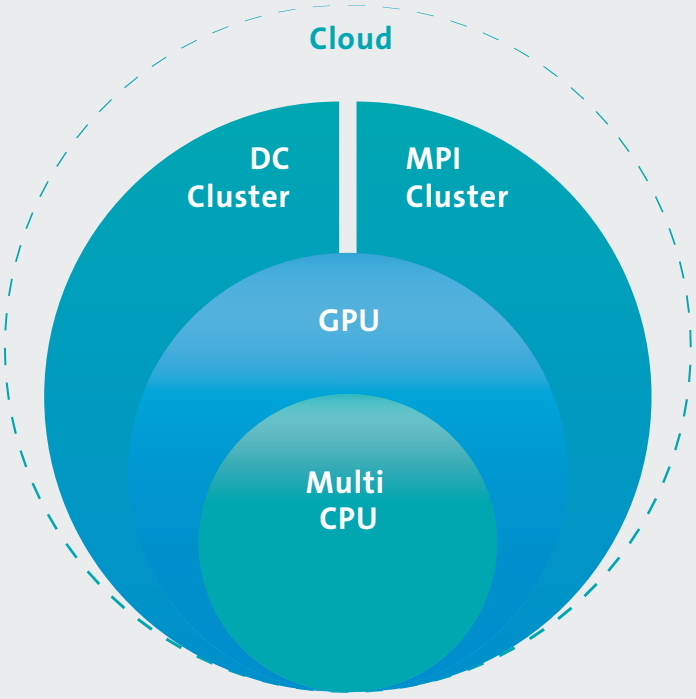
CST STUDIO SUITE

High Performance Computing Solutions

CST® STUDIO SUITE® offers a broad range of hardware based acceleration methods. The systems that are supported range from single off-the-shelf workstations to high-end cluster based solutions. A critical measure in determining the feasibility of a simulation is the computational time needed to complete the simulation to a particular level of accuracy. Although this time can be reduced by choosing an appropriate solver and solver settings that are well suited to the problem, many simulation tasks still require a high level of computational resources. This could be because of extensive parameter studies, a high model complexity, or simply a large number of mesh cells needed for the discretization. In these cases it is impractical or even impossible to handle the simulations using a standard workstation computer. High Performance Computing (HPC) techniques help reduce the computational time of such simulations, and make the handling of complex models possible.



Hardware consulting services range from review of system configurations regarding optimal performance for a certain solver to intense benchmarking and analysis.

CST HPC Consulting Services

CST offers flexibility in terms of hardware and configuration, from desktop to server to HPC cluster and cloud.

In order to help make the most of investments and make it easier to choose the most effective acceleration solution for a given simulation model, CST uses an acceleration token licensing scheme. This enables great versatility in accessing and combining high-performance computing options, allowing acceleration methods to be mixed and matched.

The HPC experts of CST are available to guide you through the process of selecting the appropriate HPC hardware which runs your simulations with the best possible performance. In-house or together with selected hardware partners CST offers benchmarking on the actual HPC hardware to give you confidence regarding the performance gain which can be achieved with a certain solution.

Choose the approach which best fits your needs.

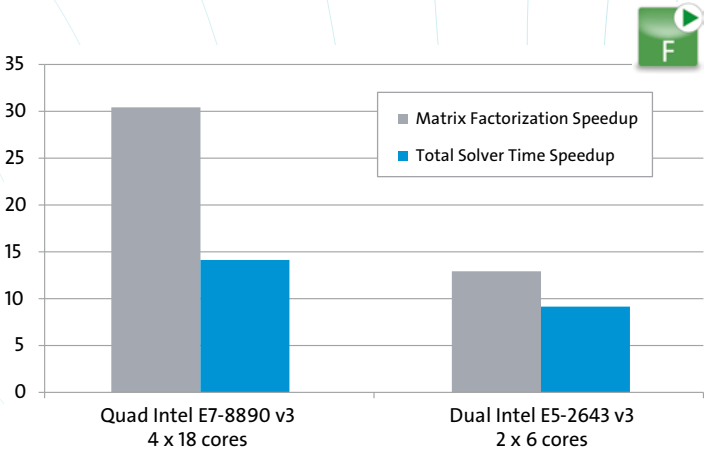
High Performance Computing Solutions

Multithreading

Modern workstations are equipped with multiple CPU cores, and often even with multiple sockets and devices which enable them to work faster by executing several computations in parallel. The CST solvers as well as the computationally expensive steps in pre- and post-processing are well prepared to utilize the capabilities of modern multi-socket systems, and the standard license enables the usage of all CPU resources found on a typical workstation at no additional cost. Additionally, the capabilities of multi-socket systems in terms of RAM memory capacity enable memory-intensive but computationally efficient solver algorithms to be run on large models.

Much of CST STUDIO SUITE (solvers, pre-, and post-processing) benefits from running on modern multicore processors because work can be distributed across the available cores.

