agreed to contribute to this document:

- The first perspective comes from PayPal, a successful, global ecommerce company that adopted HPC not long ago for real-time detection of online fraud.
- The second perspective is from the National Oceanic and Atmospheric Administration (NOAA), a government organization that for many years has relied on HPC to produce its National Weather Service forecasts and other leading-edge work.

## SITUATION OVERVIEW

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IDC offers 10 essential considerations in the sections that follow to describe the contemporary realities of HPC and the potential value of HPC, especially for CIOs.

### HPC: 10 Essential Considerations

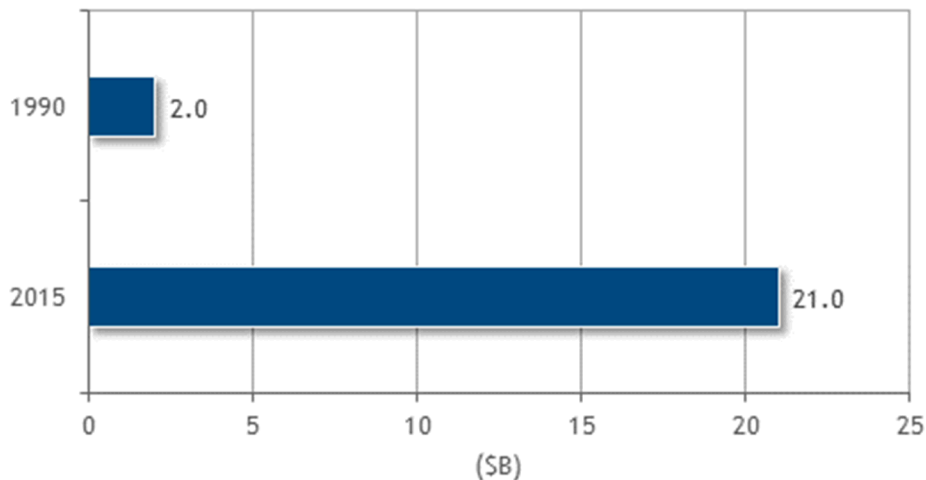
#### *1. HPC Is One of the Fastest-Growing IT Markets*

Revenue for the worldwide HPC ecosystem – servers, storage, software, and services – ballooned more than tenfold, from \$2 billion in 1990 to \$21.0 billion in 2015 (see Figure 1).

#### FIGURE 1

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#### Worldwide High-Performance Computing Revenue, 1990 and 2015



Source: IDC, 2016

Propelled by the standards-based cluster – an HPC innovation from NASA – the HPC server market expanded during the decade of the 2000s faster than the "hot" IT markets for flat-panel TVs or online gaming. In addition:

- In 2009, the worst year of the global economic recession, revenue for supercomputers priced at \$500,000 and up grew 35%, and revenue for high-end supercomputers selling for \$3 million and above jumped a whopping 65%.

The rapid growth of the HPC market in recent years has attracted new vendors to this market and has caused some of the largest existing IT vendors, including HP Enterprise, IBM, Intel, EMC, Dell, and Bull, to ramp up their HPC activities.

## ***2. Commercial Firms Began Adopting HPC in the 1970s***

Following its initial growth spurt in the late 1960s and 1970s, the market for HPC systems has expanded over time by adapting to the requirements of successive waves of new users – in large part through advances in software. Each new wave of users has expected HPC system vendors to do more for them, by providing software to make these systems easier to deploy and use.

