Global Headquarters: 5 Speen Street Framingham, MA 01701 USA P.508.872.8200 F.508.935.4015 www.idc.com

WHITE PAPER

Council on Competitiveness Study of U.S. Industrial HPC Users

Sponsored by: Defense Advanced Research Projects Agency

Earl Joseph, Ph.D.
Addison Snell
Christopher G. Willard, Ph.D.

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IDC OPINION AND OBSERVATIONS

The U.S. industrial market for high-performance computing (HPC) technical servers has been through a number of changes, evolutions, and revolutions over the past few years. In many ways, it is like going through a physical phase change from a liquid to a solid state, and things have not yet fully solidified. There are many clear trends in the U.S. industrial market today:

- Price and price/performance have both provided new possibilities and driven buyers to acquire different types of HPC servers.
- Clusters have proven themselves as capable servers to handle a sizable portion of the HPC workload.
- Industrial users are still very engaged and excited about applying HPC to help their organizations become more competitive and ultimately more successful.
- Industrial users are less interested in investing in programmers and computer scientists and have refocused their investments and people toward work directly in their business areas.
- Higher-performance computers are desired, but most sites cannot afford to purchase the fastest computers today.

U.S. industrial users/buyers really want and need faster computers that fit their budgets and that don't require specialized programming skills.

The U.S. industrial sites interviewed clearly see HPC as fundamental to the business, as the following quote illustrates: "Our business model could not exist without HPC." These sites are still strategically using HPC and are investigating new ways to apply HPC.

Recent Market Events

2003 was a good year for HPC technical servers, as the technology reversed the economic downturn from the previous two years with a healthy 12% growth in sales revenues. The expansion in the market is taking place at lower price points due to a combination of factors, including the tight economy placing pressure on budgets, the processor improvements provided by Moore's law, the usability improvements in clusters, and the lack of strong high-end product offerings. Hence the high-end capability market segment actually declined by 24%, while the lowest-end departmental segment grew by 35%. We expect to see the movement to lower-priced platforms continue over the next five years.

Definitions

HPC

In this document, the term *HPC* is used in the same way as the terms *HEC*, *HPTC*, and *high-end computing*. We are referring to computer servers used to solve computational or highly data-intensive problems. Our definition requires large scientific/engineering/economic problems.

Industrial Sector

This is a study of nongovernment and nonuniversity sites/organizations that use HPC computers in their businesses. The terms *industrial sites*, *commercial sites*, and *business sites* are all used in the same manner to represent the overall industrial sector.

Capability-Class and Capacity-Class HPC Computers

IDC defines capability-class computers as systems purchased primarily to tackle the largest, most complex single problems. Capability-class HPC systems are generally priced at $2 million to $4 million or more, with costs occasionally approaching or even exceeding $100 million. Traditional symmetric multiprocessor (SMP) technical servers and supercomputers of sufficient size fall into this category, but large-scale clusters also qualify as capability-class systems if they are purchased primarily to address large single problems.

Capacity-class systems are purchased primarily to solve many small and medium-sized problems. Capacity-class HPC systems may also be priced at more than $1 million and may include any category of HPC computer. IDC further divides capacity-class computers/servers by price band:

- **Enterprise:** $1 million or higher
- **Division:** between $250,000 and $1 million
- **Department:** below $250,000

The primary purchasing rationale differentiates capability- and capacity-class systems.

Clusters

Clusters are considered capability systems when they are used for the most challenging problems (e.g., when used for "traditional" capability-type problems). These clusters are typically very large with an average size of more than 300 nodes.

EXECUTIVE SUMMARY

This study was commissioned by the Council on Competitiveness (COC) and sponsored by the Defense Advanced Research Projects Agency to explore the usage and impact of high-performance computing (HPC) resources in industry and other business sectors — including currently available HPC computers and potential future computers assumed to be dramatically faster and easier to use. The study asked about both capacity-class computers, purchased primarily to address many small and medium-sized problems, and capability-class computers, purchased mainly to tackle the largest, most daunting individual problems.

The 33 participants in this study are seasoned private-sector chief technology officers (CTOs), chief information officers (CIOs), and production and research managers representing a wide range of business segments that employ HPC today — from leading aerospace, automotive, petroleum, electronics, pharmaceutical, life sciences, and software companies to financial services, transportation logistics, and entertainment firms.

Major Findings

High-Performance Computing Is Essential to Business Survival

High-performance computing is not only a key tool to increasing competitiveness, it is also a tool that is essential to business survival. Nearly 100% of the respondents indicated that HPC tools are indispensable, stating that they would not exist as a viable business without them or that they simply could not compete effectively. A majority (70%) of the respondents indicated that HPC is so important that their organizations could not function without it.

Nearly 100% of the respondents indicated that HPC tools are indispensable.

Typical comments include:

"There is no other way for us to complete our work. We would not exist."

"There is no other way for us to complete our work. We would not exist."

"The time to market would prohibit our business from existing."

"We would not be able to stay technologically ahead of other competing nations."

The number 1 reason given for purchasing high-end computers is their unique ability to run very large and very complex computational problems that companies must successfully address to maintain their competitive advantage. In addition to running these large-scale problems, the majority of respondents are also able to harness the computer power to run a larger number of smaller-scale, important problems than they were able to run in the past.

Companies Are Realizing a Range of Financial and Business Benefits from Using HPC

Companies described a range of impressive competitiveness benefits realized from using high-performance computing. Approximately one-quarter of the respondents were able to quantify the ROI to their organizations, in some cases in the millions of dollars. Strategic competitive benefits included gains such as shortened product development

cycles and faster time to market (in some cases more than 50% faster), not to mention the resultant reduced costs, all of which can improve a company's bottom line.

"It has been a continuous stream of revenue to our bottom line, giving us the ability to look into other development areas."

"It drives innovation, R&D effectiveness, and productivity."

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Companies Are Failing to Use HPC as Aggressively as Possible

Despite the acknowledged importance of high-performance computing to business competitiveness, a majority of respondents acknowledged that they are not using HPC as aggressively as possible. Two-thirds of the respondents indicated that they have important problems that they simply can't solve today. The remaining third said that they need more powerful systems to achieve more effective solutions. Reasons for both vary. In some cases, systems with the needed capability are on the market but companies face obstacles in owning or accessing them or in using them to their fullest capability. These barriers are discussed below. In other cases, the systems required simply don't exist.

Examples of current unsolved problems include modeling block engine assembly in full detail, simulating vehicle rollover, real-time processing of data from remote sensors, protein folding, and coordinating databases across tens of thousands of servers.

Business and Technical Barriers Are Inhibiting the Use of Supercomputing

Respondents noted a range of reasons that HPC is not used more aggressively. The largest single factor is the lack of computational scientists — human experts (internal or external) who can apply HPC tools to the problems in question — and the budget to hire them. In most cases, the concern was the lack of resources to hire people, but in a few cases, it was the lack of available talent in the marketplace. Closely related is the ease-of-use issue; most industrial sites require software compatibility in their HPC servers and the cost to change or rewrite software is frequently seen as prohibitive.

The largest single factor preventing more aggressive use of HPC is the lack of computational scientists.

Despite the often proven returns from using high-performance computing, respondents noted that upper management often does not appreciate the value of HPC hardware and software tools. As a result, HPC is often viewed as a cost instead of an investment, and many sites find it difficult to obtain internal funding to acquire additional HPC resources. More than half of the respondents expect their budgets for all HPC tools will decline (43%) or remain the same (17%) over the next two years.

Companies Don't Have the HPC Tools They Want and Need

When asked if there are currently available HPC tools they would like to own or access, a majority of the respondents answered in the affirmative. Relatively even numbers of respondents pointed to currently available software and hardware tools they would like to own or access. However, 31.6% stated that there are either hardware or software tools missing in the market today, and 21% said that they need hardware systems that are more powerful than any available on the market today.

Most Companies Do Not Rely on Remote Access to HPC

When respondents were questioned about their methods of accessing HPC resources, most responded that they use onsite purchased or leased HPC systems instead of accessing them remotely at partner or external provider sites. And most do not expect to outsource their most complex (and therefore most competitively sensitive) problems in the future. Security is an important inhibiting factor for some companies.

Dramatically More Powerful and Easier-to-Use-Computers Would Deliver Strategic, Competitive Benefits

When respondents were asked what they could accomplish with systems 100 times more powerful and/or 10 times easier to use, their replies again reflected the strategic importance of HPC to competitiveness. They saw opportunities to simulate larger, more accurate models and tackle completely new problems that they cannot address today, resulting in the ability to produce higher quality products, achieve faster time to market, and improve their financial performance.

When asked what could be accomplished if the "ease-of-use" barrier were addressed with systems that are 10 times easier to program, respondents overwhelmingly indicated that they could develop more powerful applications and fundamentally rewrite their current codes. Not surprisingly, they also indicated that they could shorten design cycles and time to market, a natural by-product of better applications. In addition, more easily programmable systems would enable a wider universe of researchers, scientists, inventors, designers, manufacturers, and mathematicians to use high-performance computing to solve their problems, extending the benefits of these systems more broadly across the private sector for increased industrial and national competitiveness.

"We could test two-generations-out models that we are researching today."

"It would increase revenues for the company and market share."

"We would look to rewrite the entire science underlying the current technology and methodology we are using."

"It would make these tools available to a much wider array of scientists who have good ideas but may not have programming skills."

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Dramatically More Powerful and Easier-to-Use-Computers Could Add Billions to the Bottom Line

Although not all respondents were able to quantify the potential benefits from access to more powerful and easier-to-use systems, those who could suggested bottom-line improvements from tens of millions to billions of dollars, an enormous increase over the positive financial benefits users are already achieving today.

"We save $1 billion from a faster product cycle."

"We save $1 billion from a faster product cycle."

"I can't release [the amount], but it is in the billions a year."

Methodology

This study was undertaken on behalf of the Council on Competitiveness and sponsored by the Defense Advanced Research Projects Agency to shed light on the factors that encourage or inhibit the use of HPC by users in the private sector to solve their current research and business challenges as well as the future applications these users foresee. The study is based on extensive interviews with 33 private sector CTOs, CIOs, and production and research managers representing a wide range of business segments that employ HPC. Appendix 1 contains a description and profiles of the sites interviewed. Appendix 2 contains the set of questions used in the interviews.

Respondents needed to be the primary buyers of HPC, or at least be actively involved in the selection process, and have:

- An excellent understanding of high-performance computing technology and its current application within their organization
- A vision for the problems that the organization should be solving in order to remain competitive but an inability to solve these problems today due to insufficient computing capability
- The ability to describe the criteria used and process followed by the organization when considering an investment in high-performance computing
- An active role in developing and presenting the bottom-line justification for this substantial investment
- The capacity to identify the factors that encourage or inhibit the use of high-performance computing tools within the organization or across the sector

Study Limitations

While IDC always aims to provide an accurate, comprehensive view of the subject being studied, certain limitations inevitably affect the results. We believe that the group of 33 private sector officials we surveyed is large and diverse enough to represent important market conditions and trends, but it would be presumptuous to claim that there are not others whose situations differ in certain respects from any in this group. Also, consistent with its purpose, this study is deliberately United States–centric and does not claim to fully mirror the tendencies of users in other parts of the world. Finally, with a group size of 33 respondents, some less popular options for responding to questions are thinly represented, occasionally with only one or two responses. IDC has tried to exercise extreme caution in generalizing from such results and cautions readers to do the same.

