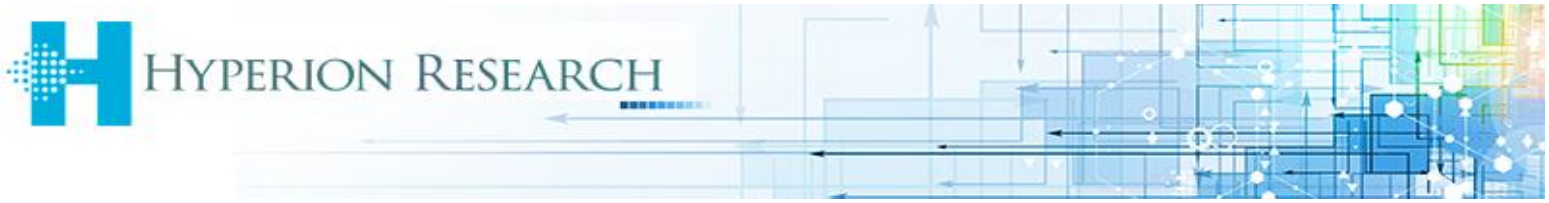

Technology Spotlight

Best Practices for Running Scalable, Cost-Effective Engineering Simulation Workloads

Sponsored by Ansys

Mark Nossokoff, Alex Norton, and Melissa Riddle
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HYPERION RESEARCH OPINION

This Technology Spotlight explores the growing importance of application software in addressing engineering workloads and supporting the success of companies and organizations running these simulations.

IT and HPC datacenters (referenced hereafter as "datacenters") provide the infrastructure required to enable innovation, foster scientific discovery, and drive business growth. In working to fulfill this charter, datacenters face an array of increasingly complex and challenging issues:

- New data-intensive workloads are driving system requirements, technologies, and applications that may substantially differ from those used in traditional engineering simulations.
- Enterprise IT datacenters with smaller budgets and less HPC expertise need to support heterogenous engineering simulation and HPDA/AI workloads.
- Datasets are growing larger, more difficult to manage, and costlier to move.
- Data is being shared across environments (on-premises, cloud, hybrid cloud), geographies, and organizations.
- Users are becoming more and more dispersed due to the impacts of the covid-19 pandemic and the related rise of remote and mobile workforces.

Datacenters rely heavily on their infrastructure partners to help them mitigate the challenges affecting their users. This is especially true for middleware (e.g., compilers, tools, libraries, system management, job management software) and application software (e.g., engineering simulation and modeling software).

Solving these challenges comprehensively is no easy task. As a leading provider of engineering modeling and simulation software solutions, Ansys is actively addressing these challenges and is well positioned to help drive and benefit from the projected growth for this important market, projected to be 9.3% and 18%, respectively, for on-prem and cloud from 2020-2024.

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SITUATION OVERVIEW

The challenges and opportunities engineering datacenter managers face are extremely dynamic and constantly evolving. Managers not only need to provide their engineers and scientists with the appropriate infrastructure tools and resources to do their jobs but also do it in a cost-effective manner while responding to constant technological innovation, tenuous budget constraints, evolving business models, and unpredictable external environmental forces. One element in their favor is a robust engineering modeling and simulation application software market.

Market Importance of Engineering Modeling & Simulation Application Software

Application software continues to be an important segment of the broader HPC market. Application software is the third largest segment, forecast to be $6.1B in 2024. See Table 1.

TABLE 1

WW HPC On-prem Revenues by the Broader HPC Market Areas ($M)

	2020	2021	2022	2023	2024	CAGR '20-'24
Server	$13,744	$13,741	$16,197	$17,708	$18,977	8.4%
Storage	$5,520	$5,605	$6,675	$7,478	$8,075	10.0%
Middleware	$1,618	$1,640	$1,946	$2,142	$2,310	9.3%
Applications	**$4,682**	**$4,643**	**$5,380**	**$5,783**	**$6,092**	**6.8%**
Service	$2,186	$2,131	$2,421	$2,552	$2,636	4.8%
Total Revenue	$27,750	$27,761	$32,619	$35,662	$38,090	8.2%

Source: Hyperion Research, May 2021

CAE (of which engineering modelling/simulation software constitutes the lion's share) is the largest industry vertical within the Hyperion Research vertical market taxonomy. See Table 2.