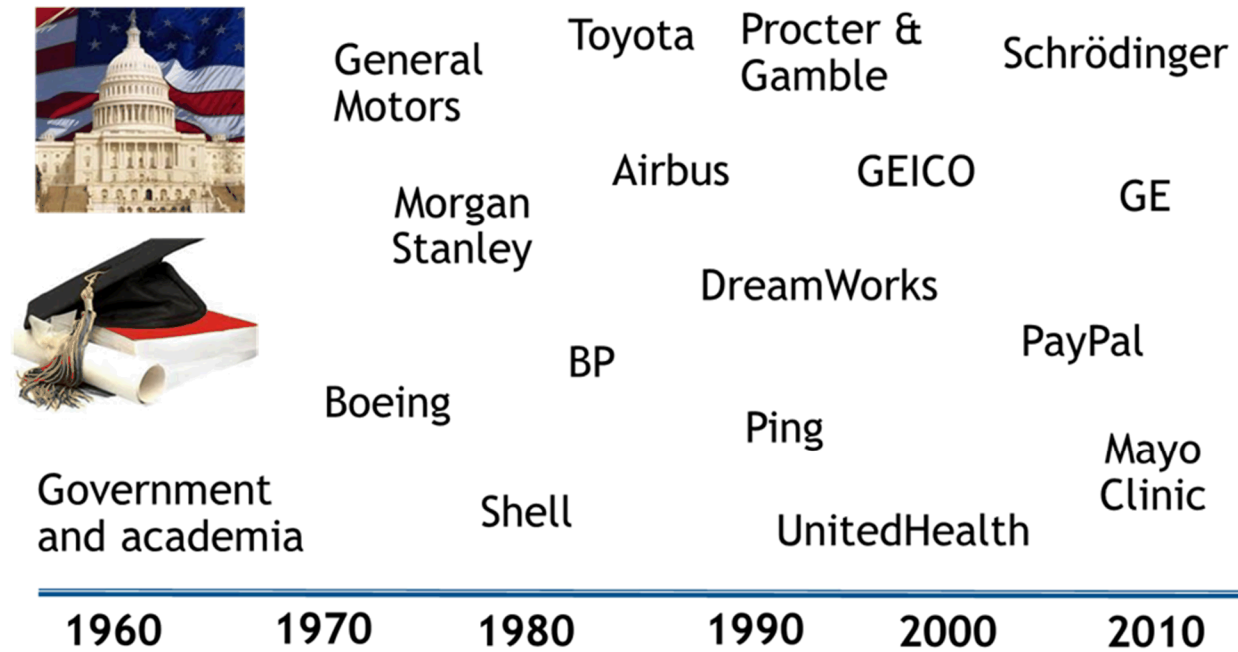
In 1976, the Cray-1 supercomputer was delivered to its first customer, Los Alamos National Laboratory (LANL), as a blazingly fast hardware platform with no operating system. Not to worry: LANL and others in the first wave of HPC users, primarily government and university researchers, typically had enough in-house technical savvy and personnel to write software themselves when the need was critical.

The second wave of adoption carried HPC into industry, initially the automotive, aerospace, and petroleum sectors, starting in the late 1970s. These users required HPC vendors not only to provide an operating system and other system software but to port the key third-party ISV applications needed to run the users' industry-specific problems – and to run the applications with the reliability expected in production computing environments.

The third adoption wave, driven by the compelling price/performance of standards-based clusters, began in 2001-2002 and continues today. This phase greatly expanded the market for HPC by making this game-changing technology affordable and tractable for less-experienced users, such as financial services firms, consumer products makers, and online companies of nearly any size. Figure 2 illustrates the range of companies employing HPC today.

FIGURE 2

HPC Adoption Timeline, 1960-2010



Source: IDC, 2016

### 3. Ninety-Seven Percent of Adopters Say HPC Is Indispensable for Their Ability to Compete and Survive

In a worldwide IDC study conducted for the Council on Competitiveness, based in Washington, D.C., 97% of the commercial firms that had adopted HPC said they could no longer compete or survive without it. The chief benefit cited by these firms is that HPC enables them to bring more innovative, higher-quality products and services to the market in shorter time frames. Whether the task is to design a commercial airplane, discover an oil reservoir in deep water, optimize a portfolio of mortgage-backed securities, create a feature-length animated film, develop a titanium golf club, or detect patterns of online consumer fraud, HPC allows more possibilities to be explored within the given time frame. In many cases, HPC makes it possible to solve problems that could not be solved otherwise. As the Council on Competitiveness puts it, "to out-compute is to out-compete."