SITUATION OVERVIEW

Criteria Used to Justify Investment in HPC

Q4. What are the primary reasons why your organization uses HPC computers?

The primary reasons given for using high-performance computers (see Table 1) mirror the business sectors of the respondents. Independent software vendors (ISVs), for example, are in the business of software development and testing, while automotive companies employ HPC computers mainly to help with the design, manufacturing, and testing of new vehicle platforms. Simulation and visualization, on the other hand, are activities common to virtually all HPC usage, whether in industry, government, or academic settings.

TABLE 1

Primary Reasons Why Organizations Use HPC Computers

Category	Number of Responses	Overall Percentage
Software development and testing (to be sold to others)	7	21
Simulation (high end)	6	18
Automotive design, manufacturing, and testing	4	12
Oil exploration/seismic processing	3	9
Microprocessor/circuit design	3	9
Visualization (high end)	2	6
Pharmaceutical research/drug discovery	2	6
Electronic data automation	2	6
Web site development	1	3
(Trucking) fleet management	1	3
Business problem-solving	1	3
Price/performance and scalability	1	3
Total	33	100

n = 33

Note: More than one response per site was allowed.

Source: IDC, 2004

Actual responses to this survey question underscore the importance of HPC to the industries and businesses in question, as the following examples demonstrate:

"We will launch 25 new [automotive] products in the next three years, and they all require major use of HPC."

"Designing and verifying a world-class microprocessor requires significant CPU power."

"Designing and verifying a world-class microprocessor requires significant CPU power."

"Oil exploration is an extremely compute-intensive process for reservoir simulation, seismic simulation, and seismic processing."

"The modeling problems are intractable for smaller systems. We have many users who share this system, so this provides a cost-effective solution to a large, diverse R&D community."

"The modeling problems are intractable for smaller systems. We have many users who share this system, so this provides a cost-effective solution to a large, diverse R&D community."

"HPC has been critical to our business model."

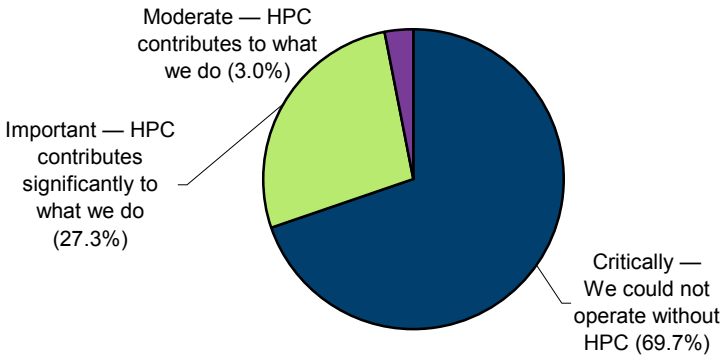
Q5: How does HPC impact your organization's primary goals and/or mission?

As Figure 1 illustrates, a decisive majority (70%) of the respondents indicated that HPC is so important that their organizations could not function without it. Another 27% said that HPC contributes significantly to what they do. Only one respondent rated HPC as merely "moderately important."

70% of the respondents indicated that HPC is so important that their organizations could not function without it.

FIGURE 1

Impact of HPC on Organizations' Primary Goals and/or Mission



n = 31

Source: IDC, 2004

"HPC is essential to today's computing needs in industry."

"We can't build airplanes without HPC."

"It is crucial for the design of our [automobile] products."

"It is a key component of our R&D. It helps us calculate properties before engaging in experiments. It has on occasion been a vital part of rescuing product development projects that were not making expected progress through experimental means."

"This is our core business, and the [petroleum] industry could not exist without it."

"This is our core business, and the [petroleum] industry could not exist without it."

"We as a company could not produce our [automotive] products, and we would not be in business."

"It allows for faster development cycles and more economical research."

Q7. How does your organization acquire access to these computing resources? (More than one response is possible.)

Most of the organizations (54%) purchase HPC systems and install them in their own facilities, and another 16% install systems in their facilities under leasing arrangements (see Table 2). Hence, 70% of the organizations access HPC systems on site — further evidence of the crucial importance of these systems.

54% of organizations purchase HPC systems and install them in their own facilities.

TABLE 2

Methods of Accessing HPC Resources

Method of Accessing HPC Resources	Number of Responses	Overall Percentage
Purchase and install them in our facilities	30	54
Use systems installed in partner facilities (e.g., vendors, universities, labs)	11	20
Lease and install them in our facilities	9	16
Use resources over a grid or from an Internet provider	1	2
Other	5	9
Total	56	100

n = 33

Note: More than one response per site was allowed.

Source: IDC, 2004

One in five of the respondents accesses HPC systems at partner facilities. This is a common practice, for instance, among independent software vendors. Many ISVs are small businesses (fewer than 100 employees) that must test their software on relatively large HPC systems from multiple vendors without having the financial wherewithal to purchase the systems. Instead, they frequently arrange to use systems at universities, government laboratories, or the sites of the vendors that manufacture the systems.

Only one of the organizations accesses HPC resources via a grid or Internet provider.

Only one of the organizations accesses HPC resources via a grid or Internet provider. In recent years, grid computing has evolved well beyond its origins in projects such as SETI Online, where many thousands of Internet-connected PCs contributed available cycles to a common, massive computing task — in effect becoming a free-of-charge throughput supercomputer. Although grid computing is actively employed today by only a minority of HPC users, a growing array of standards, software, and partnerships promises to expand its use.

Q8. If you access your HPC tools via an external provider or if you supplement your needs with access to a university or national lab, etc., who makes the decision to do it externally and what criteria are used to justify the decision? (Please list only their job title and/or organization level.)

Even among the minority of respondents who said they use external HPC resources (external providers or partners), on average only 7.5% of their total high-performance computing needs are currently being met in this way. Security concerns are an important inhibiting factor for some organizations. The decision to use outside resources is typically not assigned to a single official. Instead, these decisions may be made by various officials within an organization, depending on the momentary need for additional resources. The implication is that, at least in most cases, the use of external HPC resources is not part of a planned approach today and is not yet considered an ongoing business necessity. Because the use of outside resources is still relatively new, respondents who employ these resources also find it hard to describe their level of satisfaction when asked to do so.

Q9a. Who makes the purchase decisions for HPC tools/computers in your organization — on the technical side?

Decisions about which HPC computer an organization will purchase (or lease) can be complicated affairs. This is not surprising, given the often mission-critical importance of these resources and their substantial price tags. The extent of the purchasing process — and how high up it reaches into an organization — is often a function of the organization's size and the computer's price.

In virtually all cases, the process involves a technical decision maker. In about 75% of cases, a financial officer is also involved in making the decision.

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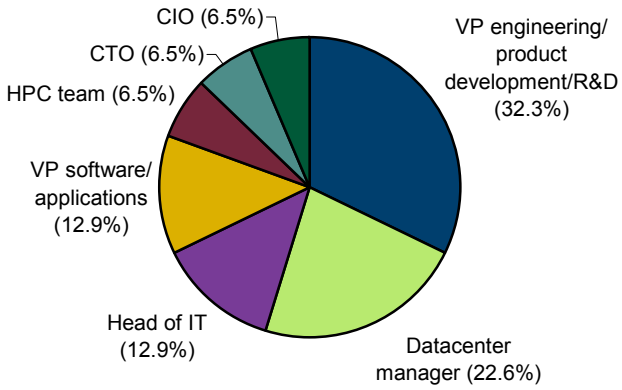
The primary technical decision maker (see Figure 2) most often (55%) is either the vice president of product development — sometimes titled vice president of engineering/R&D — or the manager of the technical datacenter. Especially in large industrial organizations, such as automotive and petroleum companies, the decision-making process frequently involves one of these "technical champions" gaining consensus among the technical staff and then advocating their proposal to financial and other nontechnical executives.

FIGURE 2

Primary Technical Decision Maker



n = 31

Source: IDC, 2004

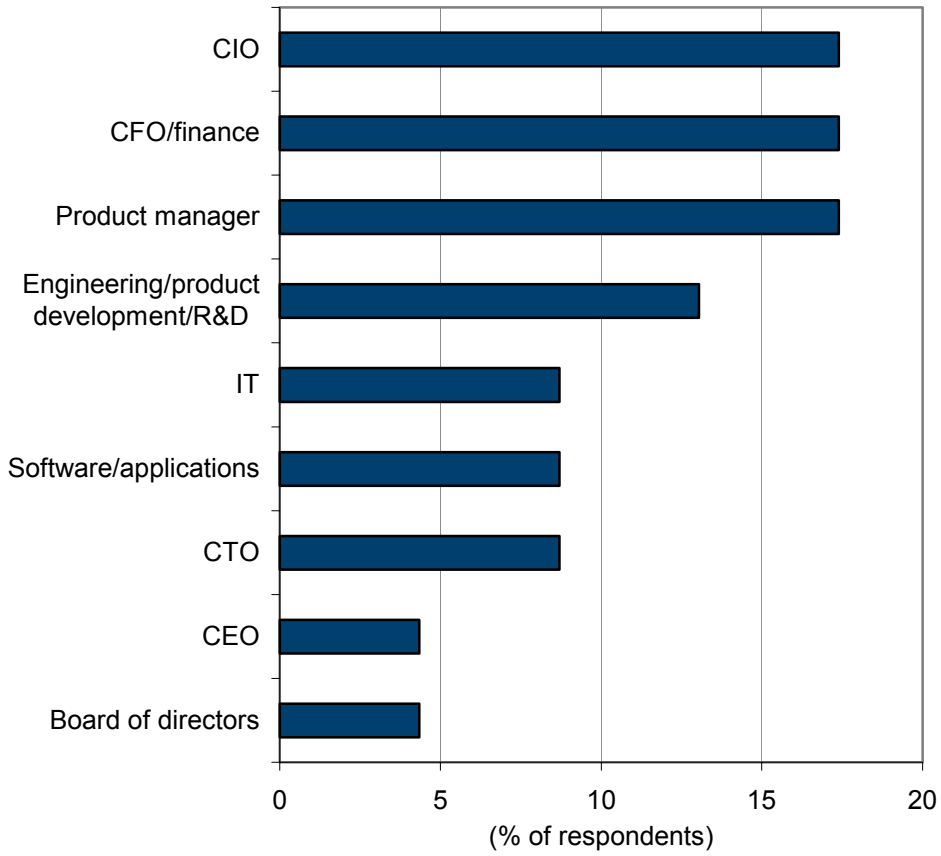
In smaller industrial organizations and ISV firms, the CTO typically has far fewer steps to follow and, in some cases, may be authorized to make the final purchase decision. In commercial (nonindustrial) organizations (e.g., in the financial or transportation logistics sectors), the CTO's role more often is CIO or head of IT.

Q9b. Who makes the purchase decisions for HPC tools/computers in your organization — on the financial side?

For the majority of purchasing processes that also require a financial decision maker, this party's title can vary dramatically — from an IT officer up to the company's CEO or even board of directors (see Figure 3).

FIGURE 3

Primary Financial Decision Maker



n = 23

Source: IDC, 2004

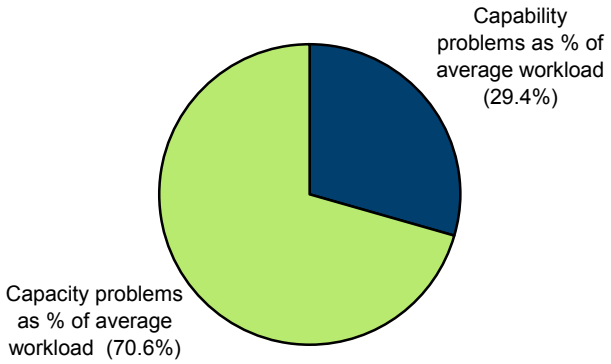
Q10. Regarding the type of computational problems running at your site, what percentage is capability and what percentage is capacity?

