GPU助力Abaqus提升有限元分析速度

黄霖 | DS SIMULIA China

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Topics

- SIMULIA & Abaqus 简介
- Abaqus GPGPU功能介绍
- Abaqus GPGPU加速计算测试
- 展望

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SIMULIA & Abaqus 简介

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SIMULIA & Abaqus 简介

DASSAULT SYSTEMES

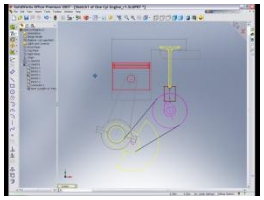
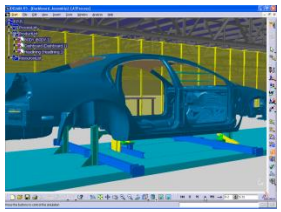
3D MCAD	Virtual Product	Virtual Testing	Virtual Production	PLM Collaboration	User Experience
+	+	+	+	+	+
SolidWorks	CATIA	SIMULIA	DELMIA	ENOVIA	3dvia
					
Productive, Easy- to-use 3D Design	***Product Excellence***	***Engineering Quality***	***Production Performance***	***Collaborative Intelligence***	***Lifelike Experience***

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Photo courtesy of BMW

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SIMULIA 产品简介

Gain significant business advantage over your competition

Abaqus Unified FEA

- Industry-leading simulation capabilities
- Same tools and models for a variety of simulations
- Associative access from variety of CAD environments

Isight

- DFSS, DOE, and Optimization
- Seamless integration of multiple tools

SLM

- Collaboration
- Lifecycle and data management

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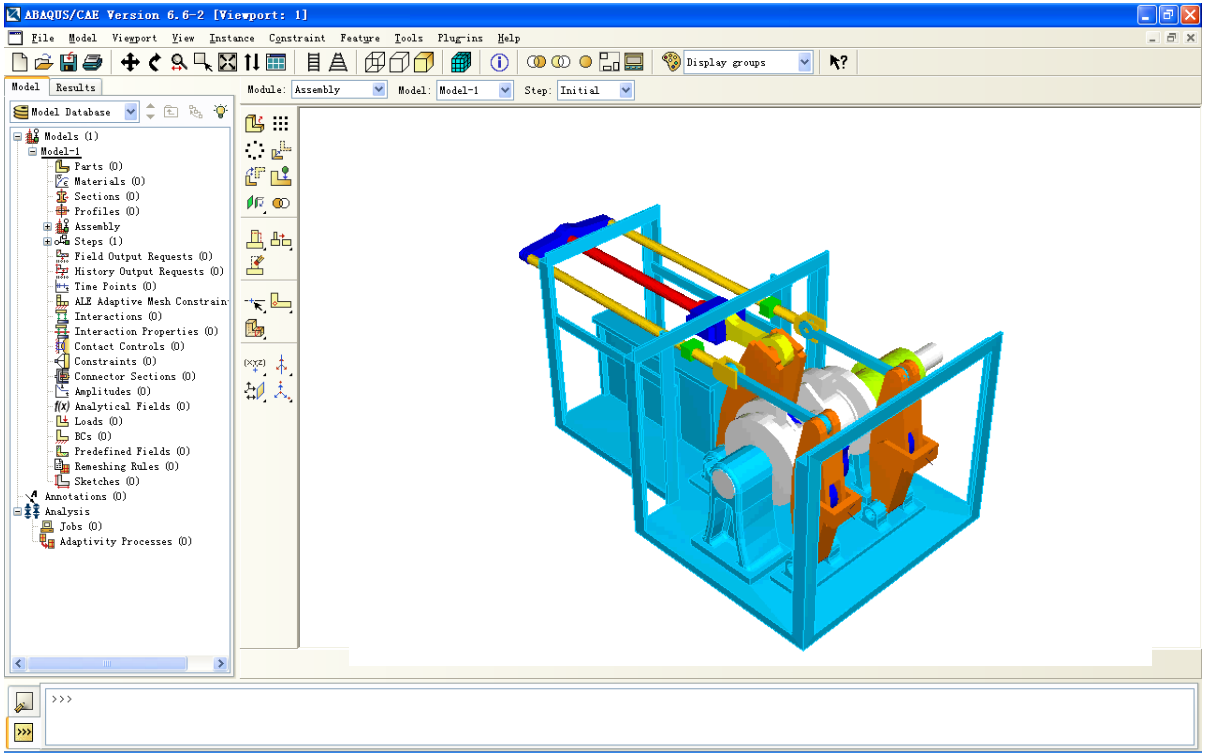
Abaqus 简介