TABLE 2

WW HPC On-prem Server Revenue by Applications ($M)

	2020	2021	2022	2023	2024	CAGR '20-'24
Government Lab	$3,364	$2,572	$3,390	$3,708	$4,110	5.1%
University/Academic	$2,189	$2,348	$2,729	$2,955	$3,037	8.5%
CAE	**$1,560**	**$1,674**	**$1,902**	**$2,079**	**$2,230**	**9.3%**
Defense	$1,361	$1,499	$1,723	$1,883	$2,017	10.3%
Bio-Sciences	$1,323	$1,376	$1,576	$1,721	$1,847	8.7%
Geosciences	$865	$917	$1,019	$1,115	$1,199	8.5%
EDA / IT / ISV	$747	$822	$942	$1,028	$1,098	10.1%
DCC & Distribution	$754	$783	$884	$965	$1,029	8.1%
Economics/Financial	$639	$712	$832	$909	$972	11.1%
Weather	$585	$644	$740	$808	$865	10.3%
Other	$151	$169	$211	$264	$284	17.0%
Chemical Engineering	$156	$172	$190	$207	$221	9.0%
Mechanical Design	$049	$052	$059	$065	$069	8.7%
Total Revenue	$13,744	$13,741	$16,197	$17,708	$18,977	8.4%

Source:: Hyperion Research, May 2021

Users are also turning to the cloud to run their CAE applications. Cloud utilization and spend is largely complementary and incremental to users' on-prem spending. Behind only Biosciences, CAE is the second largest vertical increasingly utilizing the cloud as an HPC resource. Table 3 summarizes the vertical applications' HPC cloud adoption.

TABLE 3

WW HPC Cloud Forecast by Vertical ($M)

	2020	2021	2022	2023	2024	CAGR '20-'24
Bio-Sciences	$1,345	$1,649	$1,923	$2,194	$2,427	15.9%
CAE	**$795**	**$967**	**$1,151**	**$1,349**	**$1,540**	**18.0%**
Chemical Engineering	$108	$133	$160	$190	$211	18.4%
DCC & Distribution	$244	$300	$361	$428	$519	20.8%
Economics/Financial	$213	$262	$315	$373	$430	19.2%
EDA	$316	$394	$481	$578	$677	20.9%
Geosciences	$269	$339	$419	$508	$616	23.0%
Mechanical Design	$021	$026	$032	$038	$044	19.5%
Defense	$330	$411	$501	$602	$705	20.9%
Government Lab	$304	$378	$462	$554	$625	19.7%
University/Academic	$219	$272	$332	$397	$528	24.6%
Weather	$047	$059	$128	$228	$290	57.6%
Other	$088	$110	$134	$161	$188	20.9%
Total	$4,300	$5,300	$6,400	$7,600	$8,800	19.6%

Source: Hyperion Research, May 2021

The robust market likely provides CIOs and datacenter managers confidence that compelling and effective solutions will be available to them. With that confidence, strong consideration must be given to several factors to deliver on their role in providing scalable and cost-effective IT for engineering simulation:

- Differences between public and private sector HPC datacenters
- Impact of HPDA/AI workloads
- Maturity of the cloud for IT and HPC workloads
- Consequences of the covid-19 pandemic

Public and Private Sector HPC Datacenters

Historically, government and academic HPC datacenters have supported advanced engineering research, while HPC datacenters in manufacturing enterprises have leveraged this research to help drive upstream engineering R&D. Now, the rise of AI and other high performance data analytics (HPDA) methods are blurring the lines between public- and private-sector HPC datacenters.

