SimOps

Training & Certification Program

The SimOps education/certification program offers training and certification for:

SimOps Fundamentals self assessment,
SimOps Practitioner, SimOps Professional, and SimOps Architect.

SimOps Fundamentals

This first level of the SimOps education/certification series serves as a self assessment.

SimOps Fundamentals is not a precondition for the next training levels of SimOps Practitioner, SimOps Professional, and SimOps Architect. But we recommend first taking this self-assessment and the certification exam to be well prepared for the next training levels.

SimOps

Why SimOps Training

- The skill set necessary for building, operating, and using resource infrastructures such as workstations and HPC servers for engineering simulations is not well defined
- There is often a lack of expertise in efficiently operating complex HPC infrastructures
- With SimOps, these challenges will be removed by providing expert training and expert working groups that develop best practices and structured career levels
- SimOps certifications aim at enhancing engineer’s resume and career opportunities

What is SimOps?

What is SimOps?

Simulation Operations Automation (SimOps)

The practice of **automating** processes that run **simulations**, to dramatically **increase** engineers' **productivity** & **contribution**.

And:

A new HPC community initiative focusing on simplifying use and operation of scientific and engineering simulations infrastructures.

Why SimOps?

Automating engineering simulation allows for:

- Faster time to market
- Increased manufacturing efficiency
- Improved product quality

Firms with simulation excellence:

- Accelerate their simulations
- Ease onboarding of simulation engineers
- Increase engineering productivity
- Strengthen their innovation and competitiveness

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Engineering Challenges

Engineers spend considerable time fighting operational complexity to run product simulations

A CAE worker's contribution is often limited by how much productive compute they can access

Engineers are forced to learn new work patterns, tools, and sometimes codes when moving to cloud-based HPC

Unnecessary manual tasks for engineers and IT have shifted focus away from using simulation to design better products

SimOps

The Road to SimOps Maturity

The Road to SimOps Maturity

PROVE

No-compromise engineering experience—engineers' work patterns are not disrupted

Fully leverage cloud capacity and capabilities—
run simulations much faster and at scale

SCALE

Conforms to Enterprise IT requirements—leverage IT toolchains, cloud provider,
and CSP capabilities

Increase org-wide engineering productivity—standardized simulation tools and workflows deployed across teams
and geographies

OPTIMIZE

Drive cost optimization— model cost and performance and measure against enterprise KPIs

Make simulation-based decisions—
integrate simulation into up-and downstream processes and
run system-level simulations

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Engineering Challenges Without and With SimOps

CAPABILITY	Without SimOps	With SimOps
Replicate internal engineering experience in the cloud	› Engineering work patterns are disrupted › New tools and UI's required to operate › Cannot leverage proprietary IP & codes	› Engineers work patterns are replicated as is › Run existing CAE workflows and applications › No learning curves to overcome
Exploit cloud scale and capabilities	› Struggle to perform simulation at cloud scale › Continue to rely on on-prem tools & infrastructure › No performance gain, even for 1 workload	› Simulations at scale with infinite on-demand resources › Run simulation jobs in parallel › Cloud resource orchestration and automation built-in
Integrate enterprise-wide tools	› Limited ability to integrate applications, tools, and services across IT infrastructure and assets › Requires manual coordination and unfamiliar tools › Often limited by existing vendor capabilities	› Integrate simulation environment with enterprise-wide IT tooling › SimOps operations adhere to security and compliance requirements › Native deployment provides full extensibility and integration
Org-wide deployment	› Difficulty supporting multiple teams, workflows, and geographies › No centralized app/workflow catalog to streamline processes › Limited collaboration abilities	› Support teams using a unified cloud-based environment › Well-maintained catalog enables easy discovery, access, and license management › Easy cross-team and org-wide collaboration
Workload & cost optimization	› Lack of tools to define and track performance indicators › Manual cost analysis and economic modelling › Limited ability to optimize cost and performance	› Real-time visibility into performance and cost KPIs › Ongoing economic modeling to increase overall ROI › Seamless resource and workload optimization

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SimOps - Identifying Challenge:

- Lack of a common shared perspective among stakeholders, ownership often ill-defined.
- Complex multi-physics interactions across teams and projects require advanced algorithms and specialized tools to accurately model physical phenomena.
- Efficiently allocating HPC resources and reducing costs while maintaining performance.
- Ensuring data protection, compliance with regulations, and disaster recovery.
- Shortage of skilled personnel in HPC and simulation operations.
- Facilitating cross-functional collaboration and breaking down silos across highly specialized domains (aerospace, automotive, etc.).

Challenge: Stakeholder Perspective

Lack of a common shared perspective among stakeholders, with ownership often ill-defined.

- 45% of organizations struggle with clearly defining ownership and responsibilities in simulation operations (CIMdata).
- Stakeholder misalignment leads to 30% of simulation projects failing to meet their objectives due to unclear ownership and operational burdens (McKinsey).

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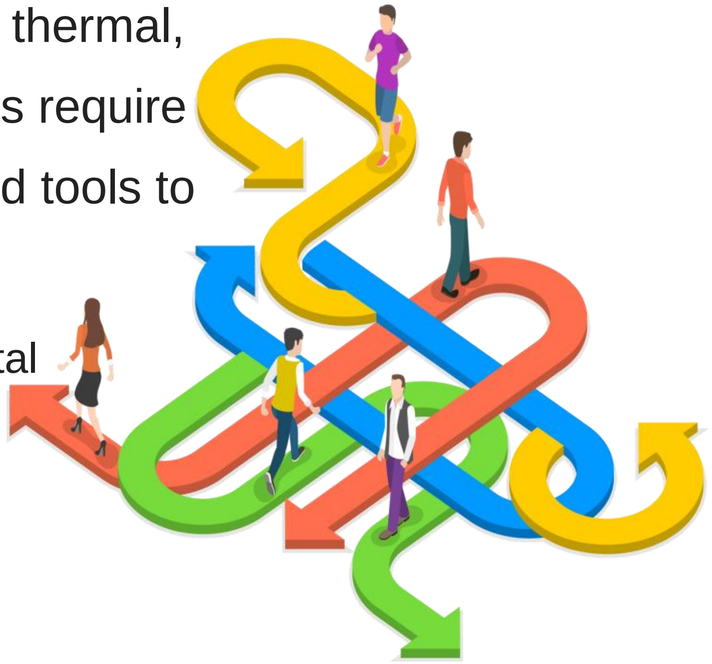
Challenge: Increasing Complexity

Complex multi-physics interactions (mechanical, thermal, electrical, etc.) across diverse teams and projects require increasingly advanced algorithms and specialized tools to accurately model physical phenomena.

- Over 75% of R&D leaders acknowledge that digital product development is essential but admit they lack the necessary capabilities (McKinsey).
- Companies expect a third of their sales to come from new products, equating to $30 trillion in revenues over the next five years (McKinsey).



Challenge: Resource Management

Efficiently allocating HPC resources and reducing costs while maintaining performance.

- Advanced product development capabilities can reduce product development costs by up to 25% (McKinsey).
- Effective resource management leads to significant productivity boosts, with some companies reporting up to 40x improvements (CIMdata).

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Challenge: Data Integrity and Security

Ensuring data protection, compliance with regulations, and disaster recovery.

- 70% of companies cite data security as a significant concern in leveraging cloud-based simulations (McKinsey).
- Ensuring compliance with data protection regulations is critical, with 65% of businesses reporting challenges in maintaining data integrity (McKinsey).

Challenge: Skill and Knowledge Gaps

Significant shortage of skilled personnel in HPC and simulation operations.

- 54% of companies report a significant gap in the skills needed to manage and utilize simulation technologies effectively (McKinsey).
- Companies with comprehensive upskilling programs report a 25% increase in simulation efficiency and effectiveness (CIMdata).

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Challenge: Collaboration

Facilitating cross-functional collaboration and breaking down silos across highly specialized domains (aerospace, automotive, etc.).