- Abaqus/CAE
  - 为Abaqus求解器提供快速交互式的前后处理环境
  - Abaqus的建模、分析、监测和控制、以及结果评估的完整界面
- Abaqus/Standard
  - 主要用于结构静态、动态线性和非线性分析
  - 耦合分析
- Abaqus/Explicit
  - 瞬态的大变形和高度非线性分析
  - 可以在Abaqus/Standard分析结束状态进行继续分析
- Abaqus/CFD
  - 流体、流固耦合分析



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Abaqus 简介

Provide Realistic Simulation solutions for all industries

- Vision: “Make simulation an integral business practice”
- Mission: “Be the leading provider of simulation solutions for engineering and scientific simulation”

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Aerospace & Defense


Automotive & Transportation

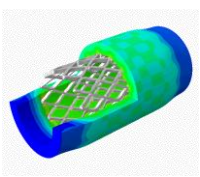

Energy


Industrial Equipment


Construction


High Tech


Shipbuilding


Life Sciences

Consumer Packaged Goods

Abaqus GPGPU功能介绍

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Motivation for GPU Acceleration

IDC's Top 10 HPC Market Predictions for 2010

February 17, 2010

6. x86 Processors Will Dominate, But GPGPUs Will Gain Traction as x86 Hits the Wall

- x86 processors went from near-zero to hero in HPC in the past decade, largely replacing RISC.
- x86 will continue to dominate, but GPGPUs will start making their presence felt more in 2010.
- Multiple Large HPC procurements have substantial GPGPU content.
  - GPGPUs play a crucial role in ORNL's planned exascale system.
- GPGPUs provide more peak/Linpack flops per dollar for politics and will inevitably provide more sustained flops for suitable applications.
- In 2010, some ISVs will announce plans to redesign their apps with GPGPUs in mind.

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What is it ?

- GPGPU stands for “General Purpose computation using Graphics Processing Unit”
- Interest is in using graphics cards to do general-purpose computing rather than only graphics
- Raw performance of high end GPUs is extremely good
  - Theoretically high end GPUs can deliver 1 TFLOP with a single card
    - To compare Abaqus requires 128 cores to deliver 1 TFLOP

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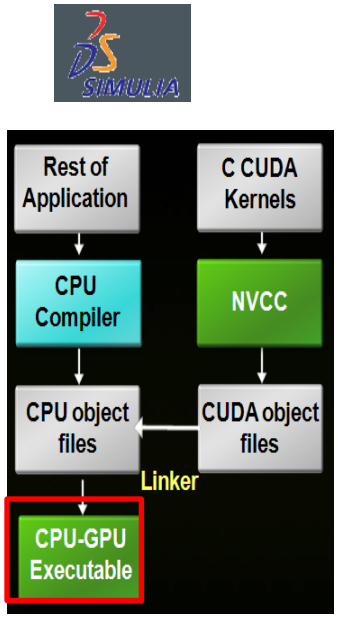
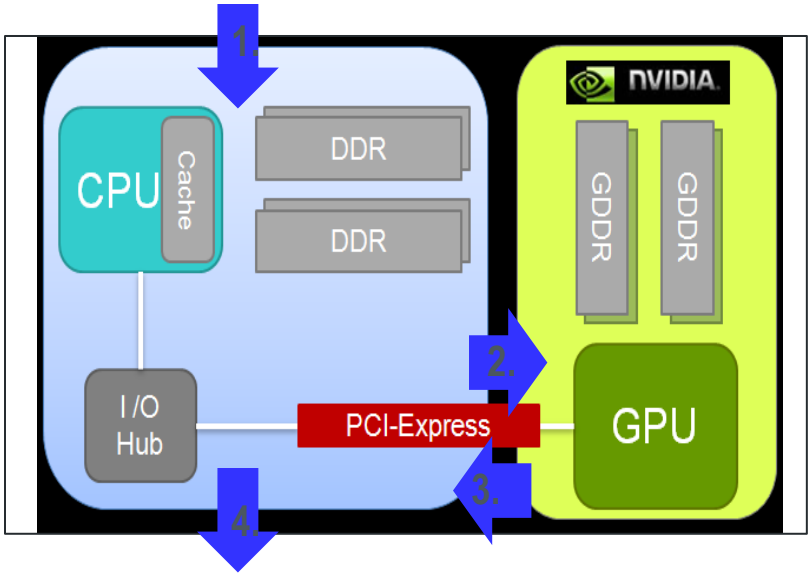
Basics of GPU Computing with Abaqus/Standard