As Figures 4 and 5 indicate, across the sites surveyed, slightly more than one-quarter (29.4%) of the average workload of the organizations consisted of capability-class problems, with capacity-class problems making up the remaining nearly three-quarters (70.6%) of the typical workload. However, 63.6% of the organizations run at least some capability problems. Most sites (55%) run a mix of capability and capacity problems.

29.4% of the average workload of the organizations consisted of capability-class problems.

FIGURE 4

Capability Versus Capacity Problems as Percentage of Workloads

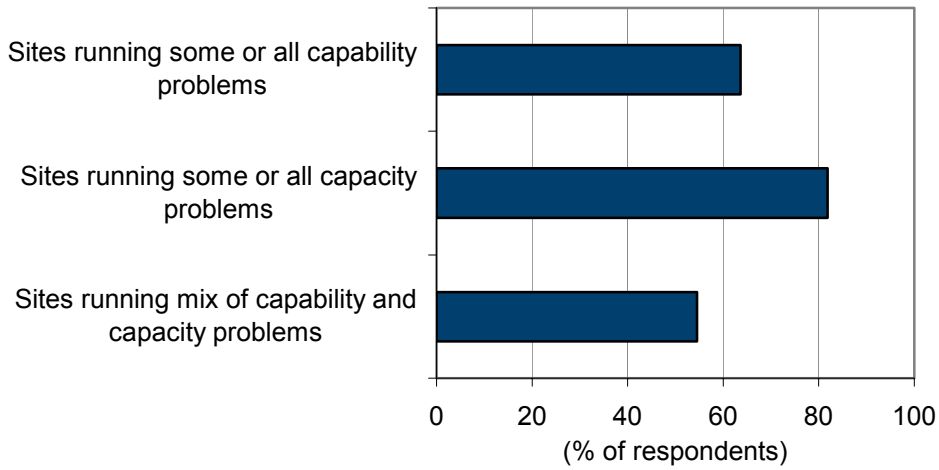


n = 28

Source: IDC, 2004

FIGURE 5

Sites Running Capability and/or Capacity Problems



n = 33

Source: IDC, 2004

Q11a. Please rate the following criteria as used by your organization to make your HPC purchase decisions for CAPABILITY-class computers (use a scale from 1 to 10, with 10 = most important and 1 = not used).

In the race for market supremacy, the ability of a particular HPC computer to run an organization's applications faster than competing computers can outweigh other considerations.

The top five criteria for purchasing capability-class computers are closely grouped in popularity, but "performance on our applications" stands out most prominently, with a rating of 8.9 on a scale from 1 to 10 (see Table 3). Solving problems — often by running the same application repeatedly to close in on an optimal solution — can be far more time-critical for industry than for government and university organizations pursuing scientific research. Industrial and other business firms are driven by external competition in a never-ending race to be first to market with the best products. In these battles for global market supremacy, faster application performance often means faster time to market. In the race for market supremacy, the ability of a particular HPC computer to run an organization's applications faster than competing computers can outweigh other considerations, including price/performance (8.0 rating) and price (7.7 rating). Cost considerations are nevertheless very important, as these ratings indicate.

Respondents explained that not all capability-class computers can run every software application. For applications to run at all on the systems, they have to be explicitly "ported" (i.e., adjusted to operate compatibly on the system). (To run as well as possible on the computer in question, the applications also need to be optimized — modified to take advantage of the system's design features.) Accordingly, the ability to run specific applications that are important to an organization figures just below application speed and cost considerations in importance (7.6 rating).

Less critical, yet still important, are the computer's quality/reliability, the reputation of the vendor, and the prospects for running next-generation applications on the system.

TABLE 3

Ratings of Criteria for Purchasing Capability-Class Computers

Criterion	Rating (10 = Most Important)
Performance on our applications	8.9
Price/performance ratios	8.0
Price or budget level	7.7
Ability to run certain software and/or applications	7.6
Quality/reliability	7.1
Vendor reputation	5.9
Future application requirements	5.5
Other	7.3

n = 19

Note: This question applies only to sites with capability-class computers.

Source: IDC, 2004

Q11b. Please rate the following criteria as used by your organization to make your HPC purchase decisions for CAPACITY-class computers (use a scale from 1 to 10, with 10 = most important and 1 = not used).

The same prioritization of purchasing criteria applies to capacity-class HPC computers (see Table 4), although application performance does not stand out quite as distinctly from the other highly rated factors. The prioritization match between capability and capacity computers is not surprising. In both cases, industrial and other business organizations are employing the computers in the same battle for market supremacy.

TABLE 4

Ratings of Criteria for Purchasing Capacity-Class Computers

Criterion	Rating (10 = Most Important)
Performance on our applications	8.8
Price/performance ratios	8.4
Price or budget level	8.1
Ability to run certain software and/or applications	7.6
Quality/reliability	6.8
Vendor reputation	5.9
Future application requirements	5.6
Other	8.3

n = 22

Note: This question applies only to sites with capacity-class computers.

Source: IDC, 2004

Q12. What percentage of your CAPABILITY-class problems are you interested in outsourcing today? In the future?

When we asked organizations about their use of external HPC resources in general (refer back to Table 2), only a small percentage said that they outsource today. The same pattern emerges when the organizations are more specifically asked what portion of their capability-class problems are being outsourced. Only about 2% of these problems are outsourced today, and that figure is expected to climb only to about 7% in the future. The highest figure reported for outsourcing today was 25%, and one organization expects to outsource as much as 75% of its capability workload in the future.

Looked at another way, 81% of the organizations said that they do not outsource any capability-class problems today. 77% have the same expectation for the future.

TABLE 5

Percentage of Capability-Class Problems Being Outsourced

	Average Percentage
Portion outsourced today	2.3
Portion to outsource in the future	6.8
% responding "zero outsourced" — today	81.0
% responding "zero outsourced" — in the future	77.0
Highest % — today	25.0
Highest % — in the future	75.0

n = 31

Source: IDC, 2004

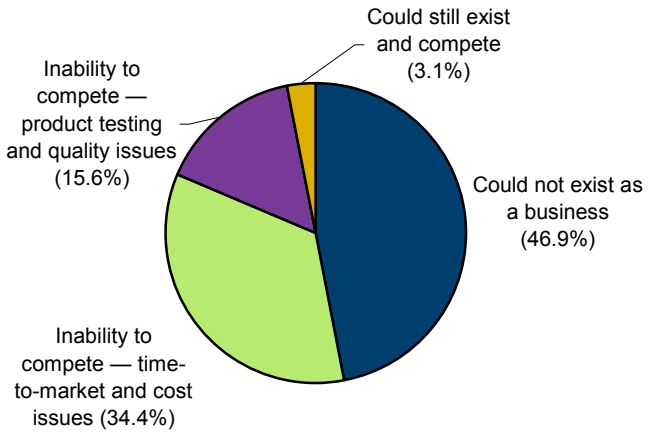
Q13. What organizational or competitive risks do you have if you DON'T have access to high-end HPC computer systems/tools?

When asked to name the most important organizational and competitive risks they would face if they did not have access to HPC computers (see Figure 6), nearly half (47%) of the organizations echoed responses to earlier questions by stating that they could not exist as businesses without HPC. An additional 50% replied that they would be unable to compete, emphasizing either time-to-market and related cost issues or product testing and quality issues. Hence, 97% of the industrial and business organizations consider access to high-end HPC computer systems/tools indispensable. Only one organization indicated that it could still exist and compete without the use of HPC.

97% of the industrial and business organizations consider access to high-end HPC computer systems/tools indispensable.

FIGURE 6

Organizational/Competitive Risks from Not Having Access to HPC Computers



n = 32

Source: IDC, 2004

"There is no other way for us to complete our work. We would not exist."

"There would be a great lack in quality."

"We would not be able to stay technologically ahead of other competing nations."

"In the semiconductor business, it is critical to continue to push the processor node to remain competitive. Lack of HPC tools similar to those of our foreign competitors could reduce our ability to compete."

"We can't build cars without them."

"The time to market would prohibit our business from existing."

"We cannot support customers without access to HPC machines. This means we would have to tell customers to run in 'at your own risk' mode, which is generally not acceptable."

"There is no other way for us to complete our work. We would not exist."

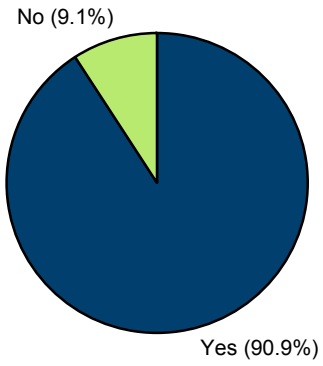
"In the semiconductor business, it is critical to continue to push the processor node to remain competitive. Lack of HPC tools similar to those of our foreign competitors could reduce our ability to compete."

Q14. Does your purchase process consider future application requirements?

Earlier in this study, some respondents listed future application requirements among the important criteria they consider when purchasing capability- and capacity-class computers. When respondents were asked whether they consider future application requirements to any extent in purchase decisions (see Figure 7), 91% replied yes and only 9% said no. For those replying yes, the average future time frame under consideration was 2.5 years.

FIGURE 7

Are Future Application Requirements Considered in the Purchasing Process?



n = 33

Note: The average number of years respondents looked is 2.5 years.

Source: IDC, 2004

Benefits from Using HPC

Q15a. What has been the benefit of HPC on your organization? Impact on bottom line — can you quantify?

About one in four (23%) organizations was able to quantify the bottom-line benefit of HPC to the organization, ranging up to millions of dollars.

Most sites have difficulty proving the direct benefits of HPC. Some of the major success stories are due to a combination of strong HPC computers, great scientists and engineers, and market conditions; therefore, sites find it hard to pinpoint and quantify which part provided the success. As Table 6 shows, about one in four (23%) respondents was able to quantify the bottom-line benefit of HPC to the organization, and most others (65%) could describe the realized benefit, ranging up to millions of dollars.

For those respondents who were able to quantify, financial benefits were typically substantial, ranging up to millions of dollars and impressive returns on investment in the HPC computers. Nonfinancial benefits included, in one case, an impressive reduction in time to market from five years to two years.

Nonquantified realized benefits from HPC computers fell into the major categories of business criticality (27%) and increased revenue (23%), with increased quality and productivity constituting less frequent responses.

TABLE 6

Bottom-Line Benefit of HPC on Organizations

Impact to Bottom Line	Typical Comment	Number of Responses	Percentage
Able to quantify			23
	50% return on capital employed (ROCE)	1	
	Greater than 5x return on investment (ROI)	1	
	Time to market dropped from five to two years	1	
	More than $1 million	1	
	Several million dollars	1	
	ROI returned within one year of purchase	1	
Can't quantify but can describe			65
	Critical to our business	7	
	Increased revenue	6	
	Reduced costs	2	
	Increased quality	1	
	Increased productivity	1	
Unable to quantify or describe			12
	Unable to quantify	3	

n = 26

Source: IDC, 2004

One respondent indicated that the use of HPC and modeling and simulation tools saved a product development effort that was on the verge of being cancelled. That product is now on its way to market.

"It has been a continuous stream of revenue to our bottom line, giving us the ability to look into other development areas."