Supported by: Most solvers | Best for: All simulations



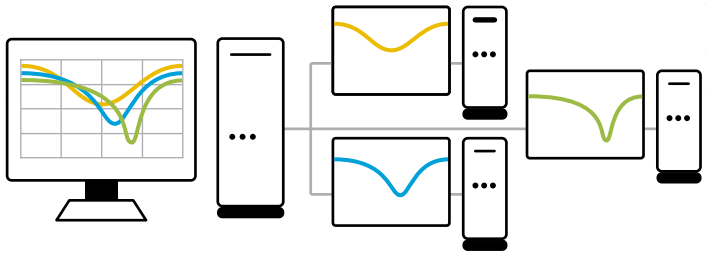
Performance of the CST MICROWAVE STUDIO® frequency domain solver (direct solver) relative to single core operation on an E7-8890 v3 four socket server as compared to a dual socket server equipped with E5-2643 v3 CPUs. The benefit of the additional CPU sockets on the quad socket server can be seen clearly.

Distributed Computing

Distributed computing – available for most CST STUDIO SUITE solvers – is an efficient method for running multiple independent simulation tasks like parameter sweeps in parallel on a computer cluster. It is ideally suited to the parallel simulation of multiple ports (using the transient solver), or multiple frequency points (with the frequency domain solver). The main controller automatically selects the computer with the most appropriate hardware for the simulation, and can control multiple solver servers with different hardware configurations.

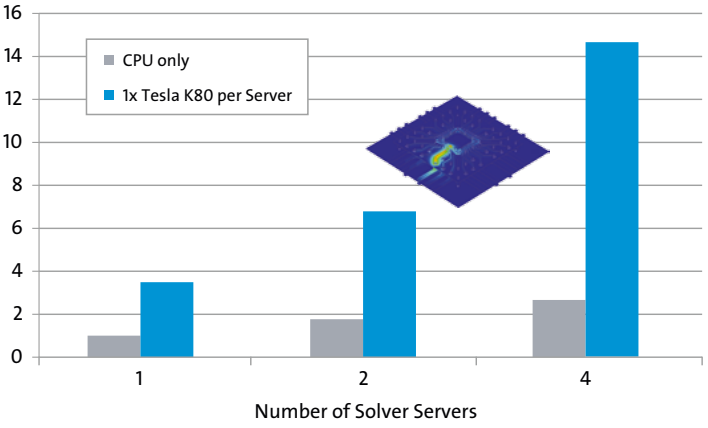
Distributed computing is particularly beneficial for multiple independent, high volume simulations of small to large models, and is available for almost all CST STUDIO SUITE solvers.

Supported by: Most solvers | Best for: Simulations with many ports or frequency points, Parameter sweeps



Distributed computing enables the distribution of independent simulation runs (such as simulations of a parameter sweep) on a computer cluster.

Distributed Computing Performance



Speed-up Dual Xeon E5-2643 v3 servers with one Tesla K80 card each, relative to a single machine with CPU only.

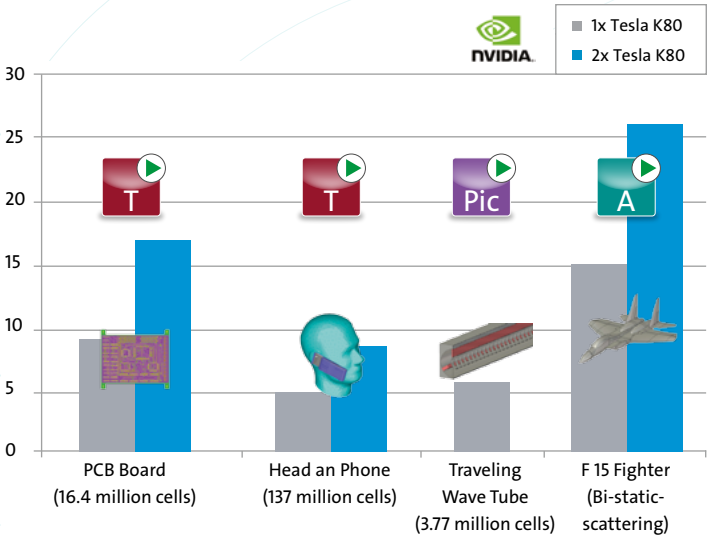
Hardware Acceleration

Some CST STUDIO SUITE solver algorithms can experience dramatic performance improvements not achievable on the CPU level by using special accelerator devices. CST STUDIO SUITE supports a broad range of accelerator devices manufactured by NVIDIA (NVIDIA® Tesla®) and Intel (Xeon Phi™) to speed up the solvers.

By stacking multiple accelerator cards, models in the range of hundreds of millions of mesh cells can be accelerated to unprecedented speeds. Hardware acceleration can also be combined with MPI cluster computing in order to speed up the simulation of models with an extreme number of mesh cells.

Hardware acceleration can accelerate the simulation of your models far beyond what is possible on even a high end CPU.

Supported by: Time domain solver, TLM solver, asymptotic solver, integral equation solver, PIC solver | Best for: Medium to large simulations



For transient simulations, the solver loop speedup is shown. For all other solvers the total speedup is shown. The CPU reference time was provided by a simulation run on a system equipped with dual Xeon E5-2643 v3 CPUs

"GPU computing has allowed us to perform some complex simulations that were previously impractical."