- GPUs are an attached accelerator to an x86 CPU
  - GPUs cannot operate without an x86 CPU present
- Abaqus/Standard GPU acceleration is user-transparent
  - Jobs launch and complete without additional user steps
- Schematic of a CPU with an attached GPU accelerator:
  - CPU begins/ends job, GPU manages heavy computations





Schematic of an x86 CPU with a GPU accelerator

1. Abaqus job launched on CPU
2. Solver operations sent to GPU
3. GPU sends results back to CPU
4. Abaqus job completes on CPU

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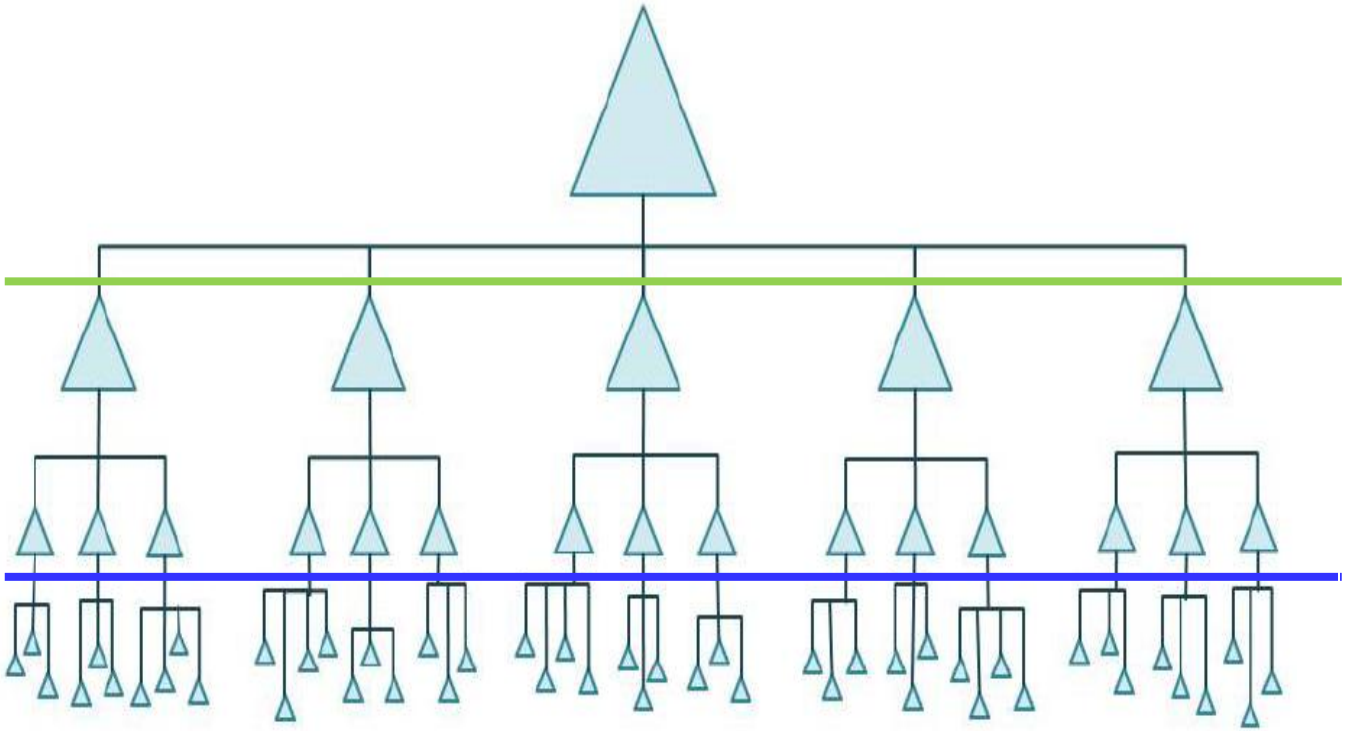
Basics of GPU Computing with Abaqus/Standard

Abaqus/Standard – deployment of a multi-frontal direct sparse solver

Large dense matrix fronts factored on GPU if not too large for GPU memory

Schematic Representation of the Stiffness Matrix that is Factorized by the Direct Solver



Upper threshold: Fronts too large for single GPU memory need multiple GPUs

Lower threshold: Fronts too small to overcome PCIe data transfer costs stay on CPU cores

Small dense matrix fronts factored in parallel on CPU – more cores means higher performance