The two types of HPC datacenters still have important differences:

- Datacenters in government organizations, academia, and major corporations often have larger budgets and deeper technical expertise to architect, deploy, and maintain state-of-the-art HPC infrastructures. They often also have the expertise to develop their own tools to manage their HPC infrastructures and some of their own modeling and simulation software to achieve their R&D goals. Government agencies also regularly leverage the greater standardization and configurability of paid third-party software for engineering simulation projects.

- As a group, private-sector HPC datacenters engaged in engineering simulation rely far more heavily on proven third-party software. Private firms are also likely to treat advances enabled by this software as proprietary "crown jewels" that need to be kept away from competitors.

Impact of HPDA/AI Workloads

Hyperion Research studies show that today, many public- and private-sector HPC datacenters are running workloads that benefit from a heterogeneous mix of modeling/simulation plus AI or other data-intensive methods. This is especially true of engineering applications such as those used in developing advanced driver-assistance systems (ADAS), diagnostic imaging systems for medicine, and novel materials. The world of advanced data analytics is making strong inroads into HPC datacenters of all kinds.

The emergence of HPDA/AI workloads, distinctly different from traditional HPC-oriented engineering modeling and simulation, has created new challenges and opportunities. HPDA and AI applications being used by data analytics workloads (e.g., business intelligence, fraud and anomaly detection, affinity marketing) are driving traditional datacenters to employ HPC techniques to fully deliver the value of AI. As these AI techniques begin to be adopted and integrated with traditional engineering simulation and modeling workflows, CIOs are now presented with the opportunity to make investments to better deliver the appropriate resources to drive multiple dimensions of business growth.

An additional impact of HPDA/AI workloads is the shift from more compute-intensive modeling/simulation to more data-intensive workloads, including machine and deep learning.

Maturity of the Cloud for IT and HPC Workloads

Datacenters, by definition, were on-premises: the actual infrastructures were frequently located where the engineers were performing their modeling and simulation. However, the growing complexity of user workloads has grown to the point where in many situations it is becoming increasingly difficult to satisfy the infrastructure requirements through on-premises investments alone. Between the cost of the systems to provide the performance necessary to complete the simulations in a timely fashion and the capability to handle the increasing number of simulations required to achieve a quality and timely design, enterprise CIOs and CFOs are challenged with providing their development teams the full resources required to drive the desired business growth.

The cloud has fortunately been maturing to a point where it can realistically be considered as an alternative datacenter environment to run many HPC workloads, including some that are tightly coupled, such as certain computational fluid dynamics (CFD) and structural analysis simulations. Hyperion Research studies have consistently shown the following requirements are the most important for successfully migrating HPC workloads, including engineering simulation, to the cloud:

- The need for burst/surge computing to increase on-premises capacity and scalability
- Access to the diversity of high-performance hardware and software solutions offered in the cloud
- Cost-effectiveness of running certain workloads in the cloud
- The ability to access and store very large datasets, especially those that have already been moved into the cloud
- The ability to speed up job turnaround times when the on-premises systems are overloaded

Of particular importance for users of modelling and simulation applications in the cloud is access to high performance hardware. Having the correct balance and mix of processors, storage, and high performance fabric is critical to minimizing users' job completion times. Processor vendors such as Intel are working with the leading CSPs to ensure their instances can provide the performance required by users for these applications.

The growing maturity of public clouds has given HPC datacenter managers and CIOs a new tool to provide their technical teams with the resources they require. At the same time, cloud maturity has given CIOs the flexibility to better optimize and balance on-premises investments (CAPEX) with cloud investments/expenses (OPEX). As a result, approximately 20% of HPC workloads are already being run in the cloud today and Hyperion Research forecasts that user investments to run HPC workloads in the cloud will grow from $4 billion today to approximately $9 billion by 2024.

Many HPC datacenter managers and CIOs have concluded that increasing cloud usage is the answer and have created a timeline for their IT operations to move to the cloud. Datacenter managers and administrators are often compelled to develop a coherent strategy to create infrastructure and workflows that seamlessly integrate on-premises and cloud environments. Many are seeking guidance from middleware software and application software providers such as Ansys who have helped pioneer this type of integration.