#### 4. Senior Government Officials Increasingly Recognize HPC's Economic Value

HPC is important for national economies, because HPC, also called supercomputing, has been firmly linked to economic competitiveness as well as scientific advances. As noted previously, 97% of companies that had adopted HPC told IDC they could no longer compete or survive without it. Worldwide political leaders increasingly recognize this trend:

- In 2009, Russian President Dmitry Medvedev warned that without more investment in supercomputer technology, Russian products "will not be competitive or of interest to potential buyers."
- In June 2010, Representative Chung Doo-un of South Korea echoed that warning: "If Korea is to survive in this increasingly competitive world, it must not neglect nurturing the supercomputer industry, which has emerged as a new growth driver in advanced countries." The Korean National Assembly then called for the creation of a national five-year plan for advancing HPC.
- In his 2011 State of the Union address, President Obama noted China's rapid progress in HPC and said that the U.S. Department of Energy's Oak Ridge National Laboratory is "using supercomputers to get a lot more power out of our nuclear facilities."
- In February 2012, the European Commission announced that it had adopted a plan to double spending on HPC to €1.2 billion, with much of that money aimed at the installation of additional large supercomputers at leading European HPC centers. In 2011, at the European Commission's request, IDC had recommended a five-year HPC strategy for Europe to implement.
- On October 21, 2015, President Obama announced the new edition of *A Strategy for American Innovation*, naming HPC one of the top investment priorities for growing the U.S. economy.

#### 5. HPC Is Different from Business Computing

IDC uses the terms *high-performance computing* and *technical computing* as synonyms to encompass the entire market for computer servers (and related software and services) employed by scientists, researchers, design engineers, analysts, and others to address computationally intensive or data-intensive modeling, simulation, and other analytical problems. HPC activities can be found in the commercial sector, government, and academia. Commercial activities include automotive and aerospace product development, oil and gas exploration, drug discovery, weather prediction and climate modeling, complex financial modeling, consumer product design and optimization, and advanced 3D animation, as well as Big Data analytical problems in many commercial domains.

In contrast to commercial computing, HPC is used for business operations such as accounting, payroll, sales, customer relationship management (CRM), enterprise resource planning (ERP), transaction processing, human resources, and purchasing. The common denominator underlying HPC problems is a degree of algorithmic complexity that is atypical for business IT problems. Business IT workloads often (though not always) consist of a large volume of tiny problems (e.g., a business computer may process tens of thousands of transactions per second). In contrast, a single HPC problem may take not a fraction of one second but hours, days, weeks, or even months to process. HPC systems are designed to support very large, long-running, I/O-intensive problems.

## 6. The Goals of IT and HPC Are Also Different

CIOs who are new to HPC often make the mistake of treating it like a typical IT function. This misperception can lead to lost productivity and, in some cases, to conflict between the CIO's office and the company's HPC staff.

As Jim Barrese, CTO of PayPal, advises in his commentary in this document:

Clearly understand that HPC is not a mass consumption technology where we enable everyone in our organization with it. This is a deep engineering function. It's custom built and includes writing software to solve cutting-edge problems ... Think of HPC not as an IT function but as a competitive business advantage. There's a hard link between HPC and PayPal's top line and bottom line.

In important respects, HPC is different from general IT deployments. IT is generally about *provisioning* – equipping each of the company's knowledge workers with the basic computing tools they need to perform their jobs productively and providing as little beyond that as possible to stay within the budget. HPC, on the other hand, is about *enablement* – providing a small subset of specialized knowledge workers with the most powerful computational tools the company can afford. A typical IT worker's desktop or laptop system is capable of fully supporting the worker's computing requirements, while there is often no limit to the amount of computing power an HPC user could exploit on the company's behalf.

Reflecting the almost insatiable demand for HPC resources, utilization for most HPC systems exceeds 90%, compared with about 30% for typical business servers. The powerful trend toward server consolidation and virtualization in enterprise datacenters has had almost no impact in HPC datacenters – because there are few unused cycles available to consolidate and exploit through virtualization.