"It drives innovation, R&D effectiveness, and productivity."

"The ROI is returned within one year of the purchase."

"The ROI is returned within one year of the purchase."

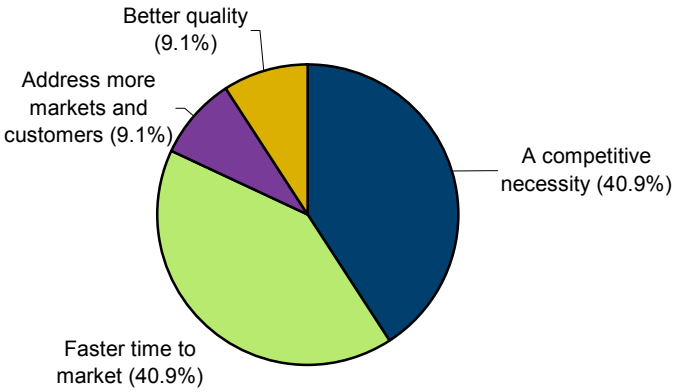
Q15b. What has been the benefit of HPC on your organization? Increased competitiveness — describe how.

Respondents were clear about HPC's benefits to their organizational competitiveness (see Figure 8). Many confirmed that HPC is a competitive necessity (41%) and that it provides faster time to market (41%). Others noted that HPC has enabled them to extend their market reach and improve product quality.

Respondents were clear about HPC's benefits to their organizational competitiveness.

FIGURE 8

Benefits of HPC to Organizational Competitiveness



n = 22

Source: IDC, 2004

"It is the only way we can keep up."

"It is the only way we can keep up."

"We can develop drugs faster."

"Can get patent quicker."

"Can get patent quicker."

"Our ability to support our software on HPC gives us an entry into many sectors, which would be difficult if we could not develop or deploy our tools on these platforms."

"These resources maintain the U.S. lead in several critical asset areas."

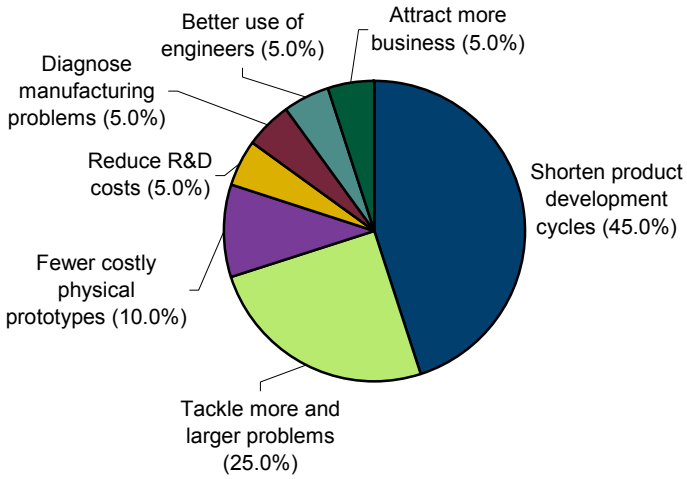
"These resources maintain the U.S. lead in several critical asset areas."

Q15c. What has been the benefit of HPC on your organization? Increased productivity — in what way?

Respondents also underscored the benefits to organizational productivity of using HPC (see Figure 9). The leading productivity benefit — supporting the all-important time-to-market goal — is shortening product development cycles (45%). The ability to tackle more and larger problems also ranks high as a productivity benefit. Presumably, some of these competitively important problems would have been unaddressed without sufficiently powerful HPC computers.

FIGURE 9

Benefits of HPC on Organizational Productivity



Source: IDC, 2004

"We can get much more done and experiment in many more ways."

"We have the ability to run more jobs and take more samples before investing millions of dollars in the physical tools."

"Better engineering analysis delivered faster allows faster [semiconductor] yield enhancement."

"Productivity is addressed on two levels: first, solving problems and doing R&D that otherwise would not be done; and second, providing more timely answers to problems."

Are Companies Using HPC as Aggressively as Possible?

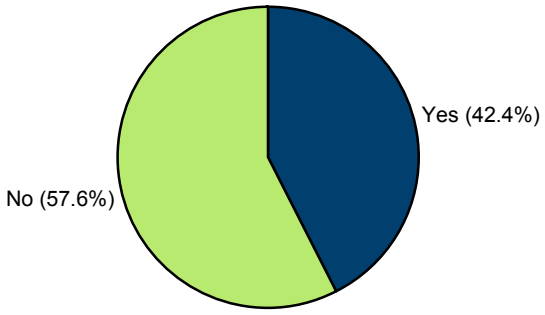
Q16. Is your organization using HPC tools as aggressively as it could?

A majority of the organizations (58%) indicated that they are not using HPC as aggressively as they could (see Figure 10). The main reasons provided were budget limitations, insatiable demand from end users, time needed to train everyone, and need for better HPC computers in the market.

A majority of the organizations (58%) indicated that they are not using HPC as aggressively as they could.

FIGURE 10

Are Organizations Using HPC as Aggressively as Possible?



n = 33

Source: IDC, 2004

Yes, Using HPC as Aggressively as Possible

"We are bringing all available tools to bear on our problems."

"We have large compute resources that are designed to run lots of jobs. Our workload was up 10x last year."

"We have access to the very latest systems."

No, Not Using HPC as Aggressively as Possible

"Despite good success, we are under continued pressure to cut the headcount of qualified computational scientists."

"There can never be enough HPC for us. Benchmarking and testing require infinite resources."

"Budget is always an issue, but the key point here is the cost of simulation software. It dwarfs the cost of the hardware."

"Despite good success, we are under continued pressure to cut the headcount of qualified computational scientists."

"Software licensing issues are causing a downsizing in the application seats we purchase. This is a sole source application."

"Without enough human resources, adding additional compute power does not matter."

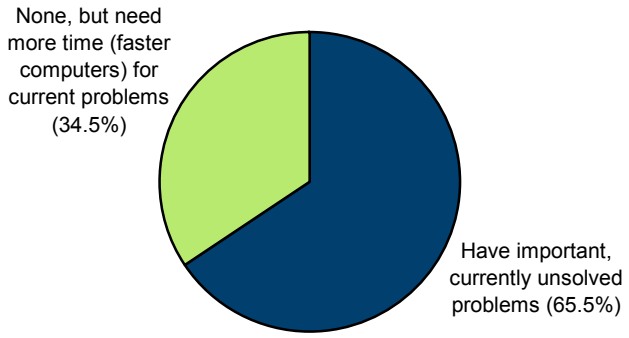
"Software licensing issues are causing a downsizing in the application seats we purchase."

Q17. What important computational problems do you have today that you can't solve today?

As Figure 11 illustrates, two-thirds of the organizations have important problems that they can't solve today. The remaining third need faster HPC computers to solve current problems more effectively.

FIGURE 11

Do Organizations Have Important Computational Problems They Can't Solve Today?



n = 29

Source: IDC, 2004

Table 7 lists the problems respondents identified as currently unsolved in their organizations or industries.

TABLE 7

Current Unsolved Computational Problems

Industry Sector	Current Unsolved Problem
Automotive/aerospace	Model engine block assembly in full detail (no "submodeling")
	Problems 10x larger than the largest problems today
	Air design and testing
	Crash tests with better body models
	3D system simulation and optimization within 24–48 hours
	Vehicle rollover
	Aero-acoustics/wind noise
	Combustion
	Manufacturing
Petroleum	Real-time processing of data from sensors in remote locations
Pharmaceutical	Protein folding
	Ab initio molecular mechanics — more than 100x current speeds
Semiconductor	2D and 3D modeling of device physics, semiconductor electronics
General (non-specific)	Highly distributed database — coordinate across our 21,000 servers
	Increase mesh size for increased resolution from our data
	Increased breadth and depth of analysis
	Simulate full system
	Compute models two generations ahead
	Problems requiring very large memory

n = 29

Note: Some of the unsolved problems listed were given by more than one site.

Source: IDC, 2004

Barriers Inhibiting Use of Supercomputing

Q18. If you are not using HPC tools as much as you think your organization should, what is holding you back? (More than one response is possible.)

Table 8 shows that the largest single factor (16%) preventing organizations from using HPC tools more aggressively today is a shortage of human experts — internal or external — able to apply the HPC tools to the problems in question. Clearly related to the shortage of expertise, ease of use of hardware and software tools ranks second as an inhibitor (11%). Some other important constraints are attributed to limited management vision: the difficulty in getting approval to make future-oriented investments (10%) and the difficulty higher-ups have in grasping the important contributions of HPC (8%). The response to question 21 indicates that computers that are easier to use and program could help reduce the top two barriers.

The largest single factor (16%) preventing organizations from using HPC tools more aggressively today is a shortage of human experts.

TABLE 8

Factors Holding Back Organizations from Using HPC Tools More Aggressively

Reason for Not Using HPC Tools as Much as Possible	Number of Responses	Overall Percentage
Availability of internal or external people to apply the tools to our problems	12	16.4
Ease of use (hardware and software)	8	11.0
Easier to get decision on investment that reduces costs now versus future	7	9.6
Cost of HPC tools (hardware, software) versus other business investments required	7	9.6
Decision makers do not grasp HPC impact versus other business pressures	6	8.2
Scalability of commercial ISV software	6	8.2
Cost of developing in-house software	5	6.8
Ease of accessing outside resources	5	6.8
Don't have the workload to justify the expense	4	5.5
Technology is changing too quickly to keep up	4	5.5
Hesitant to run company-sensitive problems on outside resources	2	2.7
Availability of appropriate commercial software or applications	1	1.4
Ability to charge against a government contract	1	1.4
Other	5	6.8
Total	73	100.0

n = 29

Note: More than one response per site was allowed.

Source: IDC, 2004

"Time to change people and their reluctance to try new things."

"Internal human resources."

"ECAD is very expensive today, and there are few sources for the types of tools we need."

"The corporate structure has been changing, so less focus has been on technology to run the business."

Q19a. Can you explain why your organization uses different tools for specific applications and the limitations of your current tools on these applications? Why did you choose these particular computational tools for your applications?

When respondents were asked to give their reasons for selecting one HPC computer over others (see Table 9), the predominant reason (31%) was superior performance on the organization's in-house application codes and related requirements. The next two reasons, which are closely related — "only choice available that meets our needs" and "perform best on external (ISV) codes we use" — elevate this overall response category to 62%. This finding is consistent with the primary importance assigned to organization-specific application performance presented earlier. For many (not all) industrial and business organizations, HPC computers are more than mere productivity tools — they are enabling tools without which, as we also saw earlier, these organizations would not be able to compete effectively and survive.

TABLE 9

Reason for Choosing HPC Computational Tools

Reason for Choosing HPC Computational Tools	Number of Responses	Overall Percentage
Perform best on our in-house codes and requirements	9	31.0
Only choice available that meets our needs	6	20.7
Perform best on external (ISV) codes we use	3	10.3
Price/performance	3	10.3
Trusted vendor relationships	2	6.9
Need to use same tools our customers use	2	6.9
Need to meet customer requirements	1	3.4
Have always used the same tools	1	3.4
Follow market trends	1	3.4
Efficiency	1	3.4
Total	29	100.0

n = 29

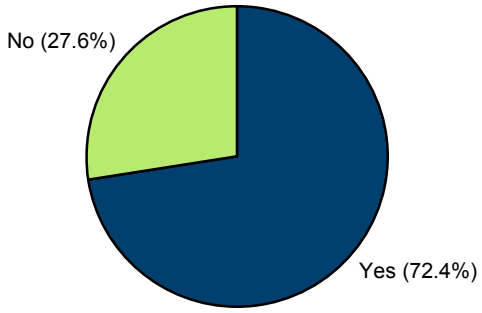
Source: IDC, 2004

Q19b. Can you explain why your organization uses different tools for specific applications and the limitations of your current tools on these applications? Are they adequate for your current needs? If not, why not?