Matt Fuller, Selex ES

MPI Cluster Computing

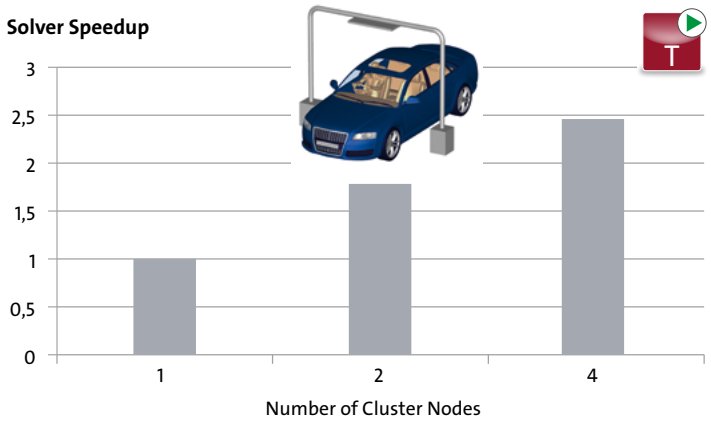
Some simulation problems require a very large number of mesh cells for discretization, either due to high geometric complexity or large electrical size. Solving such problems is often impractical – and sometimes even impossible – on a single workstation.

MPI computing allows the computational resources of an entire computer cluster to be used for a single simulation, to handle extremely large models efficiently.

CST STUDIO SUITE automatically distributes the computational tasks evenly across the cluster nodes to achieve load balancing. Hardware acceleration can be used on each cluster node in order to speed up the simulation further. This allows the accelerator memory limitation to be overcome, and makes hardware accelerated simulations possible for models of almost unlimited size.

MPI computing is an acceleration technique for the efficient simulation of very large models, and can be combined with hardware acceleration.

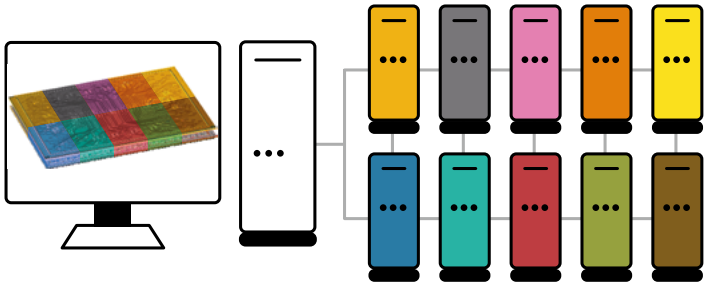
Supported by: Transient solver, integral equation solver, wakefield solver | Best for: Very large simulations



MPI Performance – Speedup for a cluster of Dual Xeon E5-2643 v3 servers with two Tesla K80 GPU cards each, relative to a single machine.
Modell: Electronic Toll Collect (ETC) application including detailed car model and human phantom model. 445 million mesh cells. CST MWS transient solver.

Intel® Cluster Ready

CST STUDIO SUITE is certified Cluster Ready by Intel.



MPI computing uses a domain decomposition technique to assign the computational workload to the cluster nodes.

High Performance Computing Solutions

Cloud Computing (Public and Private Cloud)

In the last few years there's been a trend in many companies to centralize the computing infrastructure such that the valuable resources can be accessed and shared by engineering teams working at different sites. Such in-house systems are often referred to as a "private cloud". CST provides tools and plugins to enable clean and robust integration of CST STUDIO SUITE in the environments commonly found on such private cloud systems including:
LSF, PBSPro, Torque, GridEngine, SLURM, HTCondor, EnginFrame.
CST's engineers are available to help with the integration of CST STUDIO SUITE in other environments not listed here as well.

For smaller companies and research groups, it often does not make sense to buy a cluster and pay for its upkeep when very demanding simulation projects only come along occasionally. For users who need short term access to high-performance computing resources on a moderate budget, cloud computing on the public cloud is the way forward. Rather than using an on-site system, the simulation model is uploaded via a secure channel to a HPC cluster maintained by a cloud computing provider, and the simulation is carried out on the remote system. Special licenses are available from CST for cloud computing on the public cloud.

CST STUDIO SUITE is available on the systems of various HPC cloud partners. The most up-to-date information is available on the "Cloud Computing" section of the CST website (www.cst.com/cloud).



HPC in the private cloud allows you to
- manage HPC resources to optimize simulation throughput.
- enable convenient access to centralized HPC computing infrastructure for users.

HPC in the public cloud allows you to
- cover high-end simulation workloads which require short term access to HPC resources.
- add additional hardware and license resources to scale your simulation capabilities up when your projects demand it.

www.cst.com/HPCflyer

Please contact your local CST representative or email info@cst.com for advice on the best technique for your needs. We can also perform benchmarks with your models, or work with your hardware vendor to test and benchmark highend hardware to ensure you achieve the best results from CST STUDIO SUITE.

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