## 7. Key IT Datacenter Technologies Have Trickled Down from HPC

There is a perennial debate between those who argue that key IT technologies "bubble up" from the low end, such as embedded and desktop devices, and those who counter that key technologies "trickle down" from the high end, especially HPC. In reality, of course, both arguments are correct.

Technological innovation is bidirectional, flowing up and down. In addition:

- During the decade from 2000 to 2010, for example, clusters based on standard x86 processors from Intel and AMD supplanted RISC processor-based computers to become the dominant species of HPC systems. The x86 processors bubbled up from the market for desktop/laptop computers.
- Conversely, clusters themselves were born in the HPC market and later trickled down into enterprise IT datacenters. The original Beowulf cluster was developed at NASA in 1994 by Thomas Sterling and Donald Becker, although standards-based clusters didn't begin to gain strong market traction in HPC until 2001-2002.
- The Linux operating system has played a major role in making clusters dominant in HPC. Soon after their adoption by leading-edge HPC sites, Linux clusters began moving into commercial datacenters. Among the first commercial adopters were the back offices of investment banks and other large financial services firms, where "quants" used the Linux clusters for complex tasks including global risk management, pricing exotic instruments, and optimizing investment portfolios.

- Grid computing and cloud computing are two more important technologies that have trickled down from HPC to mainstream commercial markets. And today, as the PayPal sidebar within this document attests, commercial companies are increasingly using HPC systems and approaches to tackle daunting problems such as real-time detection of online consumer fraud in high-volume Big Data environments.
- On the bubble-up front, multiple processors and coprocessors have been making their way from the embedded systems market into HPC, including GPUs, ARM, and Atom devices.

## 8. HPC Systems Now Start at Under \$10,000

At one time, decades ago, entry pricing for a supercomputer was in the range of \$25 million to \$30 million. Many people think buying an HPC system still means ponying up millions of dollars. But thanks to the transition to clusters based on industry-standard technologies, pricing for HPC systems now starts at less than \$10,000. In addition:

- Last year, HPC systems sold for under \$250,000 each accounted for \$5.8 billion in revenue, about half (51%) of the \$11.4 billion in worldwide HPC server revenue. The average price paid for one of these HPC systems was \$63,510.

With entry prices this low, HPC systems have become affordable for many more companies than ever before.

## 9. Commercial Firms Are Also Adopting HPC for Challenging Big Data Problems

*High-performance data analysis (HPDA)* is the term IDC coined to describe the convergence of the established data-intensive HPC market and the high-end commercial analytics market that is starting to move up to HPC resources. In addition:

- A good commercial example is PayPal, a multibillion-dollar company, which integrated HPC servers and storage into its datacenter workflow to perform sophisticated fraud detection on credit card transactions in real time. Real-time detection can catch fraud before it hits credit cards. IDC estimates that using HPC has allowed PayPal to save hundreds of millions of dollars to date.
- Another commercial adopter is GEICO, which is using HPC to perform weekly updates of insurance quotes for eligible U.S. households and individuals.

Simulation-driven HPC is the longest-standing part of the HPDA market. Since the start of the supercomputer era in the 1960s, important HPC workloads, such as cryptography and weather and climate research, have been data intensive. The newer kid on the HPDA block is analytics, which comes in many flavors. Of course, the financial industry has been running analytics on HPC systems at least since the late 1980s. But newer methods, from MapReduce/Hadoop to graph analytics, have greatly expanded the opportunities for HPC-based analytics.

The common denominator underlying simulation- and analytics-based HPDA workloads is a degree of algorithmic complexity that is atypical for transaction processing-based business computing. With the help of sophisticated algorithms, HPC resources are already enabling established HPC users, as well as commercial adopters such as PayPal, to move beyond "needle in a haystack" searches in order to discover high-value, dynamic patterns. IDC believes that HPC resources will be increasingly crucial for extending Big Data capabilities from *search* to *discovery*.