- 50% of R&D leaders indicate that lack of collaboration tools hinders their simulation efforts (McKinsey).
- Organizations that implement cross-functional collaboration tools see a 30% improvement in simulation accuracy and relevance (McKinsey).

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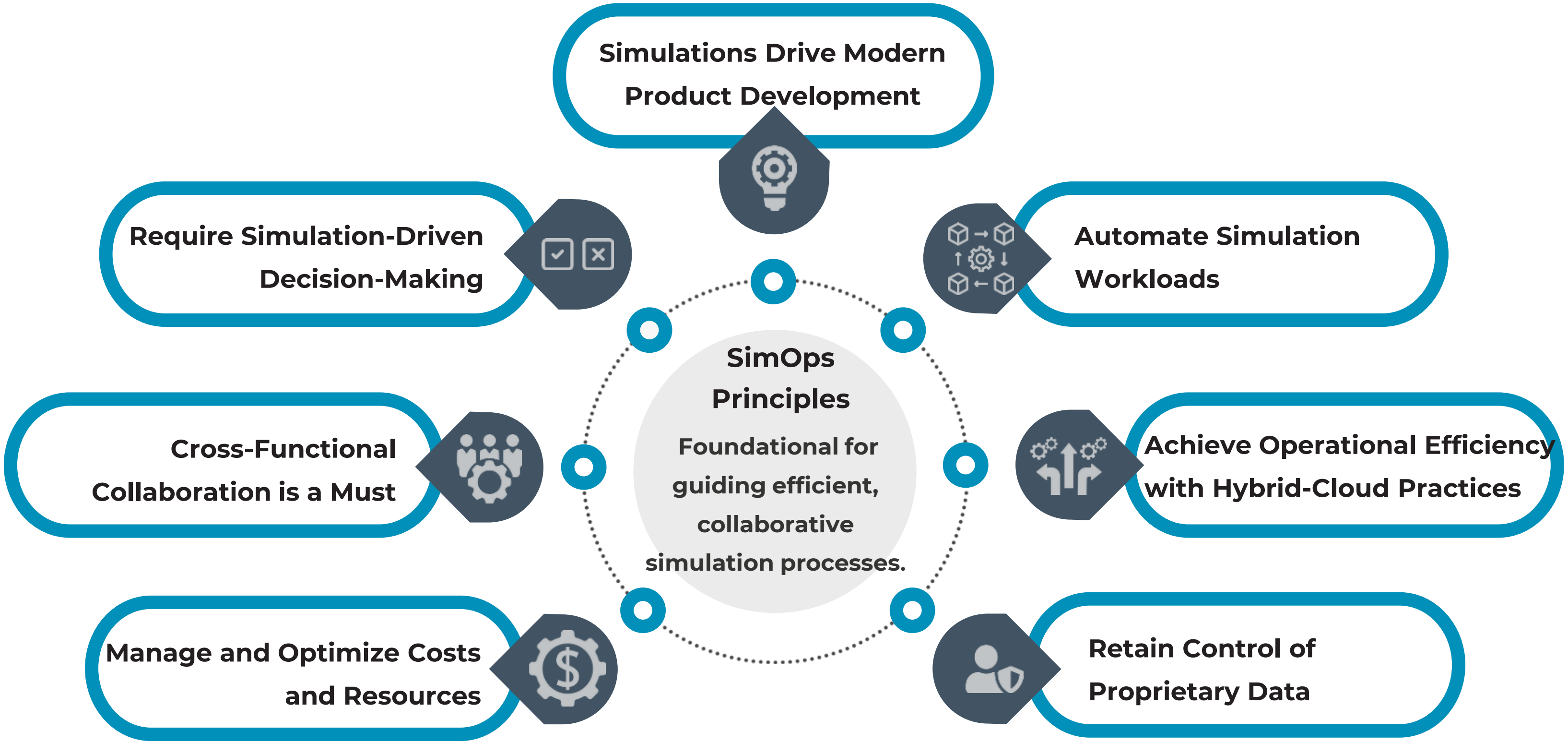
SimOps Principles



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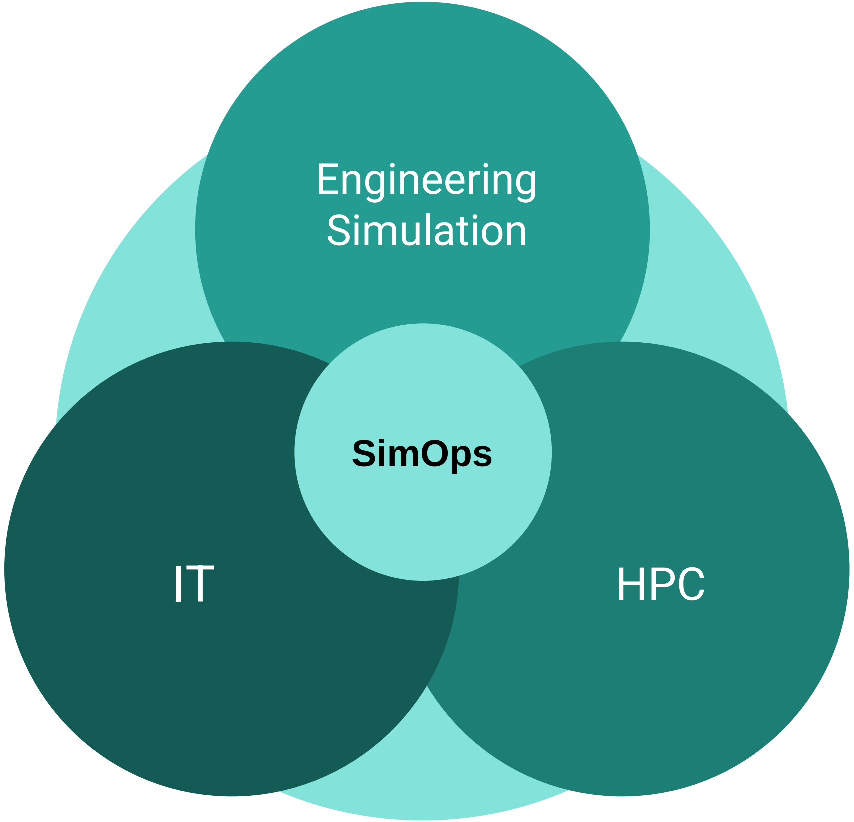
SimOps Pillars



SimOps Pillars

HPC Fundamentals

- HPC architectures
- Resource management
- Job management
- HPC technologies
- HPC total cost of ownership

IT Fundamentals

- Computers
- Operating systems
- Storage
- Networking
- Workload portability
- Cyber security

Engineering Simulation Fundamentals

- Applications of CAE
- Parallel execution
- Licensing models
- Performance optimization
- Simulation workflows

HPC

- HPC architectures
- Resource management
- Job management
- HPC technologies
- HPC total cost of ownership
- Cloud HPC

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What is HPC?