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Abaqus GPGPU加速计算测试

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GPGPU测试环境

- **Abaqus 6.11-1**
- 硬件：**HP Z800** 工作站
  - CPU：Intel Xeon X5675 3.06GHz (6 core × 2)
  - **显卡：NVIDIA Tesla C2070**
  - 内存：48 GB
  - 硬盘： Seagate 15000rpm SAS 高速硬盘
- 操作系统：Redhat Server 5.6 x64

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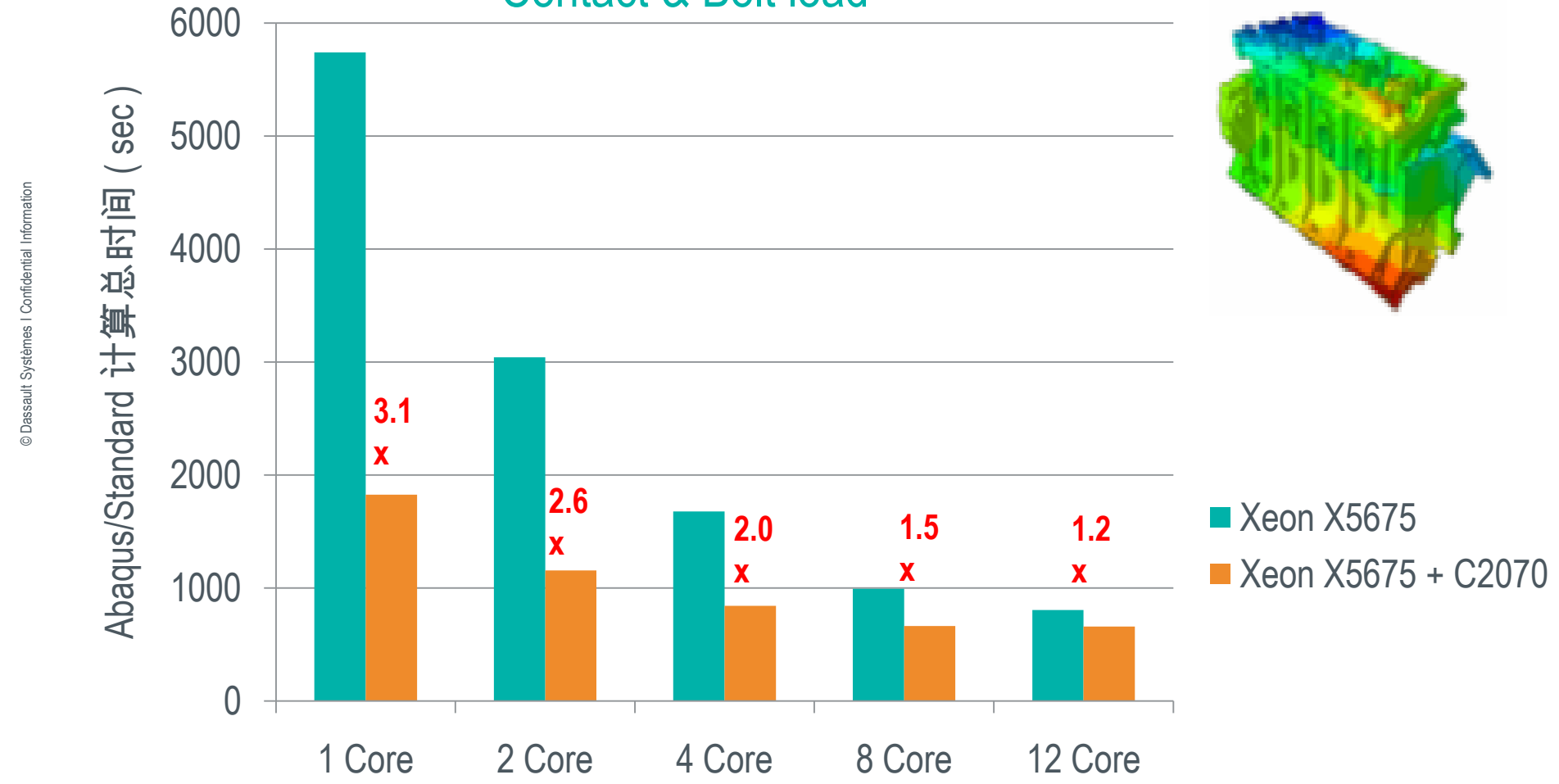
Abaqus standard benchmark – s4b