Most organizations (72%) believe that HPC hardware and software tools currently available in the market are adequate for their needs, whereas 28% do not. For the latter group, the reasons for the inadequacy are almost as various as the respondents (see Table 10). Insufficient computing power is one repeated theme, however.

FIGURE 12

Are Currently Available HPC Hardware Tools Adequate for the Organizations' Needs?



n = 29

Source: IDC, 2004

TABLE 10

Reasons Why Current Tools Are Inadequate

Reason	Number of Responses
Do not provide high enough problem resolution	1
We always need the next generation	1
We lack high-end systems to do real science	1
Development tools on newer (cluster) systems lag traditional SMPs	1
Need better file system than NFS	1
Third-party software is cost-prohibitive	1
We are still growing and must balance the costs	1
We need more linked systems to provide the best information to customers	1
Total	8

n = 8

Source: IDC, 2004

HPC Tools That Industry Would Like to Have

Q19c. Can you explain why your organization uses different tools for specific applications and the limitations of your current tools on these applications? Are there any other HPC tools (hardware or software) on the market today that you would like to own or have access to? (Please list them).

Most organizations are more limited by their budgets and not the computers available in the market. Relatively even numbers of respondents pointed to currently available software (42%) and hardware (37%) tools that they would like to own or access. The most desired currently available tools are cluster management software and clusters based on AMD Opteron processors. 21% of the respondents said that the higher-performance computer hardware systems that they need are not available today. Figure 13 shows that 31.6% feel that adequate hardware and/or software tools are not currently available in the market today.

TABLE 11

HPC Tools Available Today That Organizations Would Like to Own or Access

Tool Desired	Specific Comment	Responses	Percentage
Software			42.0%
	Cluster management software	3	
	Grid management software	1	
	Cluster- and grid-enabled modeling tools	1	
	Distributed memory tool kit	1	
	Affordable Linux file system	1	
	Affordable back-end design software	1	
Hardware			37.0%
	Opteron cluster	3	
	SMP system	1	
	Rendering gear	1	
	Alternative architectures	1	
	More powerful system	1	
Tools we need are unavailable			21.0%
	More powerful computers than today	4	

n = 19

Source: IDC, 2004

"It would be useful to have access to 32–64-way SMP machines with 250–500GB of RAM and approximately 5TB of disk."

"The area where we could use additional refinement is cluster management."

"The area where we could use additional refinement is cluster management."

"The AMD [Opteron] systems we use are the fastest in the world. If we were to use products based on competitive processors, we'd be over budget and late to market."

"The market lacks good products."

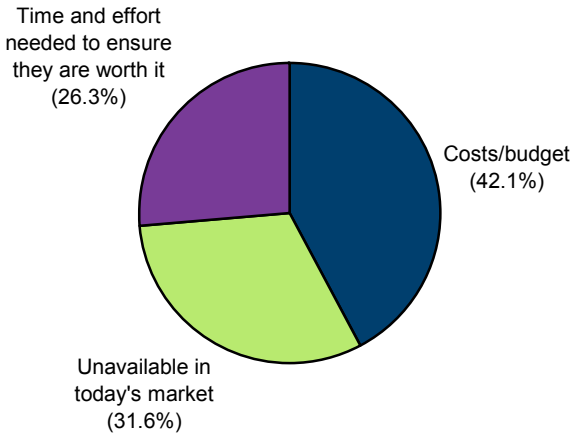
"Better computers are needed."

Q19d. Can you explain why your organization uses different tools for specific applications and the limitations of your current tools on these applications? What is stopping you from owning/accessing them?

Costs/budget limitations are the primary reason (42%) that organizations cannot acquire the HPC tools they currently do not have and want, but the unavailability of the desired tools in today's market is not far behind (32%) as a stated reason (see Figure 13). A number of organizations (26%) simply lack the time to determine whether the desired HPC tools truly live up to their promise. (Note: Figure 13 applies to all aspects of the system including hardware, software, networking, etc.)

FIGURE 13

Reasons for Not Owning/Accessing Desired Tools



n = 19

Source: IDC, 2004

"Cost is primary. Buying such machines is outside our budget. Finding such machines that we can use extensively is difficult."

"Budget is too tight."

"We have budget. The tools are just not there yet."

"They do not exist. We need a really good global shared file system. Current ones are immature."

"Before we implement a new technology, we have to be sure it meets our business needs, which can be a very time-consuming endeavor."

Impact of 100x Performance and 10x Ease of Use

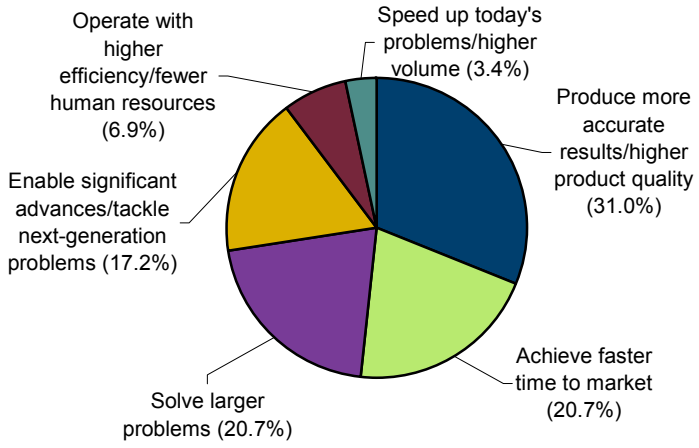
Q20a. If you had access to a computer with 100x performance, how would you use it and what new computational science issue could you address?

Naturally enough, HPC users look forward to the arrival of dramatically faster computers. When asked about the impact of a computer 100 times faster than those available today, respondents cautioned that this would need to mean 100 times faster on their applications and then described the effects they foresaw (see Figure 14). Chief among these effects (31%) is the ability to produce higher-quality products based on more accurate simulation. Faster time to market and the ability to tackle larger problems (21% each) also were popular choices, closely followed by the ability to address next-generation problems and make breakthrough advances (17%).

Chief among these effects (31%) is the ability to produce higher-quality products based on more accurate simulation.

FIGURE 14

Overall Impact of Computer with 100x Current Performance



n = 29

Source: IDC, 2004

"100x faster on our codes would be very helpful against our large competitors, in both commercial and military aircraft designs."

"If it is really 100x faster on our applications, we could accomplish some real advances in our science. Better products, better financials."

"We can always find ways to use more power. The first would be to shorten the design cycle while designing better cars."

"We could substantially improve our time to market and chip design variance studies."

"We could test two-generations-out models that we are researching today."

"It could collapse some multiday processes into a few hours and reduce the overall design and manufacturing cycle."

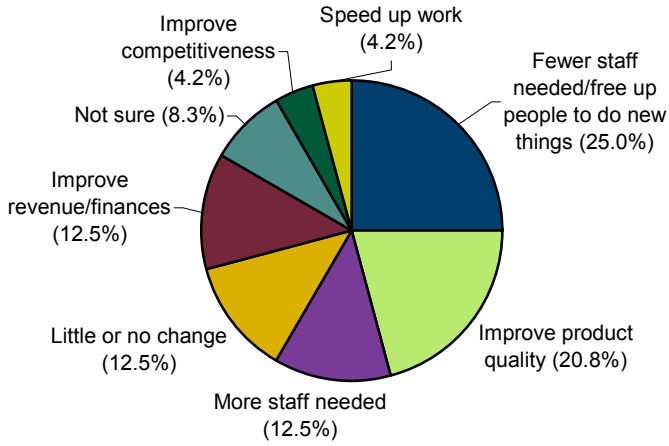
"If it is really 100x faster on our applications, we could accomplish some real advances in our science. Better products, better financials."

Q20b. If you had access to a computer with 100x performance, how would it change your organization?

Respondents were less certain about the organizational impact of a 100-fold faster HPC computer (see Figure 15). A fair number (25%) thought the main impact would be to reduce staffing levels, while others (13%) assumed that more staff would be needed. One in five (21%) respondents believe that a dramatically faster computer would mean little or no change, or else they were not sure what the impact might be.

FIGURE 15

Organizational Impact of Computer with 100x Current Performance



n = 24

Source: IDC, 2004

"It would reduce the time we spend on current tasks, and we could do the other research and program development we want to do."

"We would have to hire a lot more scientists to look at the additional data."

"We would have to hire a lot more scientists to look at the additional data."

"It wouldn't change the organization."

"It would increase revenues for the company and market share."

"Not much [change] at first until we understood the system."

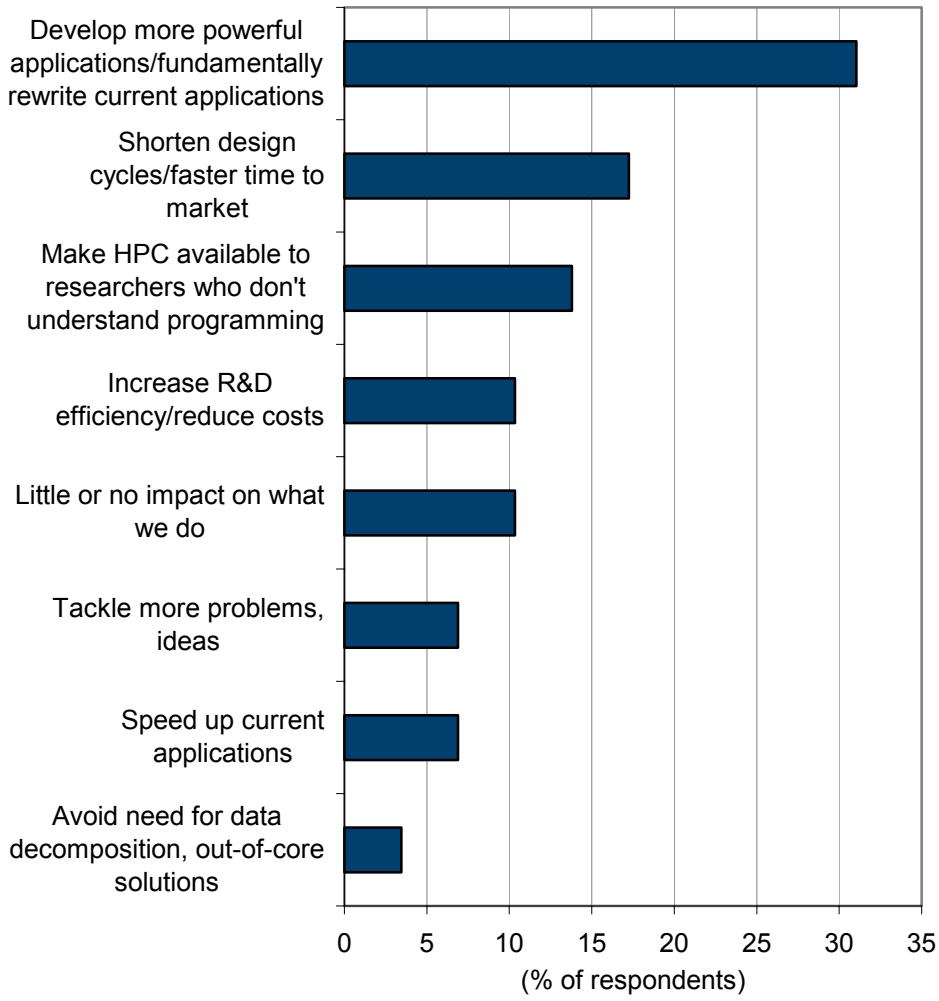
Q21. What could you accomplish if computers were 10x easier to program?