HPC (High Performance Computing) refers to the use of aggregated computing power for handling compute and data intensive tasks including simulation, modeling, rendering, data analytics, digital twins, and machine learning – that standard workstations are unable to address. [1]

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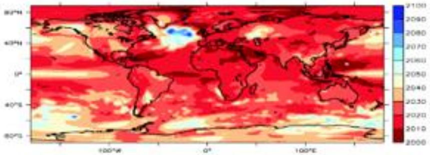
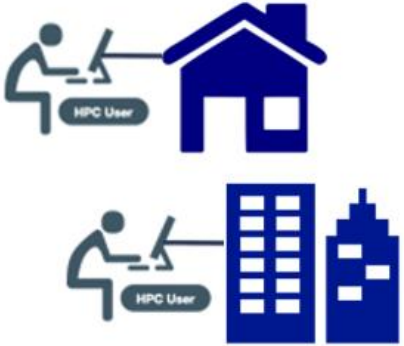
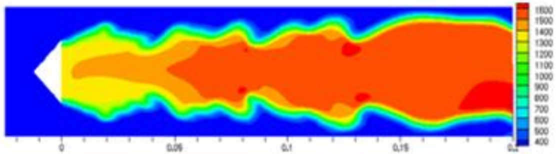
Engineers & Scientists Are Modeling the World With Computers

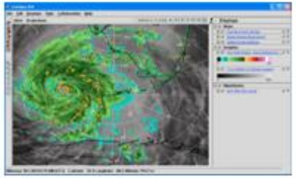


Climate

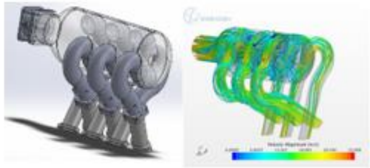




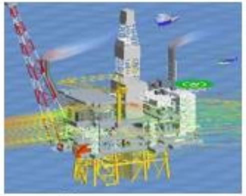
Combustion



Environment

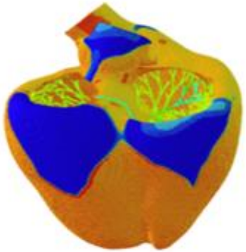


Automotive



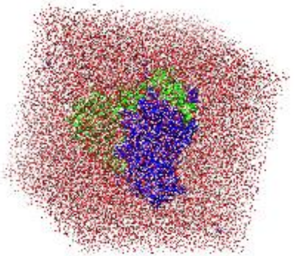
Oil & Gas

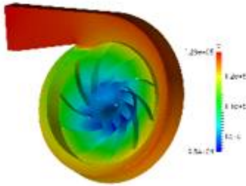
Personalized Healthcare



Virology

Drug Design





Turbomachinery

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Why HPC?

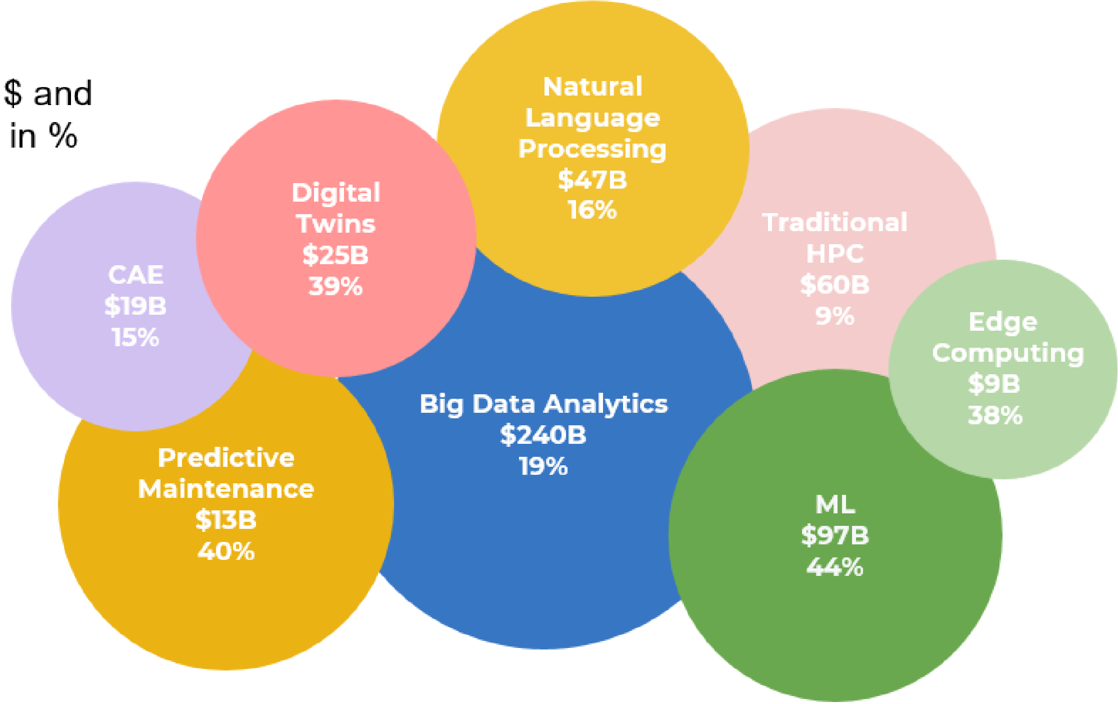
Computational problems often evolve beyond the limited power available in your laptop or desktop computer. There might not be enough memory, not enough disk space or it may take too long to run computations. Your laptop or desktop computer will become unresponsive and may even crash.

In some cases, you might want to run a design of experiments with hundreds or thousands of cases (e.g. parameters). Then you might want to offload that workload to a bigger better machine so you can continue doing other things on your own computer.

Quo vadis, HPC?

HPC is Everywhere, as a foundation for new, evolving applications

2025 Market Size in $ and Annual Growth Rate in %



References Predictive Maintenance | CAE | Digital Twins | Natural Language Processing | Traditional HPC | ML | Big Data Analytics

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Parallel Computing

Just throwing more compute resources at a problem might not solve the memory or runtime issues. The simulation workflow you run has to be architected to leverage the compute power that's available and crunch numbers simultaneously.

The compute cores in a cluster are organized into sockets and racks, with network cables connecting each other. This way the cores are able to work together (in parallel) and solve problems faster.

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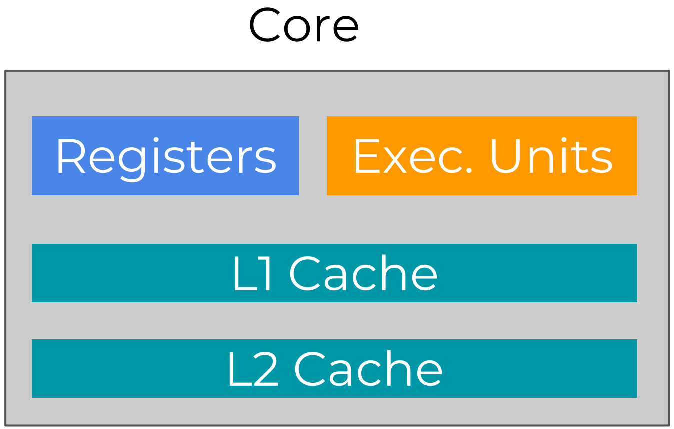
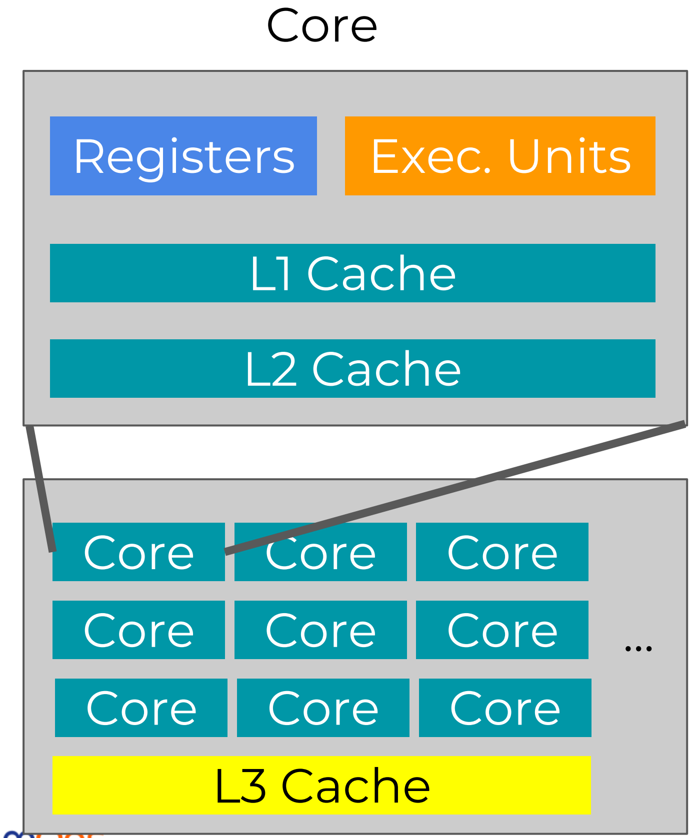
HPC Structure Overview