Consequences of the Covid-19 Pandemic

CIOs were abruptly confronted with the new reality dictated by the covid-19 pandemic. Remote work, once an optional privilege for some, became mandatory for most. The rise of remote work brought unique challenges for teams no longer able to work together in the same building. Communication, collaboration, and data management tools were rapidly adopted and deployed to safely and efficiently transfer data to keep geographically distributed users productive. Demand for such solutions ramped up as companies began realizing they were facing more than just temporary delays.

From an HPC and engineering simulation perspective, data protection and process traceability (i.e., visibility of how/where simulations are being used) have become increasingly important. On-demand and secure access of remote resources was critical and continues to be a prominent concern.

Emerging Role for Datacenters to Provide Scalable and Cost-Effective IT for Engineering Simulation

The end result of the factors described thus far is the increased importance HPC datacenters and their cloud alternatives have relative to the on-going business success of their organizations. Resources need to be efficiently and cost-effectively managed and deployed to optimize the ability of engineers to provide quality and timely modeling and simulation for new product development. This becomes critically important with the adoption of complex, expensive HPC techniques to address the increasing sizes and amounts of modeling and simulation workloads, along with the application of new AI methods.

These challenges also provide CIOs and datacenter managers tremendous opportunities to improve the productivity of their engineers, support higher quality results, and improve the bottom line of their organization's businesses. HPDA-AI can augment traditional HPC modeling and simulation to deliver faster time to results and subsequently support an increased number of simulations in the same amount of time. Cloud-based HPC can also improve job queue times and provide access to the latest architectures that may not be available to many on-prem datacenters.

HOW ANSYS HAS ADDRESSED THE NEW DATACENTER REQUIREMENTS

Ansys, a leading supplier of engineering simulation software, has extensive experience in helping engineers overcome complex design challenges to high performance products ranging from heat exchangers to avionics electronics motors to golf balls. Stemming from these customer experiences and their view of the evolving HPC landscape, Ansys has conceived a lessons-learned based best practices for helping their customers address the challenges of the new datacenter realities:

- The ability to take advantage of the latest HPC hardware and software technologies. The benefits from advancements made in both hardware and software combined can be greater than the sum of benefits from individual hardware and software advancements. Hardware and software advancements clearly go hand in hand and can take users to higher levels of simulation fidelity, engineering insight, and innovation. HPC and cloud partnerships better optimize simulation software performance on next-generation processors and accelerators and ensure that user's ROI in HPC is maximized.

  Ansys works closely with hardware partners to ensure their modelling and simulation tools are optimized to run on the latest hardware, and that the latest hardware will have the features to support the requirements of Ansys's tools. For example, in working with Intel, Ansys:

  - Uses technologies such as AVX 512 to optimize performance of explicit analysis with Ansys HPC applications, such as Ansys Fluent.
  - Accelerates implicit analysis of Ansys applications (e.g., Mechanical, HFSS, and LS-DYNA) through utilization of Intel's Math Kernel Libraries, AVX-512 and Optane Persistent Memory
  - Jointly advises customers on matching the appropriate cloud processors instances to the Ansys HPC applications
  - Gains valuable insights and knowledge from early access to pre-production processors for software performance profiling and benchmarking purposes.