There was greater certainty about the impact of computers that are 10 times easier to program than today's HPC products (see Figure 16). The two most popular responses are not surprising: the ability to develop more powerful applications and fundamentally rewrite current codes (31%) and the ability to shorten design cycles for faster time to market (17%). Less expected was the third-ranking response (14%): the ability to make HPC available to an expanded universe of researchers who don't understand programming — and, with easier-to-program computers, they would not need to train scientists in computer programming areas.

Computers that are easier to use and program could help reduce the top two barriers cited in question 18.

FIGURE 16

Impact of Computers That Are 10x Easier to Program



n = 29

Source: IDC, 2004

"We would look to rewrite the entire science underlying the current technology and methodology we are using."

"We would be able to develop more powerful and reliable codes."

"It would make these tools available to a much wider array of scientists who have good ideas but may not have programming skills."

"We could try a lot more ideas and significantly reduce the number of assumptions we make."

"We would look to rewrite the entire science underlying the current technology and methodology we are using."

"If ISV codes are ported, then we could accomplish a lot more — shorten design cycles, faster time to market."

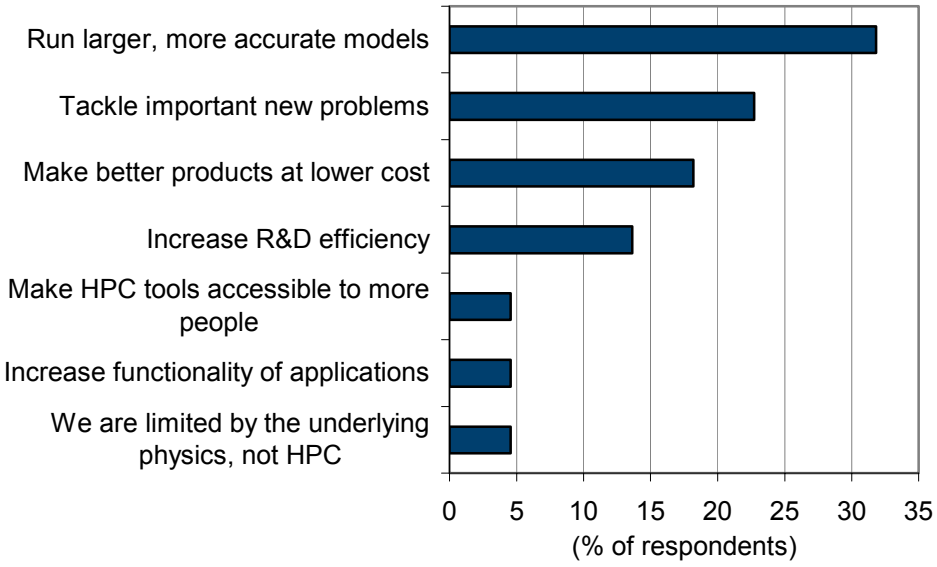
"Not applicable. We mostly use off-the-shelf tools."

Q22. What could you do that you cannot do today if you had these tools?

Figure 17 summarizes the new advances that respondents believe would become possible with computers 100 times more powerful and 10 times easier to program than today's HPC computers. The most important advance (32%) would be in the ability to simulate larger, more accurate (detailed) models. Tackling important new problems (23%), improving product quality while lowering cost (18%), and boosting R&D efficiency (14%) were also mentioned frequently. All of these advances would increase organizational competitiveness.

FIGURE 17

New Advances Made Possible If Organizations Had the Tools They Desire



n = 22

Source: IDC, 2004

"We could achieve unprecedented accuracy in the models and significantly reduce the number of assumptions we currently make."

"We could try more ideas with many more techniques."

"We could rewrite all of our underlying science with the new thought processes."

"We could build better aircraft at lower cost."

"We could build lower-cost cars with many additional types."

"We could achieve unprecedented accuracy in the models and significantly reduce the number of assumptions we currently make."

Q23. What features or capabilities would you MOST like to see in future HPC computers, looking over the next five to 10 years? (Please rate on a scale from 1 to 10, with 10 = most important and 1 = not important.) (More than one response is possible.)

Greater processor speed (highest point total) and better price/performance (highest average rating) were popular choices for features organizations would most like to see in HPC computers five to 10 years from now. Greater processor speed refers to greater *delivered* performance. As Table 12 illustrates, there are a number of site-specific desired features/capabilities that were highly rated.

TABLE 12

Desired Features/Capabilities in Future Systems

Desired Feature/Capability in Future Systems	Number of Responses	Average Rating
Individual, site-specific features/capabilities	4	8.5
Better price/performance	27	8.1
Ability to run larger problems	29	7.9
Greater processor speed (delivered performance)	30	7.8
Better system price	25	7.6
Ability to do new science	27	7.3
Easier-to-program computers	23	7.0
Increased reliability	28	6.6
Improved life-cycle cost	27	6.4
Easer-to-use computers	26	6.4

n = 33

Source: IDC, 2004

Comments from the "Individual site-specific features/capabilities" category:

"We need better memory access speeds [mostly bandwidth]. Greater processor speed without better memory bandwidth is making less sense."

"We want to see more memory bandwidth. It seems CPU speed is alright."

"We need a big step change in the data storage — disk write capability."

"We need additional fault tolerance capabilities."

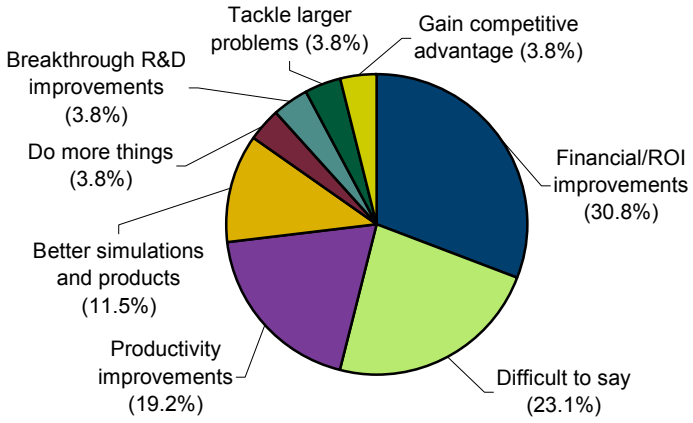
"We need better memory access speeds [mostly bandwidth]. Greater processor speed without better memory bandwidth is making less sense."

Q24a. Given the availability of dramatically better and easier-to-use HPC tools, what would be the impact to your bottom line if you had more capable computers as described above (and they were able to address the problems that you listed above)?

Asked about the bottom-line impact of more capable computers (see Figure 18), the largest percentage of respondents (31%) pointed to anticipated financial improvements. Productivity advances (19%) and better simulations/products (12%) were also noted. Nearly one-quarter (23%) of the organizations found the impact hard to predict.

FIGURE 18

Bottom-Line Impact of More Capable Computers



n = 26

Source: IDC, 2004

Q24b. Given the availability of dramatically better and easier-to-use HPC tools, what would be the impact to your bottom line if you had more capable computers as described above (and they were able to address the problems that you listed above)? Can you quantify the value of solving these problems?

When asked more specifically to quantify the value of solving currently intractable problems, only 17% of respondents were able to do so (see Table 13). For those who did quantify, amounts were large and ranged from $10 million to several billion dollars. Of the remaining 83%, some expect unspecified financial benefits and faster development of improved products, and two respondents said that they are not permitted to discuss anticipated benefits.

TABLE 13

Can You Quantify the Value of Solving Currently Intractable Problems?

Response	Specific Comment	Number of Responses	Percentage
Unable to quantify but can categorize			83.0
	No specifics given	7	
	Financial/ROI benefits	6	
	Better products, faster	2	
	Not permitted to disclose	2	
	New research areas possible	1	
	More efficient use of resources	1	
Able to quantify			17.0
	$10 million	1	
	5% overall gain	1	
	$1 billion	1	
	Multiple billions of dollars	1	

n = 23

Source: IDC, 2004

"There would be significant savings to the entire healthcare system in the areas of surgeon effectiveness, recovery time, and better diagnosis."

"With faster turnaround, we could attract more clients."

"We save $1 billion from a faster product cycle."

"I can't release [the amount], but it is in the billions a year."

"We save $1 billion from a faster product cycle."

Q24c. Given the availability of dramatically better and easier-to-use HPC tools, what would be the impact to your bottom line if you had more capable computers as described above (and they were able to address the problems that you listed above)? What would be the impact to your competitiveness?

91% of the organizations (see Table 14) expect that dramatically faster, easier-to-use HPC computers would boost their competitiveness, most prominently by enabling them to bring better products to market faster or by increasing their financial strength. The remaining organizations argued that the impact of the improved computers would be competitively neutral because "we are already the leader in our business."

TABLE 14

Competitive Impact of Dramatically Better, Easier-to-Use HPC Computers

Competitive Impact	Specific Comment	Number of Responses	Percentage
Positive impact			91.0
	Better products, faster	9	
	Increased financial strength	4	
	Ability to keep pace with competition	3	
	First to market	2	
	Increased customer confidence	1	
	Expand current leadership	1	
	No specifics	1	
Neutral impact			9.0
	Already the leader in our business	2	

n = 23

Source: IDC, 2004

"We would be even more competitive and use the natural resources [oil and gas] to a better degree, creating more financial freedom."

"It would shorten our design cycles and make our cars safer, more reliable, and more interesting so that customers buy them more often."

"It would help us compete against the European manufacturers."

"It would help us compete against the European manufacturers."

"We are staying ahead of the world in specific technical problems. This would just expand that lead."

"We have plenty of market share currently. We just don't want it to decrease."

Q24d. Given the availability of dramatically better and easier-to-use HPC tools, what would be the impact to your bottom line if you had more capable computers as described above (and they were able to address the problems that you listed above)? Other effects?

Other positive effects of dramatically better HPC computers cited by respondents include more powerful pharmaceutical drugs and faster disease cures, more environmentally friendly manufacturing, reduced litigation expense, and more entertaining animated films.

"It would allow our clients to accomplish more research, thus leading to better drugs in a smaller time frame."

"Quicker research means we could get to a cure much faster and reduce long-term healthcare costs."

"Better *in silico* research can have a dramatic environmental impact."

"Lower lawsuit costs."

"Shorter design cycles mean higher margins."

"People would get better animated movies to watch."

Q25. If HPC computers were easier to use and therefore required less dependence on HPC programming experts:

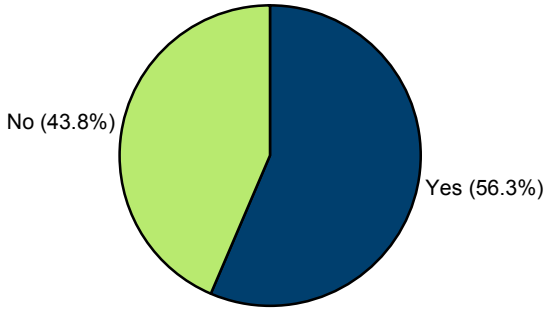
Would that increase your use of HPC computers in general?