HPC Structure Overview



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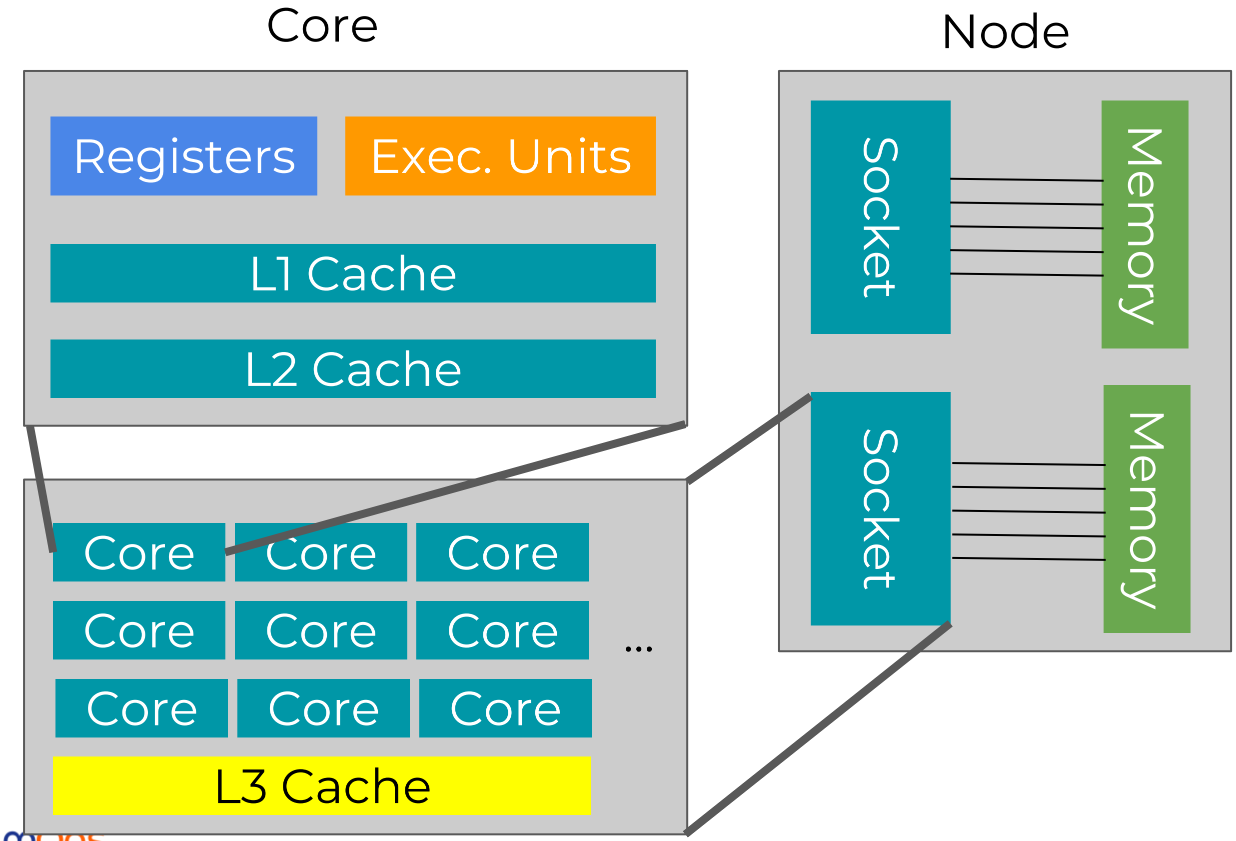
HPC Structure Overview



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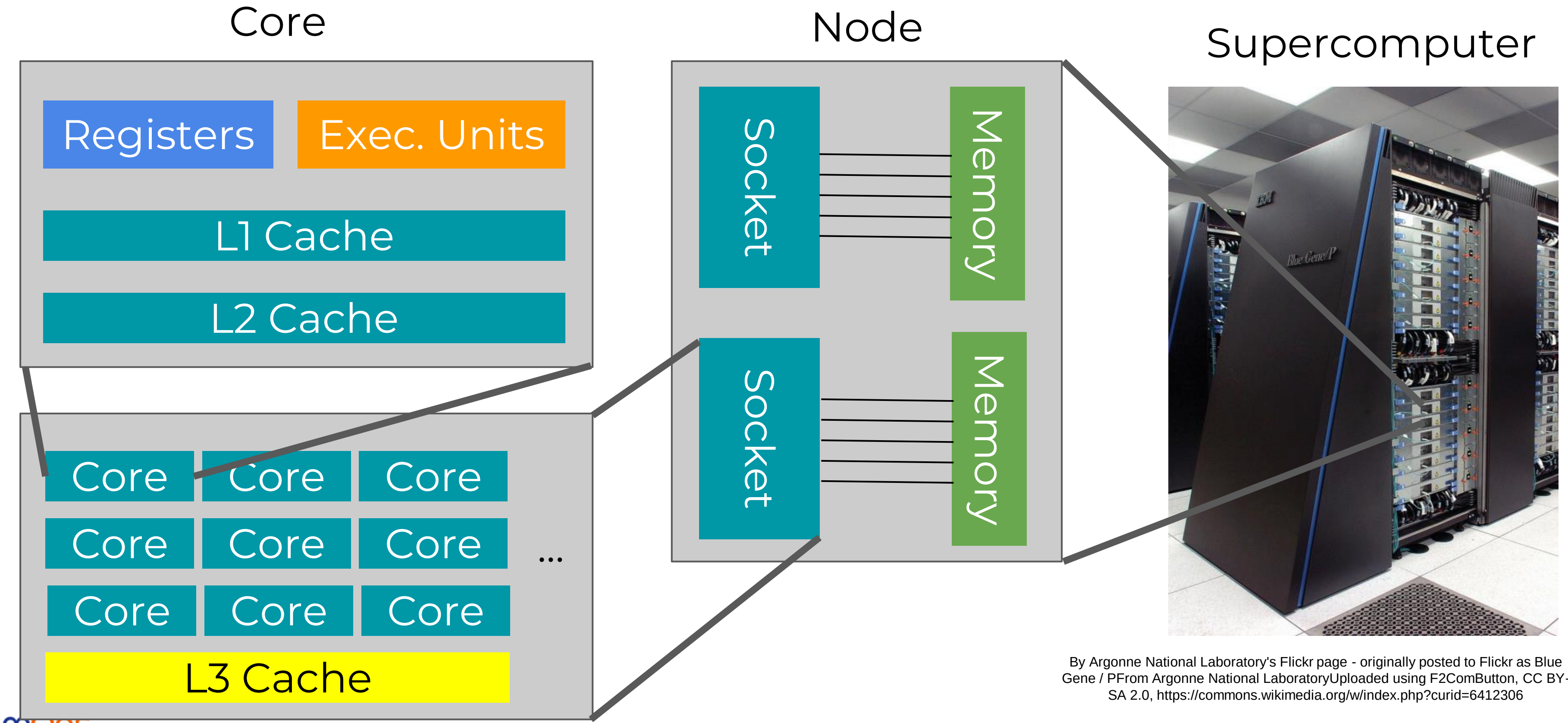
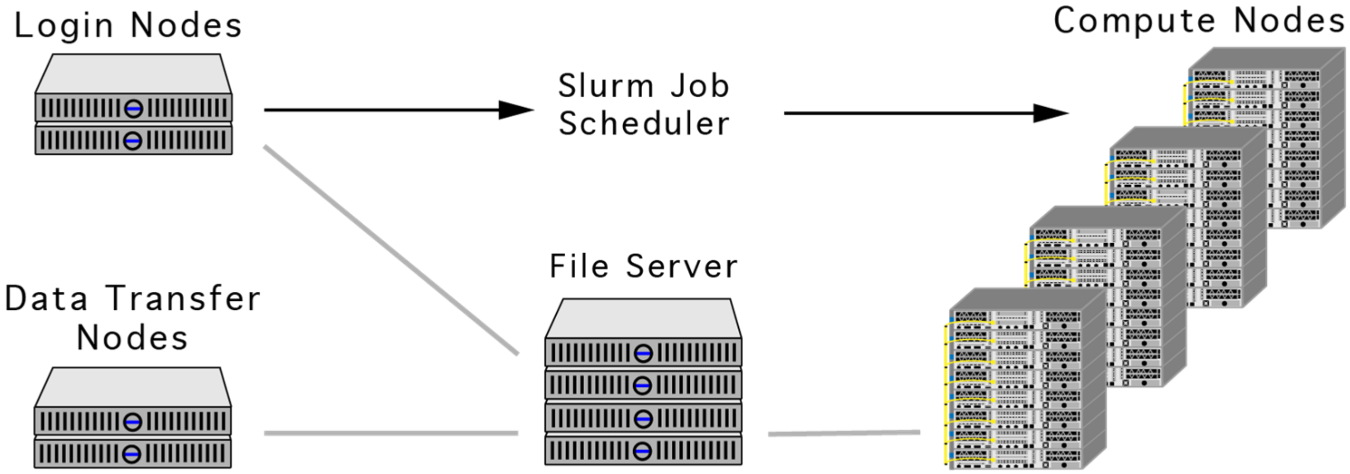
HPC Structure Overview