IDC forecasts that revenue for HPC servers acquired primarily for HPDA use will grow robustly, increasing from \$739 million in 2012 to exceed \$3.1 billion in 2019. Revenue for the whole HPDA

ecosystem, including servers, storage and interconnects, software, and service, should double the server figure alone. A good chunk of this revenue will come from commercial firms.

## ***10. There Is More on Tap from HPC***

One of the next important developments IDC expects to come out of the HPC market is more capable network technologies to speed communications between cores, processors, servers, and nodes. This development should help address the so-called memory wall, the growing gap between escalating processor peak speeds and the lagging ability of internal networks to feed processors with enough data to keep them busy. Improving network bandwidths and latencies should be especially important for challenging Big Data tasks faced by businesses and government organizations alike.

Think here not only of switch vendors such as Mellanox and Cisco but also of initiatives by processor vendors to move up a level of integration to provide capable fabrics. AMD's SeaMicro initiative comes to mind, along with Intel's acquisitions of QLogic's InfiniBand assets and Cray's proprietary interconnect assets. IDC expects significant progress to occur on this front in the next five to six years, with benefits for both enterprise and HPC datacenters.

## **Case Studies**

### ***The National Oceanic and Atmospheric Administration: HPC as a Mission-Critical Tool***

Interview with David Michaud, deputy director, High Performance Computing and Communications (HPCC), NOAA:

The National Oceanic and Atmospheric Administration's mission is to understand and predict changes in the Earth's environment, from the depths of the ocean to the surface of the sun, and to conserve and manage coastal and marine resources. From daily weather forecasts, severe storm warnings, and climate monitoring to fisheries management, coastal restoration, and supporting marine commerce, NOAA's products and services support economic vitality and affect more than one-third of America's gross domestic product. HPC has long been indispensable for carrying out NOAA's mission.

At NOAA, high-performance computing is well integrated with the leadership and management of the typical enterprise IT services. Our CIO has two titles, CIO and director of high-performance computing and communications. So these subtleties are dealt with directly under a consistent perspective.

HPC is a critical tool needed for NOAA to carry out its mission on a daily basis. The extent of NOAA's HPC capability and capacity is directly linked to our mission performance. To ensure our HPC is acquired, implemented, and allocated for the maximal benefit to our organization, we have developed a well-established governance structure. The CIO and director of HPC chairs our High Performance Computing Board, which includes senior leaders from all of NOAA's major missions, such as weather services, satellite services, ocean services, fisheries services, and our applied research groups. These representatives who participate in overseeing HPC are generally non-technologists who are responsible for setting programmatic priorities within their mission areas. Beneath this group are the technologists responsible for acquiring HPCC systems and operating them on a daily basis, along with program managers in charge of allocating and prioritizing the HPC resources.

From the CIO's perspective, the highest priority is IT security, but HPC is a close second. Without HPC, we can't perform our mission work. NOAA's senior leaders recognize that HPC is a key component of our value chain for producing NOAA's weather reports and other products. Weather



observations are very important, and HPC is important for turning all that data into meaningful information. We invest over a billion dollars each year in observations. HPC is crucial for leveraging those investments. The final crucial element is dissemination, getting the data out to the public.

At its core, HPC needs to be about enabling an organization's mission, not just putting together a computing program for technology's sake. There are important benefits, even for organizations that are just starting out in HPC. You can use a simple cluster to aggregate disparate applications within an organization and increase the performance of those applications. Within an HPC system, you can also aggregate all the data sources in one place and extract value from them in one place. These activities often reveal or create previously unknown dependencies between applications, which tighten relationships among groups within an organization. All of these benefits yield cost efficiencies. And while you shouldn't expect all the benefits to be realized immediately, even in the first year, you should expect to see important benefits with some targeted applications.

Thanks to HPC's strong connection to our CIO, at NOAA, we are able to provide HPC from an enterprise perspective. We started this integration of HPC into enterprise IT in 2006. Now, NOAA is looking to collaborate across federal agencies by providing HPC resources in a shared services paradigm. We're really good at knowing how to exploit midsize HPC systems cost-effectively in a high reliable manner, and we can help other organizations that have similar needs. One part of this challenge is working with a mix of experienced and less-experienced users. In turn, we leverage other federal agencies' facilities such as the Department of Energy and National Science Foundation to understand how to exploit their larger, leadership-class HPC systems.