Many organizations (56%) said that easier-to-use HPC computers would increase their use of these systems (see Figure 19). A smaller but still substantial percentage (39%) said the same thing vis-à-vis capability-class computers (see Figure 20).

Many organizations (56%) said that easier-to-use HPC computers would increase their use of these systems.

FIGURE 19

Would Easier-to-Use HPC Computers Increase Your Use of These Systems?



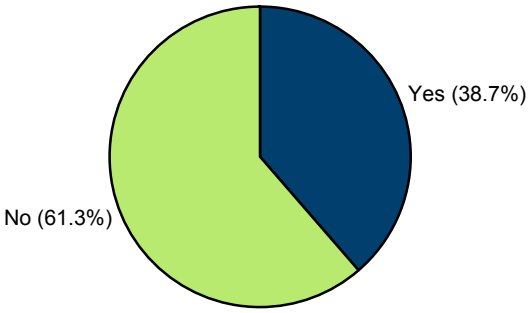
n = 32

Source: IDC, 2004

Would it increase your use of CAPABILITY-class computers?

FIGURE 20

Would Easier-to-Use Capability-Class Computers Increase Your Use of These Systems?



n = 31

Source: IDC, 2004

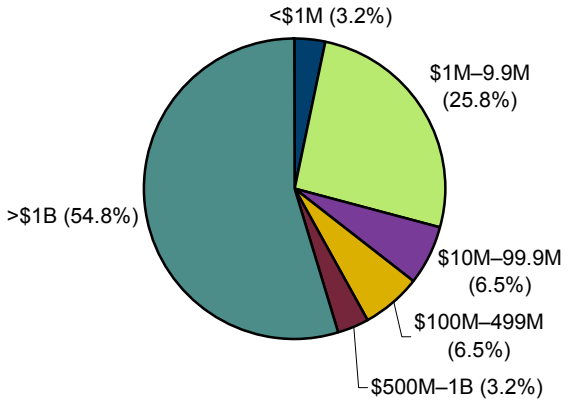
Budgets and Budget Growth

Q28. Using the following broad categories, what was your company's revenue last year?

As Figure 21 illustrates, more than half (55%) of the organizations' annual revenues exceeded $1 billion in 2003, with another 26% of the organizations reporting revenues in the $1 million to $9.9 million range. This same bifurcated distribution has been evident in prior IDC studies of the U.S. industrial HPC market.

FIGURE 21

2003 Revenue of Respondents' Organizations



n = 33

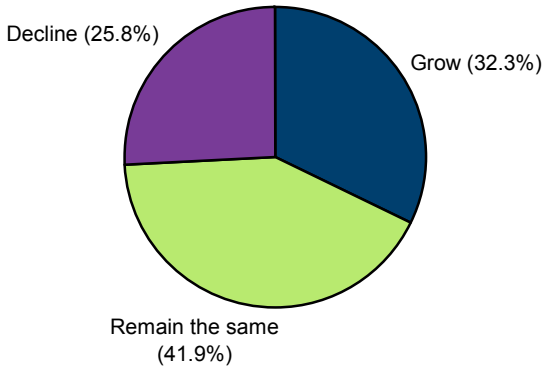
Source: IDC, 2004

Q26. Did your budget over the last year grow, shrink, or stay the same?

Nearly three-quarters (74%) of the budgets (for all HPC solutions including hardware, software, networking, and services) either grew or remained stable during the past year, whereas one-quarter declined (see Figure 22).

FIGURE 22

Budget Change During Past Year



n = 31

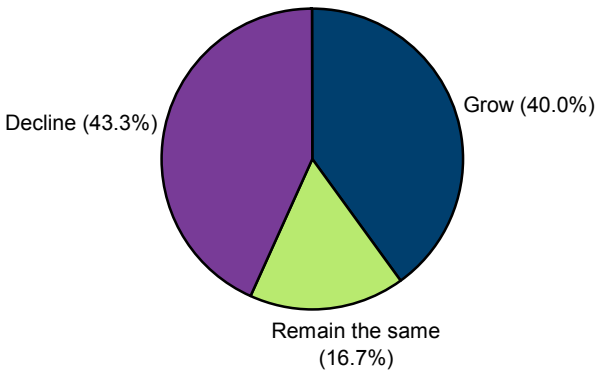
Source: IDC, 2004

Q27. Will your budget over the next two years for <u>all HPC</u> spending grow, shrink, or stay the same?

For the next two years, 57% of respondents expect budgets to increase or remain the same, with 40% of the sites interviewed stating that they expect their budgets for HPC to increase. Meanwhile, over the next two years, 43% of respondents expect their budgets to decline and 17% of respondents expect their budgets to stay the same (see Figure 23).

FIGURE 23

Budget Change over Next Two Years



n = 30

Source: IDC, 2004

CONCLUSION

HPC in the United States is an important tool for fostering commercial competitiveness. Buyers have changed the type of systems they acquire and how they apply them to their problems, but they still see HPC as a critical technology for their organizations.

The U.S. industrial market for HPC technical servers has been through a number of changes, evolutions, and revolutions over the past few years. In many ways, it is like going through a physical phase change from a liquid to a solid state, and things have not yet fully solidified.

Major findings in this study include:

- High-performance computing is essential to business survival.
- Companies are realizing a range of financial and business benefits from using HPC.
- Companies are failing to use HPC as aggressively as possible.
- Business and technical barriers are inhibiting the use of supercomputing.
- Companies don't have the HPC tools they want and need.
- Most companies do not rely on remote access to HPC.
- Dramatically more powerful and easier-to-use computers would deliver strategic, competitive benefits.
- Dramatically more powerful and easier-to-use computers could add billions to the bottom line.

Companies are realizing a range of financial and business benefits from using HPC.

Dramatically more powerful and easier-to-use computers could add billions to the bottom line.

Additional observations from recent IDC studies of U.S. industrial HPC end users include:

- Industrial users are still very engaged and excited about applying HPC to help their organizations become more competitive and ultimately more successful
- Price and price/performance have both provided new possibilities and driven buyers to acquire different types of HPC servers.
- Clusters have proven themselves as capable servers to handle a sizable portion of the HPC workload.
- Higher-performance computers are desired based on actual delivered results on end-users computational problems, but most sites cannot afford to purchase the fastest computers available in the market today.

The U.S. industrial sites interviewed clearly see HPC as fundamental to the business, as the following quote illustrates: "Our business model could not exist without HPC."

"Our business model could not exist without HPC."

These sites are strategically using HPC and are investigating new ways to apply HPC.

According to one respondent, "… the use of HPC saved a product development effort that was on the verge of being cancelled. Within a few days, a compound was modeled that would meet all the design criteria and exceed some of them. That product is now on its way to market. The difference between canceling the project and going to market with an improved product could be worth several million dollars."

When respondents were asked if there are currently available HPC tools that they would like to have, 79% answered yes. The inability of so many organizations to access desired current tools due to financial or budget constraints may explain why only a minority indicated that today's tools are inadequate.

HPC users look forward to the arrival of dramatically faster computers. When asked about the impact of a computer 100 times faster than those available today, respondents cautioned that this would need to mean 100 times faster on their applications. The chief benefit they foresee is the ability to produce higher-quality products. One benefit of computers that are 10 times easier to program than today's HPC products is surprising: the ability to make HPC available to an expanded universe of researchers who don't understand programming. For those who were able to quantify dramatically better HPC computers, amounts ranged from $10 million to several billion dollars for their organization alone.

For those who were able to quantify dramatically better HPC computers, amounts ranged from $10 million to several billion dollars for their organization alone.

Other positive effects of better HPC computers include more powerful pharmaceutical drugs and faster disease cures, more environmentally friendly manufacturing, reduced litigation expense, and more entertaining animated films.

APPENDIX

Appendix 1: Site Background and Profiles

Q1. What type of business or industry is your company/department primarily in?

The participants in this study substantially reflect the range of industries and business sectors that employ high-performance computing tools today (see Table 15). In addition, the number of respondents from each industry or business sector is roughly proportionate to the prevalence of HPC tools in that industry or sector. For example, HPC tools are more commonly used in the aerospace, automotive, and petroleum industries today than in the telecommunications or transportation logistics sectors.

HPC tools are more commonly used in the aerospace, automotive, and petroleum industries today than in the telecommunications or transportation logistics sectors.

TABLE 15

Primary Business or Industry of Respondents' Organizations

Industry	Number of Responses
IT and electronics	6
Energy (petroleum, oil, and gas)	5
Chemical	5
Pharmaceutical, biological, life sciences, biomedical	5
Aerospace	4
Automotive	4
Software company	2
Entertainment	2
Telecommunications	1
Transportation and logistics	1
Financial services and economic modeling	1
Other	4
Total	40

n = 33

Note: More than one response per site was allowed.

Source: IDC, 2004

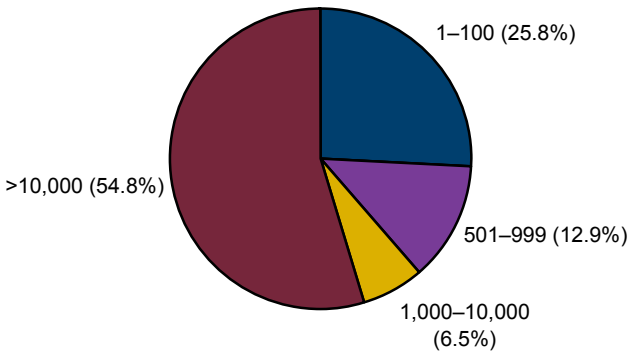
Q29. How many employees are employed at your company?

As Figure 24 illustrates, organizations employing HPC tools tend to be either relatively small (fewer than 100 employees) or relatively large (500 to thousands of employees). The smaller organizations include independent software vendors (ISVs), which may employ as few as a dozen people to develop, test, and maintain crucial third-party software applications. The largest organizations include well-known multinational corporations.

It was interesting to find that the smaller companies and large companies had similar concerns and needs.

FIGURE 24

Number of People Employed at Respondents' Organizations



n = 31

Source: IDC, 2004

Q3. What categories of HPC computers are currently installed or being used by your company? (More than one choice is possible.)

It is not uncommon for organizations that employ HPC to own more than one HPC computer.

For example, the organizations represented in this study have 2.4 HPC computers installed on average. Some organizations acquire multiple HPC computers because each is best-suited for certain problems. Other organizations have multiple HPC systems because they use both current-generation and prior-generation systems. The installed computers may vary greatly in size and purchase price.

The organizations represented in this study have 2.4 HPC computers installed on average.

The preponderance of symmetric multiprocessor (SMP) servers and supercomputers (including vector computers) at the respondents' organizations is not surprising (see Table 16). These systems have been the traditional workhorses of industrial high-performance computing, dedicated to the largest and most daunting computational tasks. Clustered HPC systems as a whole account for approximately half the installed

systems; whether purchased from HPC vendors or assembled in-house by user organizations, they offer lower initial prices and better price/performance compared with the more traditional systems. Largely because of these cost benefits, clusters are used for an increasing number of problems in industry and business, although the most challenging problems are generally still reserved for the traditional systems.

TABLE 16

Types of HPC Computers Currently Installed at Respondents' Organizations

Computer Type	Number of Responses	Overall Percentage
SMP technical servers or supercomputers	23	29
Clusters purchased from an HPC vendor	16	20
Beowulf workstation or PC clusters assembled in-house	15	19
Grid computers	14	18
Use of compute cycles from an external party	7	9
Vector computers	4	5
Total	79	100

n = 33

Note: More than one response per site was allowed.