HPC Architecture

The main components of an HPC architecture are below

- Compute nodes
- Network infrastructure
- Storage
- Workload manager or scheduler



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HPC Architectures

Compute nodes

Compute nodes are workhorses that perform the computations. They constantly send status updates back to the scheduler so that the cluster is efficiently process the jobs submitted by the users.

Network infrastructure

The compute nodes, storage devices and other components of an HPC architecture are interconnected with a low latency, high bandwidth networking fabric like InfiniBand. This high speed network infrastructure is critical in eliminating bottlenecks in single and multi node execution of computations.

HPC Architectures

Storage

Applications and data associated with the various jobs running on an HPC cluster are stored in high speed storage systems. As with networking, the Write and Read speeds to the storage need to be high to avoid bottlenecks in the computational performance.

Workload manager or HPC scheduler or batch scheduler

The workload manager receives job requests from users and runs the job based on the compute and other resource requirements

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HPC Terminologies

Parallel Computing

Parallel computing is the simultaneous use of multiple compute resources to solve a computational problem. A problem is broken into discrete parts that can be solved concurrently on multiple processors.

Message Passing Interface (MPI)

The Message Passing Interface (MPI) is a standardized and portable message-passing library designed to function on parallel computing architectures. There are several MPI implementations like Platform MPI, Intel MPI and OpenMPI which are often packaged with commercial simulation applications for HPC execution.

HPC Terminologies

Node Interconnect

Node interconnect is the low latency, high bandwidth networking infrastructure that connect the compute nodes in a cluster to enable data communications among nodes for solving computational problems parallelly.

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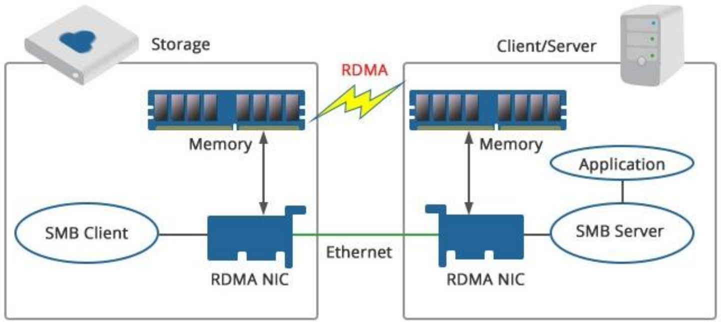
HPC Terminologies

Remote Direct Memory Access (RDMA)

In computing, remote direct memory access (RDMA) is a direct memory access from the memory of one computer into that of another without involving either one's operating system. This permits high-throughput, low-latency networking, which is especially useful in massively parallel computer clusters.



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HPC Terminologies

InfiniBand

InfiniBand (IB) is a computer networking communications standard used in high-performance computing that features very high throughput and very low latency. InfiniBand is also used as either a direct or switched interconnect between servers and storage systems, as well as an interconnect between storage systems.

RoCE (RDMA over Converged Ethernet)

RoCE (pronounced “Rock-ee”) is a cheaper alternative to InfiniBand that uses high speed Ethernet cables to achieve a similar performance for RDMA. RoCE is heavily used in cloud computing data centers.

Click here to learn more

Total Cost of Ownership (TCO) cost of HPC

There are many capital expenditure and operational expenditure costs involved in HPC. It is critical to consider these costs if an organisation is planning to move to the cloud for HPC.

- **Hardware:** servers, storage, networking, cabling, etc.
- **Electrical equipment:** power distribution units, UPS, generators, etc.
- **Cooling systems:** air conditioners, water cooling, etc.
- **Infrastructure** for the data center, power adaptation issues, etc.
- **Energy** consumption of the hardware and cooling systems
- **Software** licences
- **Human** resources
- **Maintenance**

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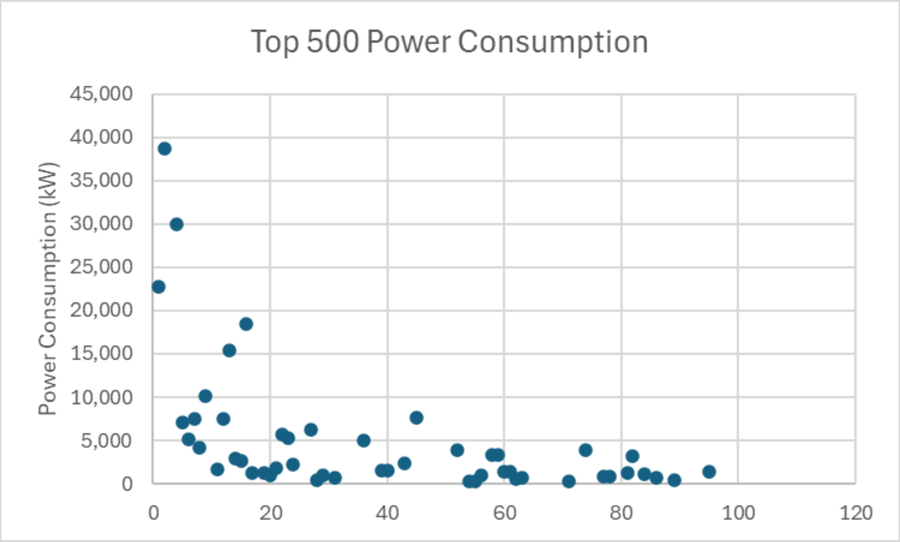
Power Consumption of HPC

Power usage of an HPC cluster is important because the power consumption of the system is a large fraction of the cost of maintenance and contributes a substantial fraction of the cost of calculations done with the system. The large HPC resources in the TOP500 list have power consumption in the range of tens of megawatts which is 1 million times more than an average home consumes.



[Click here to learn more]

Cloud HPC

- Why Cloud HPC?
- Cost Saving of Cloud HPC

Engineers & Scientists Are Modeling the World With Computers

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Why Cloud HPC?

Increase Engineering Agility with Cloud
Enable your key engineers to run applications faster and better, on flexible hardware that powers your innovation and adjusts to changing business conditions.

Lower Total Cost of Ownership
Eliminate upfront hardware capital expenses, and increase cost effectiveness and transparency. Leverage on-demand hardware to lower overall cost-per-simulation.

Improve IT Security and Control
Platform runs in your own cloud account enabling you to leverage the multi-billion dollar security capabilities of cloud providers. Full visibility and control for IT.

What are your options to the cloud?

Independent Software Providers

HPC System Integrators

Cloud Services Providers

Cloud Providers

Do-It-Yourself (DIY)

Option 1: Independent Software Vendors' Clouds

Ansys, Cadence, Dassault, Siemens, . . .