### ***PayPal Exploits HPC for Fraud Detection***

Interview with James Barrese, CTO, PayPal:

PayPal is a mobile payment company that operates in 200 countries and processed 4.9 billion payments in 2015. By deploying HPC servers, storage, and software, PayPal is able to detect fraud in near real time before it hits consumers' credit cards. HPC has helped PayPal to catch substantial additional fraud.

PayPal's decision to use HPC goes back to our innovative technology roots. More than \$5,200 is transacted every second across our platform, and it's our responsibility to not only deliver great customer experiences but keep our customers' financial information safe. As our company continued to rapidly grow, we saw both a challenge and an opportunity with handling fraud and risk while delivering more personalized shopping experiences. Our approach to these types of situations is to be very entrepreneurial and aggressive. We asked, "How can we solve this business problem?" and our HPC team said, "Hey, this problem's been solved before, using HPC." This led to an HPC pilot and then to deployment.

I think we're in the most interesting time in my career – the pace of technology change is accelerating. There's a whole new S-curve with being able to leverage HPC and machine learning on a real-time basis. HPC helps us manage large, globally distributed systems. With HPC, we're able to do risk analysis in real time and detect fraud before it happens. We're also able to leverage HPC to further personalize the consumer experience. Say, you walk by a Jamba Juice and we know you like smoothies, so we deliver a coupon to you right then and there.

When you are evaluating whether or not HPC is right for your company, here are some tips:

- You need the right talent to be able to deliver results. I would urge people to start with clear objectives and have the right people on board. We had the nucleus of HPC talent and have been recruiting more HPC talent aggressively.
- Clearly understand that HPC is not a mass consumption technology where we enable everyone in our organization with it. This is a deep engineering function. It's custom built and includes writing software to solve cutting-edge problems.
- Think of HPC not as an IT function but as a competitive business advantage. There's a hard link between HPC and PayPal's top line and bottom line. HPC is key to our company's strategy because PayPal is redefining an industry, and it's all driven by technology. HPC is enabling new business capabilities that are really product driven.

## FUTURE OUTLOOK

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The history of computing machines dates at least as far back as the 19th century, but the development of modern electronic computers, including HPC systems and business mainframes, was spurred mainly by the national security/military requirements of World War II (1939-1945) and the subsequent Cold War (1945-1991). Starting in the late 1970s, HPC systems, also called supercomputers, spread from their original homes in government and university research to tier 1 commercial firms. During the 2000-2010 period, the compelling price/performance of standards-based clusters made them the dominant species of HPC systems and greatly expanded the size of the HPC market. For the first time, even SMEs and start-ups could afford to move up to HPC. Today, HPC technology is helping companies and government organizations of all sizes to innovate, compete, and survive.

IDC forecasts that the HPC market will continue to grow faster than the market for general business servers, owing partly to the irrelevance of server consolidation in HPC. Existing commercial users of HPC will expand their usage, and more companies will adopt HPC for the first time to tackle daunting business challenges. On the business analytics/business intelligence side, IDC expects more firms to follow the examples of PayPal and GEICO in deploying HPC for high-value problems that cannot be effectively addressed with MapReduce/Hadoop and similar useful, but limited, approaches.

IDC believes that CIOs will increasingly be expected to become familiar with the benefits of HPC, whether they decide to adopt this technology or not. Because of the proven game-changing value of HPC, CIOs will also increasingly be expected to know which of their competitors is exploiting HPC.

## ESSENTIAL GUIDANCE

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- **CIOs should gain a basic understanding of HPC and ensure that their organizations carefully consider whether to adopt this technology.** CIOs who do not assess the potential benefits of HPC will increasingly risk losing ground to competitors that have learned how to exploit HPC to accelerate and improve innovation.
- **HPC is no longer an ultraexpensive, arcane technology.** Prices for HPC systems now begin at under \$10,000, and the vast majority of HPC systems are sold for less than \$100,000 – although the biggest supercomputers fetch more than \$100 million each. HPC systems are also much easier to install, deploy, and manage than in former times. They ceased long ago to be the exclusive province of white-coated lab scientists.