- **Consolidate both HPC and the data, and in addition enable remote simulations**. Consolidating or centralizing the HPC infrastructure helps to increase operational efficiency. It is easier to manage in one location, users have a single set of tools for end-users to access it, and users can better collaborate and share simulation projects across multiple sites.
  - Another aspect is that engineers want to avoid moving large simulation data (100's of gigabytes per file) between the end-user and the datacenter.
  - If users are going to keep the data in the datacenter or in the cloud, end-users need full interactive and graphical access to simulations which go beyond batch number crunching. This involves putting a graphics-capable server in the datacenter with server-side accelerated 3D graphics or using VDI on a 3rd party cloud infrastructure. For some users, this requirement is part of a more general virtual desktop initiative. End-users will need easy ways to submit and manage their jobs, possibly through a mobile device.
- **The ability to manage simulation data securely.** Sufficient data security ensures effective IP protection and compliance to allow users to efficiently find, retrieve, and re-use and share the data. This step has been found to be challenging, especially in the context of larger product lifecycle management (PLM) initiatives. Simulation data (which many users today are only loosely managing) has unique scale and velocity, compared to design data, and needs to be linked to PLM, but managed under an adjacent system that recognizes those unique requirements.
- **Take advantage of standardized or common tools and centralize licensing.** As centralization takes place, tool proliferation and utilization rates become more visible and companies are encouraged to evaluate how to best manage and optimize their SW assets. Instead of migrating every application to the datacenter, it makes sense for companies to standardize on *common tools* versus *point solutions,* and to *centralize licensing*, so that utilization rates can be as high as possible.
- **Establish and leverage a mature and growing partnership-based ecosystem.** Streamlined workflows can benefit greatly from an integrated best-of-breed hardware and software environment. Partnerships with leading platform providers such as Intel to optimize software for next generation processors and technologies with the intent to deliver a performance advantage and differentiated customer value are increasingly critical. An open ecosystem will foster continued innovation and accelerate engineering and scientific breakthroughs.

By supporting the above strategy in its investment approach to product innovation and customer enablement, Ansys has raised the bar for continuing its leadership in the important and growing engineering and modeling application software market.

FUTURE OUTLOOK

HPC datacenters will continue to evolve in delivering the infrastructure required to support the demands of engineers for complete, timely, and high-quality modeling and simulation to support the business needs of their organizations. Remote work will likely grow as it is more feasible now that covid-19 has made the workforce learn how to work effectively from home. CIOs will be challenged and required to develop a strategic and cost-effective strategy to address the hybrid needs of the organization across many dimensions:

- On-premises and cloud
- New hardware, software, and approaches to solving problems
- Embarrassingly parallel and tightly coupled workloads
- Compute-intensive modeling and simulation and data-intensive HPDA/AI/ML/DL workloads
- Onsite teams and remote engineers

Driven by these heterogeneous needs, datacenters will need to partner with trusted vendors to help them architect, manage, and deploy their infrastructure. Application software is key to many of these datacenters to deliver the necessary functional and performance requirements. Additionally, they must be designed to easily and seamlessly support the constantly evolving HPC infrastructure and data environment.

Ansys is aiming the architecture and design of their engineering modeling and simulation solutions to broadly address the emerging challenges and opportunities for engineering simulation software:

- Supporting the latest HPC technologies: providing more of the full performance capabilities provided by HPC system vendors.
- Embracing remote simulations: providing HPC resources “anywhere” through cloud computing, including support of remote display tools and VDI.
- Managing simulation data: providing a knowledge management application that secures critical simulation data and provides simulation process and decision support to simulation teams across geographies and functional silos.
- Delivering tool standardization and license centralization: providing a consolidated simulation platform that is scalable, extensible, and pervasive.
- Creating and enabling a broad, robust, ecosystem: delivering partnerships to drive pervasive, timely, and high quality engineering simulation.

Hyperion Research believes that with successful execution of this strategy, Ansys is well positioned to help drive and benefit from the robust growth forecast for the CAE market.

About Hyperion Research, LLC

Hyperion Research provides data-driven research, analysis and recommendations for technologies, applications, and markets in high performance computing and emerging technology areas to help organizations worldwide make effective decisions and seize growth opportunities. Research includes market sizing and forecasting, share tracking, segmentation, technology and related trend analysis, and both user & vendor analysis for multi-user technical server technology used for HPC and HPDA (high performance data analysis). Hyperion Research provides thought leadership and practical guidance for users, vendors and other members of the HPC community by focusing on key market and technology trends across government, industry, commerce, and academia.

Headquarters

365 Summit Avenue
St. Paul, MN 55102
USA
612.812.5798
www.HyperionResearch.com and www.hpcuserforum.com