- Ideally suited for SMEs with limited projects, and software from just one ISV
- Some support cloud tokens / elastic units = per hour per node credits
- The latest software releases/versions for one or several solvers offered by the ISV
- Some limitations: e.g. choice and number of compute nodes
- Often, data download to local machine required
- No GPU acceleration for compute
- Runs in ISVs own cloud subscription
- Customer does not have full control

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Option 2: Cloud Services Providers

Rescale, SimScale, Simr, . . .

- More flexible than ISV Clouds, more options, more applications, more cloud providers
- Some are limited to solvers, some to open source, others can do complex workflows
- Some are limited in the choice of resources, compute nodes, others offer any
- Some focus more on SMEs, others on large enterprises
- Some offer just one software release, others multiple solver releases
- Some handle complex and custom workflows (in-house, FSI, Digital Twins, AI, . . .)
- Some offer access to **any** Cloud and arbitrary multi-node parallel clusters (scalability)
- Some request data download to local machine, some also download to cloud storage
- Some offer just CPUs, others CPU/GPUs for compute, post-processing, remote HD viz
- Most important: Only a few run in customer‘s cloud subscription (exclusive control !)

Option 3: HPC System Integrators (SI)

GNS, Atos/s&c, Do-IT, TotalCAE, . . .

- Many large companies collaborate with HPC SIs
- Excellent HPC / CAE expertise, for many years
- Their major business is to sell HPC
- They know their customer IT in and out
- And, some offer also HPC Cloud services
- Well suited, if your company collaborates with an HPC SI already, and this SI has proven experience with successful HPC Cloud implementations

Option 4: HPC Cloud Providers

Amazon AWS, Microsoft Azure, Google GCP, Oracle OCI, . . .

- 100+ different cloud services: HPC infrastructure, software tools, AI, etc.
- Total cost of implementation and consumption often not easy to calculate
- Too many customers but not enough great experts managing complexity
- Therefore, well suited for standard cloud services
- But, for more complex cloud service, they collaborate with cloud services partners
- Perfect approach: Work with CSP who takes **your** Cloud Provider on board =>
- Joint Discovery Meeting => Proof of Concept => Minimum Viable Product => Production

Option 5: Do-It-Yourself (DIY)

Work with your IT Department

- Do you have the combined and hands-on expertise and experience on HPC and on CAE and on HPC Cloud?
- Cloud infrastructures get updated and enhances often, be up to date
- Think big, start small – start with a proof of concept, with one ‘easy’ application
- Still, the risk of failure with DIY is high
- And it always takes much longer than you thought.

Cost Saving & ROI Gains with Cloud HPC

- Using reserved and spot instances save 40% – 80% of on-demand list price instances
- Due to faster/more hardware, e.g. 2x, increasing your CAE license efficiency by 2x
- 20% to 50% cost savings by monitoring, analysis, and optimization tools
- More productive engineers: On-prem: 1 engineer (cost p.a. $250K) 10 hours for 10 simulations Cloud: 1 hour on 10 cloud servers (running in parallel) = 10 engineers on prem. Saving: $2.25M p.a.
- More simulations (in the cloud) allow you to discover potential failures in your next-gen products earlier in the design/development cycle, thus potentially saving millions of $$
- Cloud OPEX replaces most of on-prem CAPEX, thus no large upfront expenses and long procurement, implementation, and quality testing times.
- More compute resources enable more simulations with more parameters thus producing better results (finding better materials, geometries, physics) and thus higher quality products that allow you to charge more and/or to out-compete your competitors.

[Click here to learn more]

CXO Benefits in Strategic Term

- Shortening of product development and thus **time to market**
- Improvement of **product quality** through detailed and faster parameter studies
- Thus strengthening your **competitiveness** and ability to **innovate** fast
- **Cost savings**, expensive acquisitions and maintenance are no longer necessary
- **Integrability** of the HPC environment into the company IT environment (as part of the company-wide digital transformation) and thus abolition of internal IT silos
- No cloud lock-in through containerization and Kubernetes
- If necessary for some projects, repatriation is straight forward

Benefits for **Corporate IT**

- Save time by avoiding unforeseeable efforts due to “Do It Yourself”
- Provide tools to Corporate IT for managing, monitoring, health-checking, maintaining, operating, and supporting the engineers' simulation environment
- Interact with external engineering team to continuously update and improve the cloud services
- Few IT teams have the combined Cloud-HPC-CAE experience of external devs, devops, and finops teams
- 20% to 50% proven cost savings by monitoring, analysis, and optimization tools, in addition to huge time savings.

Benefits for **Engineers & Their Managers**

- **Fully automated** cloud process
- Conversion of on-prem HPC to "**HPC as a Service**"
- Greatest **flexibility** in the use of resources
- **10X increase in productivity of** simulation engineers
- Always access to **latest** hardware & software
- User friendly: "Cloud with one click", "no learning needed"
- Secure access to simulation environment from anywhere
- Containers contain engineer's workflow and a virtual desktop
- Remote viz of results, GPU acceleration

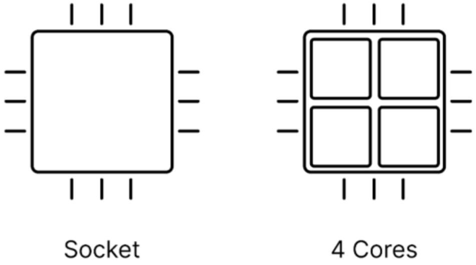
IT

- Computers
- Operating systems
- Storage
- Networking
- Workload portability
- Cyber security

IT Terminologies

Compute hardware

A CPU (Central Processing Unit) core is a single processing unit within the CPU that can execute instructions. A socket is generally understood to mean a single physical processing unit. Modern processor architectures usually have multiple physical processing units or cores on each physical CPU or socket. Compute nodes are the primary processing units in a HPC cluster. They can homogenous and consist of only CPUs or GPUs, or be heterogeneous and contain both.



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IT Terminologies

Linux Operating Systems

Linux and Unix based Operating Systems (OS) power billions of phones, tablets, smart watches, and even cars. Some popular builds are Ubuntu, RedHat, CentOS and Fedora.

Native support for Shell programming languages like Bourne shell, Csh, Zsh makes Linux the top choice for server side applications including HPC. It makes it easy to automate and orchestrate applications on HPC clusters.

[Click here to learn more]

IT Terminologies

NFS (Network File System)

Network File System (NFS) is a distributed file system protocol that allows file access over a computer network much like local storage is accessed. The NFS protocol is primarily used to attach file systems in the network to Linux based computers and hence is frequently used in HPC clusters.

Samba Server

Samba is a free software re-implementation of the SMB (Server Message Block) networking protocol that allow NFS devices to be mounted on Windows based computers.

Click here to learn more

IT Terminologies

Lustre file system

Lustre (Portmanteau of Linux, Cluster) file systems are scalable, parallel distributed file systems that can service multiple HPC clusters with tens of thousands of client nodes and providing aggregate I/O throughput of up to 10 TB/s. Many CAE applications require Lustre as default due to their high I/O demand.

Fabric Attached Storage (FAS)

Fabric Attached Storage (FAS) is a storage technology that can serve storage over multiple file-based, block based protocols eliminating the need for having dedicated Samba or NFS storages.

IT Terminologies

Cloud computing

Cloud computing delivers computing services over the internet. There are multiple levels of cloud services like Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS).

Cloud lowers the cost of entry and democratizes the access to HPC. The major Cloud Service Providers (CSP) have services that specifically cater to building and using HPC clusters for R&D and industry deployment. In addition to CSPs, there are SaaS companies that offer simulation capabilities with Cloud Infrastructure as the backbone.

Click here to learn more

IT Terminologies

Virtual Machine (VM)

A virtual machine (VM) is a compute resource that uses software instead of a physical computer to run programs and deploy applications. It functions as an isolated system with its own CPU, memory, network interface, and storage, created from a pool of hardware resources. Software called a hypervisor isolates the necessary computing resources and enables the creation and management of VMs. This technology allows Cloud Service Providers to build data centers with thousands of computers and make them available as an Infrastructure as a Service (IaaS) as VMs can be launched and destroyed on any machine with the click of a button.