- **HPC should not be treated in the same way as other corporate IT functions.** If general IT provisioning is a gunshot, then HPC enablement is a more highly targeted rifle shot. HPC has a much narrower focus than general IT and is typically meant for a small subset of an organization's knowledge workers. But as IDC studies consistently confirm, HPC can have a much greater strategic impact on organizations that exploit this game-changing technology.

## LEARN MORE

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### Related Research

Related research from IDC includes the following documents:

- *The Formative Market for High Performance Data Analysis: Big Data Meets HPC.* Global study for a private client. April 2015
- *High Performance Computing in the EU – Progress in the Implementation of the European HPC Strategy.* IDC interim report for the European Commission Directorate-General for Communications Networks, Content & Technology. E. Joseph, S. Conway, R. Sorensen. March 2015
- *HPC Speeds Innovation for Suppliers and Other SMBs* (IDC #252680, November 2014)
- *EESI2: Special Study to Measure and Model How Investments in HPC Can Create Financial ROI and Scientific Innovation in Europe.* Earl C. Joseph, C. Dekate, S. Conway. August 2014
- *Creating Economic Models Showing the Relationship between Investment in HPC and the Resulting Financial ROI and Innovation – and How These Can Impact a Nation's Competitiveness.* Worldwide pilot study for U.S. Department of Energy. October 2013
- *Clouds for Science and Public Authorities.* Final Report for the European Commission. SMART 2011/0055. August 2013
- *An Assessment of the Likely Supercomputers Available in 2017.* Global study for a private client, based on in-depth interviews with more than 40 HPC technology vendors from throughout the world, concerning their plans and opinions on technology futures. June 2013
- *Special Investigation of HPC Applications Used in Industry: Their Usage and Needs and the State of the Art in the Science Underlying the Algorithms.* Research study for the (U.S.) National Science Foundation and NCSA (IDC #236250, August 2012)
- *Science and Supercomputing: New Capabilities Illuminate Nature's Complexity.* S. Conway, IDC. HPC Source. SC11 Special Edition, November 2011
- *Financing a Software Infrastructure for Highly Parallelised Codes.* IDC Final Report for the DG Information Society of the European Commission. SMART 2010/0052. July 2011
- *IDC Special Study: A Strategic Agenda for European Leadership in Supercomputing: HPC 2020.* IDC Final Report of the HPC Study for the DG Information Society of the European Commission. E. Joseph, S. Conway. September 2010

## Synopsis

This IDC study provides market data and analysis aimed at ensuring that CIOs in commercial, government, and other settings have essential information about the contemporary realities and potential value to their organizations of HPC. HPC has firmly established its value for accelerating and improving innovation in corporate as well as government and academic organizations. Commercial adoption helped make HPC one of the fastest-growing IT markets in the past two decades, faster than the markets for flat-panel televisions or online gaming.

"Because HPC is fundamentally different from other corporate IT functions, CIOs often don't understand the potential benefits of adopting HPC or how to treat the HPC function after adoption occurs," according to Steve Conway, IDC research vice president for HPC. "Successful CIOs will need to acquire this understanding or risk losing ground to competitors that learn how to exploit HPC effectively."

## About IDC

International Data Corporation (IDC) is the premier global provider of market intelligence, advisory services, and events for the information technology, telecommunications and consumer technology markets. IDC helps IT professionals, business executives, and the investment community make fact-based decisions on technology purchases and business strategy. More than 1,100 IDC analysts provide global, regional, and local expertise on technology and industry opportunities and trends in over 110 countries worldwide. For 50 years, IDC has provided strategic insights to help our clients achieve their key business objectives. IDC is a subsidiary of IDG, the world's leading technology media, research, and events company.

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