Source: IDC, 2004

Q6. How long (years) has your organization been using HPC technical servers?

The survey respondents as a group are industry veterans who have been using HPC systems for an average of 15 years (see Table 17).

TABLE 17

Number of Years Organizations Have Been Using HPC Technical Servers

Average	Median	High	Low
14.9	15	30	3

n = 33

Source: IDC, 2004

Appendix 2: Survey Questionnaire

Council on Competitiveness Study by IDC
The Industrial Use of HPC Technical Compute Servers

Name: _____
Title: _____
Company: _____
Phone: _____
Fax: _____
Email: _____

****

Qualifiers

I. Do you currently have any technical servers or supercomputers installed at your site or have access to which are used to directly support R&D, engineering and scientific efforts such as simulation, modeling, research, computer-aided design, etc. or computers used to solve problems that are computationally intensive?
____Yes (→ go to question III.)
____No (→ go to question II.)

II. Did your organization previously use HPC technical servers?
____Yes (→ please explain in detail why your organization no longer uses HPC, then end the interview)
____No (→ end the interview)

III. Have you evaluated or been directly involved in the purchase evaluation of a HPC computer system?
____Yes
____No

IF NO -- Is there any other person or department in your organization that may be involved in purchasing system used for technical applications?
Referral Name: _____
Phone Number:_____

****

About IDC

IDC delivers dependable, high-impact insights and advice on the future of all computing markets in the information technology arena such as the high performance computing market.

IDC divides the technical server market into four competitive market segments:
Technical Capability: Systems configured and purchased to solve the largest most demanding problems
Technical Enterprise: Systems purchased to support technical applications in throughput environments selling for $1 million or more
Technical Divisional: Systems purchased for throughput environments selling from $250,000 to $999,000
Technical Departmental: Systems purchased for throughput environments selling for less than $250,000

Additional information about IDC and the reports we produce can be found at www.idc.com and www.idc.com/hpc.

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Site Overview Questions
Note: For all questions the use of the term HPC computers is used the same way as technical servers, supercomputers, clusters, etc. including Grids, HPC software and storage and is meant to apply to all technical computers used for scientific and engineering problems and applies to computers used to solve problems that are computationally intensive.

Q1. What type of business or industry is your company/department primarily in?

a. ___ Petroleum, oil and gas
b. ___ Chemical
c. ___ Pharmaceutical, biological, life sciences & biomedical
d. ___ Financial services and economic modeling
e. ___ Aerospace
f. ___ Automotive
g. ___ Telecommunications
h. ___ IT and electronics
i. ___ Transportation and logistics
j. ___ Entertainment
k. ___ Other: _____

Q2. What type of major high performance compute servers do you currently have installed or have access to? Please list the major systems in use by vendor name, model, number of processors and the top applications and/or problems that you use the computers to solve:

Vendor	System Model	Number of CPUs	Top Applications Or Problems Being Solved	Installed or Have External Access
A				
B				
C				
D				
E				

Q3. What categories of HPC computers are currently installed or being used by your company (more than one choice is possible).

a. ____ SMP technical servers or supercomputers
b. ____ Vector computers
c. ____ Clusters purchased from a HPC vendor
d. ____ Workstation Clusters or PC Clusters Beowulf assemble in-house
e. ____ Grid Computers
f. ____ Use of compute cycles from an external party – Where? (E.g., university, national, lab, service bureau)

****

Next We Would Like To Explore Why You Acquire and Use HPC Technical Servers

Q4. What are the primary reasons why your organization uses HPC computers?

_____
_____
_____

Q5. How does HPC impact your organization's primary goals and/or mission?

_____
_____
_____
_____

Q6. How long has your organization been using HPC technical servers?: ___ (# of years)

Q7. How does your organization acquire access to these computing resources?

___ Purchase them and install them in our facilities
___ Lease them and install them in our facilities
___ Use systems installed in partner facilities (including universities & labs)
___ Use resources over a Grid or from an Internet provider
___ Other (please explain: _____)

Q8. If you access your HPC tools via an external provider or if you supplement your needs with access to a university or national lab, etc. -- Who makes the decision to do it **externally** and what criteria is used to justify the decision? (**Please** only list their job title and/or organization level)
_____/_____ (Title and organization level)
Decision justification/criteria: _____
_____
_____

c. What percentage of your computing are you using external resources today?
____ % of HPC computing done externally
d. What is your level of satisfaction with external sources
(10 = Great, 1 = very low): ___
If low, why: _____

e. What could be done to improve your satisfaction:
_____
_____

f. If you had access to external HPC resources along with experts to guide you, would you make use of additional external HPC computers resources?: ____ Yes/No

Q9. Who makes the **purchase decision** for HPC tools/computers in your organization (**Please** only list their job title and/or organization level)
Technical decisions are made by: _____/_____ (Title and organization level)
Who makes the overall HPC financial decisions (or sets the budgets):
_____/_____ (Title and organization level)

Q10. Regarding the type of computational problems running at your site:
Are you currently running CAPABILITY class problems?: ___ Yes/No,
if Yes, what is the percentage _____ %
Are you currently running CAPACITY class problems?: ___ Yes/No,
if Yes, what is the percentage _____ %

Q11.a. Please rate the following criteria as used by your organization to make your HPC purchase decisions for **CAPABILITY CLASS** computers (use a scale from 1 to 10, with 10 = most important and 1 = not used):
_____ Price or budget level
_____ Performance on our applications
_____ Price/performance ratios
_____ Quality/reliability
_____ Ability to run certain software and/or applications
_____ Vendor reputation
_____ Future application requirements
_____ Other (Please explain: _____)

Q11.b. Please rate the following criteria as used by your organization to make your HPC purchase decisions for **CAPACITY CLASS** computers (use a scale from 1 to 10, with 10 = most important and 1 = not used):
_____ Price or budget level
_____ Performance on our applications
_____ Price/performance ratios
_____ Quality/reliability
_____ Ability to run certain software and/or applications
_____ Vendor reputation
_____ Future application requirements
_____ Other (Please explain: _____)

Q12. What percentage of your **CAPABILITY** class problems are you interested in outsourcing:
a. _____ % Today
b. _____ % In the future

Q13. What organization or competitive risks do you have if you DON'T have access to high end HPC computers systems/tools?

_____
_____
_____
_____

Q14. Does your purchase process consider future application requirements?
___ Yes -- How far into the future to look and/or consider: ____ (years)
___ No

****
Next We Would Like To Explore Your Use of HPC

Q15. What has been the benefit of HPC on your organization?
___ Impact on bottom line—can you quantify:
_____
___ Increased competitiveness—describe how:
_____
___ Increased productivity—in what way:
_____
___ Other: _____

Q16. Is your organization using HPC tools as aggressively as it could?: _____ Yes/No
Please explain:
_____
_____
_____
_____

Q17. What important computational problems do you have today that you can't solve today?
_____
_____
_____
_____
_____
_____
_____

Q18. If you are not using HPC tools as much as you think the organization should, what is holding you back?
___ Technology is changing too quickly to keep up
___ Final decision-makers do not understand sufficiently the potential impact of using high performance computing to adequately evaluate this investment decision against other business requirements/pressures.
→ If this is the case, where is the internal selling process breaking down:
_____
_____
_____
___ Easier to get a decision on an investment that reduces costs now versus an investment that has future payoffs
___ Availability of internal or external people to apply the tools to our problems
___ Availability of appropriate commercial software or applications
___ Don't have the workload to justify the expense
___ Cost of HPC tools (HW and SW) versus other business investments required
___ Ability to charge against a government contract
___ Ease of use (HW and SW)
___ Scalability of commercial ISV software
___ Cost of developing in-house software
___ Ease of accessing outside resources
___ Hesitancy in running company-sensitive problems on outside HPC resources

___ Other: _____

Q19. Can you explain why your organization uses of different tools for specific applications, and the limitations of your current tools on these applications:

a. Why did you choose these particular computational tools for your applications?

_____
_____
_____

Are they adequate for your current needs? If not, why not:

_____
_____
_____

b. Are there other HPC tools (hardware or software) on the market today that you would like to own or have access to? (Please list them):

_____
_____
_____

What is stopping you for owning/accessing them?

_____
_____
_____

****

Next We Would Like To Explore What Would Be Possible If You Could Obtain Significantly More Powerful HPC Computers

Q20. If you had access to a computer with 100x performance, how would you use it and what new computational science issues could you address?

_____
_____
_____

… And how would it change your organization?:

_____
_____
_____

Q21. What could you accomplish if computers were 10X easier to program?

_____
_____
_____

Q22. What could you do that you cannot do today if you had these tools?
(PLEASE EXPLAIN IN DETAIL)

_____
_____
_____
_____
_____

Q23. What features or capabilities would you MOST like to see in future HPC computers looking out over the next 5 to 10 years (please rate with 10 = the most important and 1 = not important):

a. ___ Better System Price
b. ___ Improved Life cycle cost
c. ___ Better Price/Performance
d. ___ Increased Reliability

e. ___ Greater Processor speed
f. ___ Ability to run larger problems
g. ___ Ability to do new science
h. ___ Easier to use computers
i. ___ Easier to program computers

___ Other: _____

Q24. Given the availability of dramatically better and easier-to-use HPC tools:

a. What would be the impact to your bottom line if you had more capable computers as described above (and they were able to address the problems that you listed above)?

_____
_____
_____

b. Can you quantify the value of solving these problems?

e.g. reduced costs through more simulation and fewer physical experiments or prototypes; increased revenue from faster introduction of new products. For example, if you could shave off X% of your development costs, this would equate to $Y in cost savings. Or if you could introduce a new product one year early, that could equate to $Y in additional revenue:

Please explain: _____
_____
_____
_____

c. What would be the impact to your competitiveness?
e.g. your ability to increase market share though the development of more new products and/or faster time to market with new products, able to respond more quickly to changing customer needs/demands:
Please explain: _____
_____
_____
_____
_____

d. Other effects?
e.g. safer products, reduced environmental hazards from more efficient manufacturing process, faster development of products that affect health/well-being of society etc., reduced prices for customers due to development cost savings, more efficient products/products with longer life-cycle for customers, reduced reliance on foreign manufacturer for important product:
Please explain: _____
_____
_____
_____
_____

Q25. If HPC computers were easier to use, and therefore required less dependence on HPC programming experts:
a. Would that increase your use of HPC computers in general?: _____ Yes/No
b. Would it increase your use of **CAPABILITY** class computers?: _____ Yes/No

****

Next We Would Like To Explore How Your HPC Budgets Are Changing

Q26. Did your budget over the last year?:
____ Grow → By what percentage _____%
____ Shrink → By what percentage _____%
____ Remained the same

Q27. Is your budget over the next two years for **all HPC** spending?:
_____ Growing → By what percentage _____%
_____ Shrinking → By what percentage _____%
_____ Remaining the same

****

Additional Company Demographics

Q28. Using the following broad categories, what was your company's revenue last year?
a. ___ < $1 Million
b. ___ $1M - 9.9M
c. ___ $10M - 99.9M
d. ___ $100M - $499M
e. ___ $500M - $1B
f. ___ >$1B

Q29. How many employees are employed at your company?
a. ___ 1 to 100 employees
b. ___ 101 to 500 employees
c. ___ 501-999 employees
d. ___ 1,000-10,000 employees
e. ___ Over 10,000 employees

Thank you for your assistance with this research.