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[Click here to learn more]()

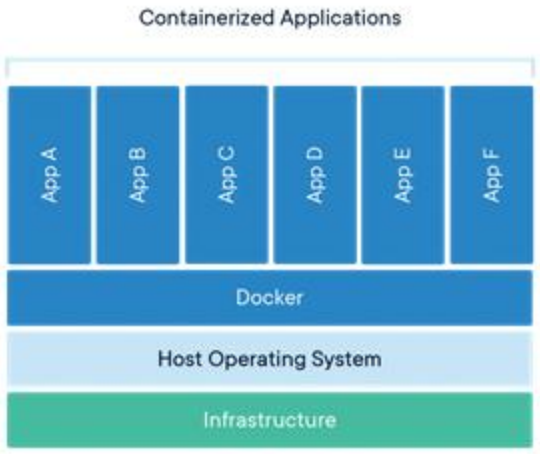
IT Terminologies

Containers (workflow portability)

Containers are lightweight packages of your application code together with dependencies such as specific versions of programming language runtimes and libraries required to run your software services.

Portability is the ability to seamlessly operate in multiple environments, without rebuilding the dependencies.

The most popular way to achieve portability is the use of software called Containers (Docker, Apptainer etc). The containers encapsulate the application software, system tools and libraries, and a base operating system. The container runtime is the only component that needs to be installed to run a container.



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IT Terminologies

Container orchestration (Kubernetes)

Container deployment can be automated using container orchestration software like Kubernetes (K8S). K8S can automatically deploy, maintain and scale containerized applications to meet needs of different workloads.

Engineering Simulation

- Applications of CAE
- Parallel execution
- Licensing models
- Performance optimization
- Simulation workflows

What is CAE?

CAE stands for Computer Aided Engineering.

CAE is the use of **computers** to **aid** in **engineering** tasks (e.g. simulations).

This includes steps like:

- Preparation (CAD preparation, meshing, setup) - Memory and computationally intense
- Solving (Computing) - Heavily dependent on GPU/CPU and networking
- Post-processing (Analyzing results) - Memory and GPU intense

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Mesh

A mesh partitions space into elements (or cells, zones, volumes) over which algebraic equations are solved, which then approximates the mathematical solution over the geometry domain.

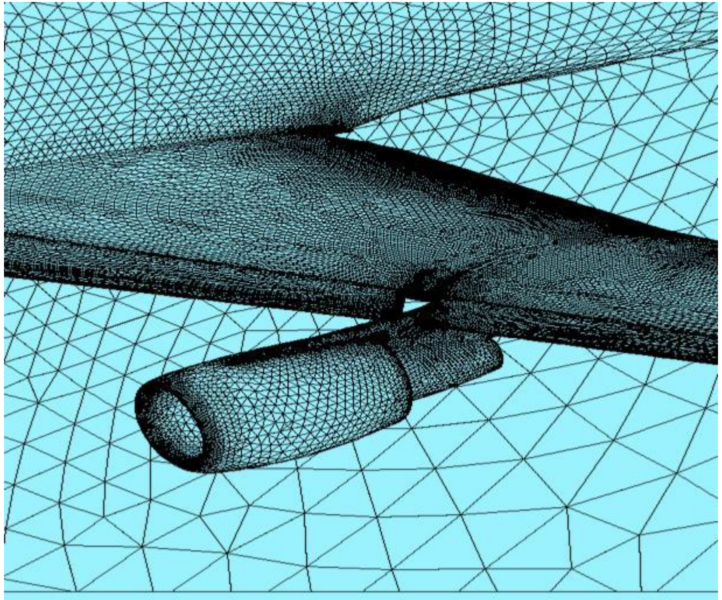
The size of the mesh dictates the computational complexity of the simulation (finer mesh = more computation power and memory).

There are many types of mesh types:

- Structured
- Unstructured
- Hybrid
- Adaptive

Common mesh counts for industrial CFD/FEA problems are in the order of 100,000,000 cells, currently often limited by the memory and performance of on-premise computers.

Accuracy of the numerical solution depends on the mesh size, the finer the mesh the more accurate the solution.

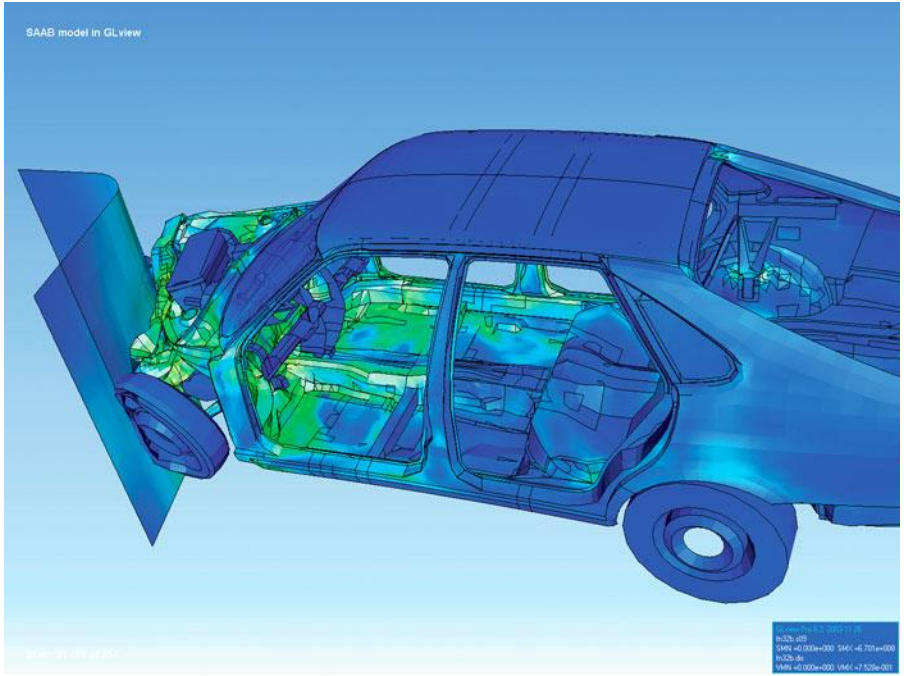


Mesh Generation in CFD by Ideen Sadrehaghighi, Ph.D.

Types of CAE

Finite Element Analysis (FEA)

- Structural analysis software based on the finite element method.
- Off-the-shelf codes: Abaqus, LS-DYNA, NASTRAN, etc.
- Used in analyzing structural, fatigue, and deformation cases.



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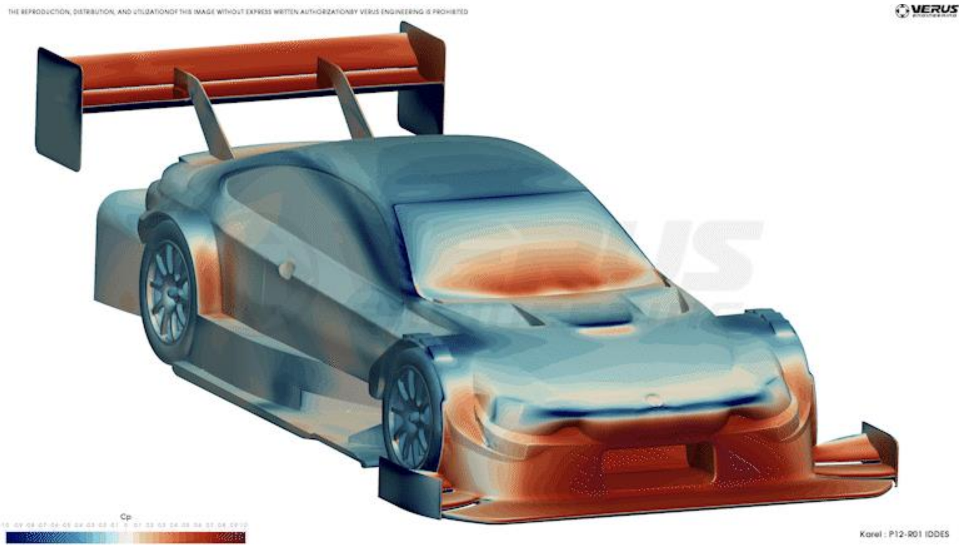
Types of CAE

Computational Fluid Dynamics (CFD)

- Fluid analysis software based on the finite difference method, finite volume method, or smoothed particle hydrodynamics.
- Off-the-shelf codes: OpenFOAM, Ansys Fluent, Siemens Simcenter STAR-CCM+, Fifty2 PreonLab, etc.



By Cfd racer - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=126831736

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Types of CAE

System modeling (1D modeling)

- System modeling uses various physics and numerical techniques to capture long dynamic system behavior.
- Off-the-shelf codes: AVL CRUISE M, Simulink/Simscape, Modelon, etc.
- Block-based modeling.

https://www.avl.com/en/simulation-solutions/software-offering/simulation-tools-a-z/avl-cruise-m

Click here to learn more

Types of CAE

ADAS/Autonomous

- ADAS simulations involve scenarios, sensors, and environments.
- Can be open-source (CARLA, etc.) or off the shelf (AVL, Applied Intuition, Ansys, etc.).

https://www.theverge.com/2021/7/6/22565448/waymo-simulation-city-autonomous-vehicle-testing-virtual

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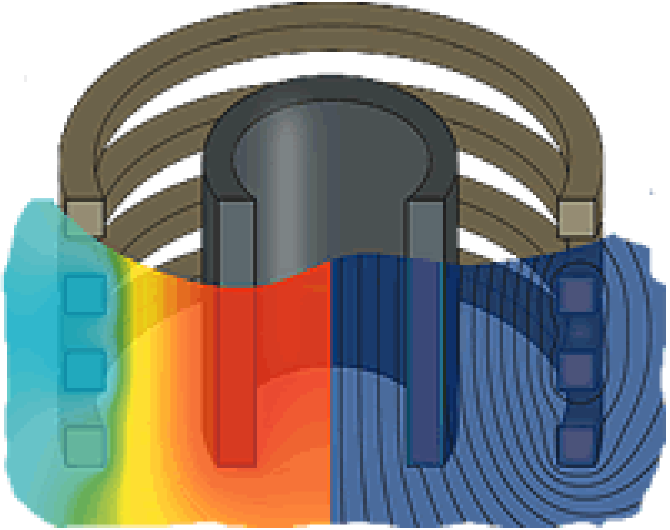
Types of CAE

Electromagnetics

- Based on Maxwell's equations for electromagnetism.
- Results can be used for magnetic design or input into electronic circuits.
- Most methods use a mesh based approach with finite element or boundary methods.
- Popular tools are Ansys AEDT, COMSOL, etc.



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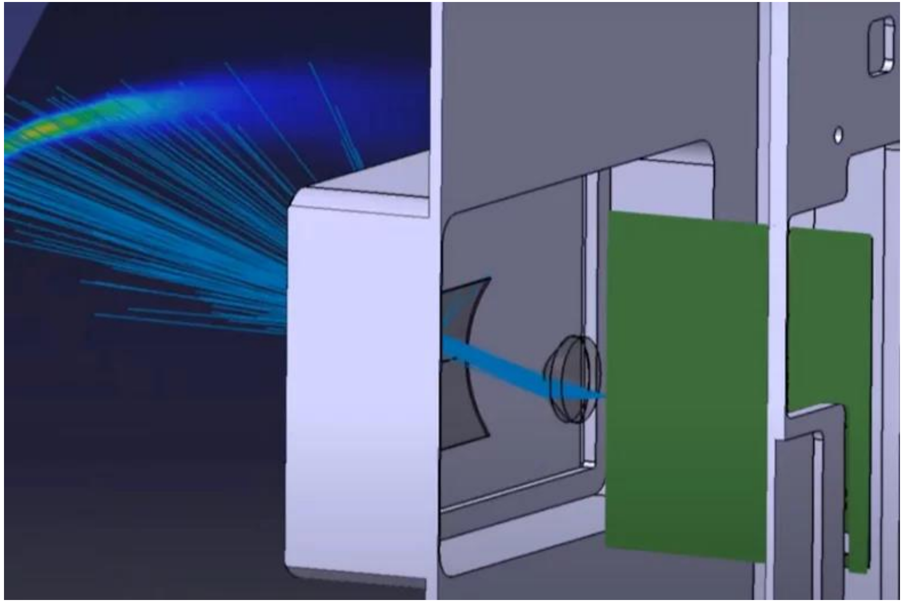
Types of CAE

Optical Simulation

There are 3 types of optical simulation:

- **Geometric Optics:** Simulates the behavior of light as it passes through optical components, taking into account the angles of incidence and refraction.
- **Physical Optics:** Simulates the behavior of light as it interacts with the physical properties of materials, such as diffraction and absorption.
- **Non-Sequential Optics:** Simulates the behavior of light as it passes through complex optical systems, including multiple reflections and refractions.



https://www.ansys.com/applications/autonomous-sensor-development

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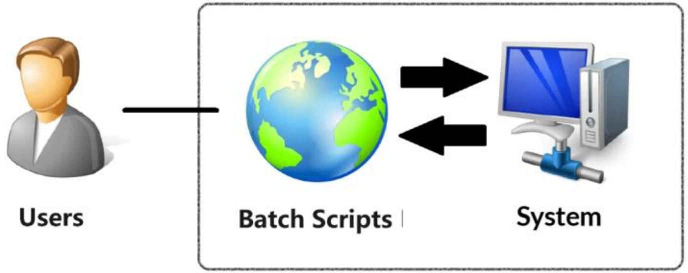
Post-processing

- Post-processing helps analyze the generated simulation results in a visual format.
- Can be very memory intense and high utilization of GPU for rendering.
- Most codes have built-in capabilities but some can be self-developed.

Application Execution

Batch Execution

Using scripting languages to automate the execution of applications without requiring user intervention is called Batch processing or running applications in a batch mode. These scripts can be setup to take input parameters before hand and run large number of computations without having the user to open the Graphical User Interface (GUI) provided with the application.

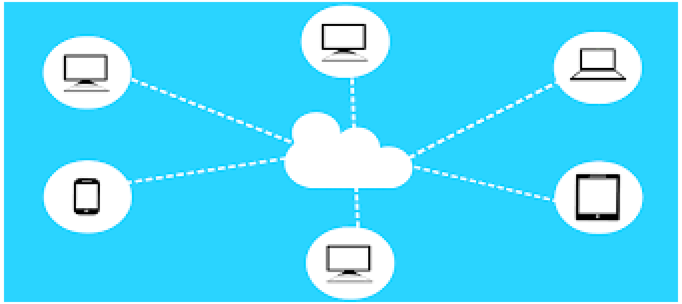


[Click here to learn more]

Application Execution

Distributed processing

Distributed processing is where a job is sent out multiple times across many processors or nodes with varying inputs, one job per input per processor. The previously mentioned network interconnects (InfiniBand, RoCE, etc.) are important. This is usually due to a statistical strategy as part of the simulation workflow such as design of experiments, optimization, or AI/ML methods.



[Click here to learn more]

Licensing Models

- **Node-locked** is a license that designates the user by MAC Address.
- **LAN (Local-Area Network)** is a license pool that gets checked out locally within a facility. It's also called "floating license".
- **WAN (Wide-Area Network)** is license usage mostly restricted to state or country.
- **GWAN (Global Wide-Area Network)** is license usage for global license pools.
- Token model is when each product in the CAE ISV's portfolio has a certain token cost per license. This is a pool that allows dynamic access of a CAE portfolio.

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Congratulations

SimOps Foundation Self Assessment Completed

We invite you now to take the SimOps Fundamentals Exam and get your Certification:

https://www.classmarker.com/online-test/start/?quiz=6xh66b9e25747ded