Engine Block Model of ~5M DOF

Contact & Bolt load



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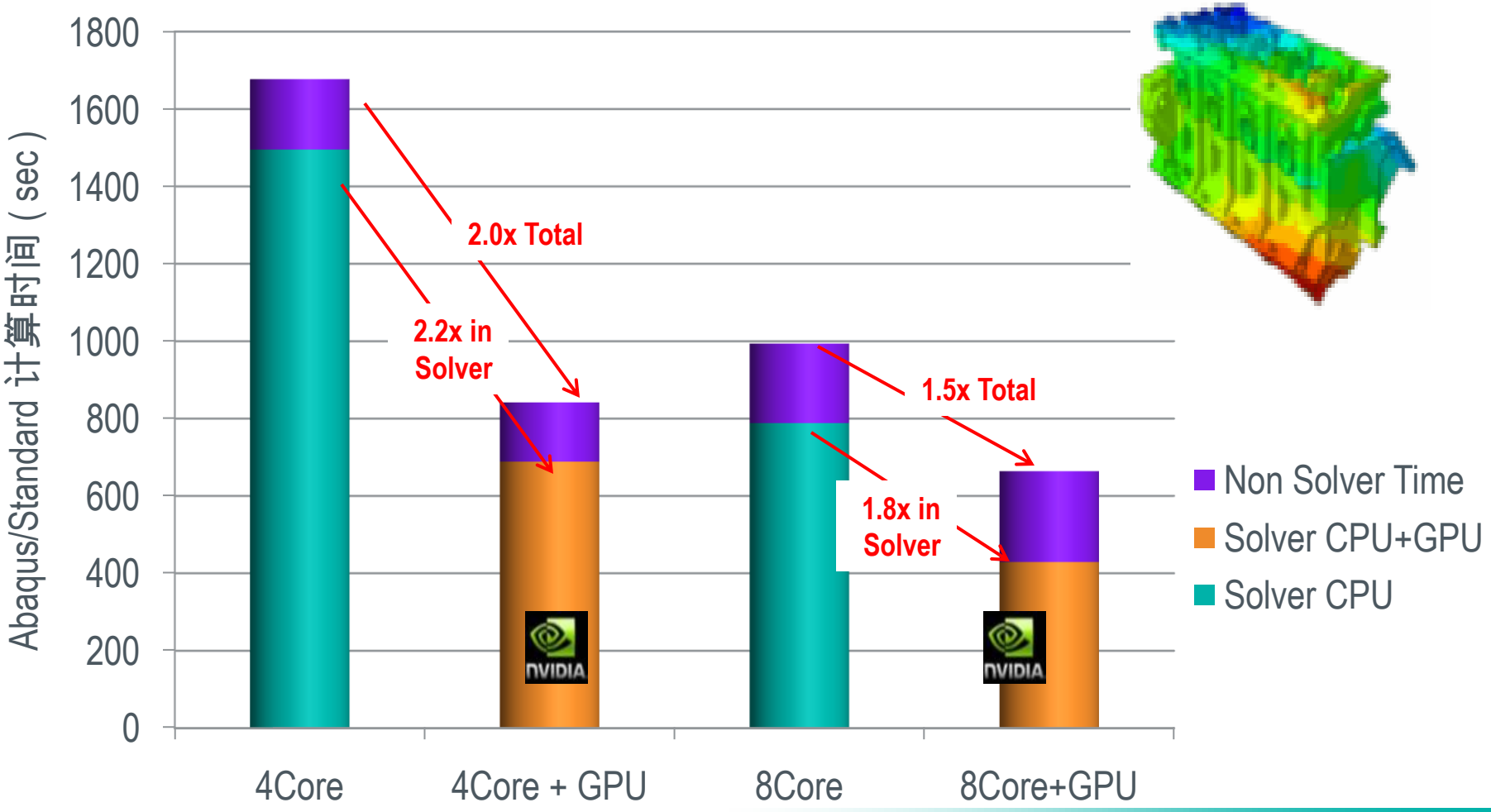
Abaqus standard benchmark – s4b

Engine Block Model of ~5M DOF

Contact & Bolt load



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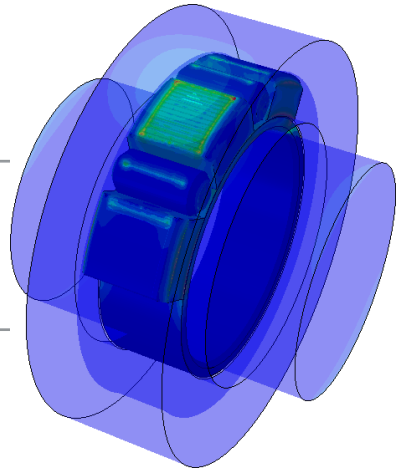
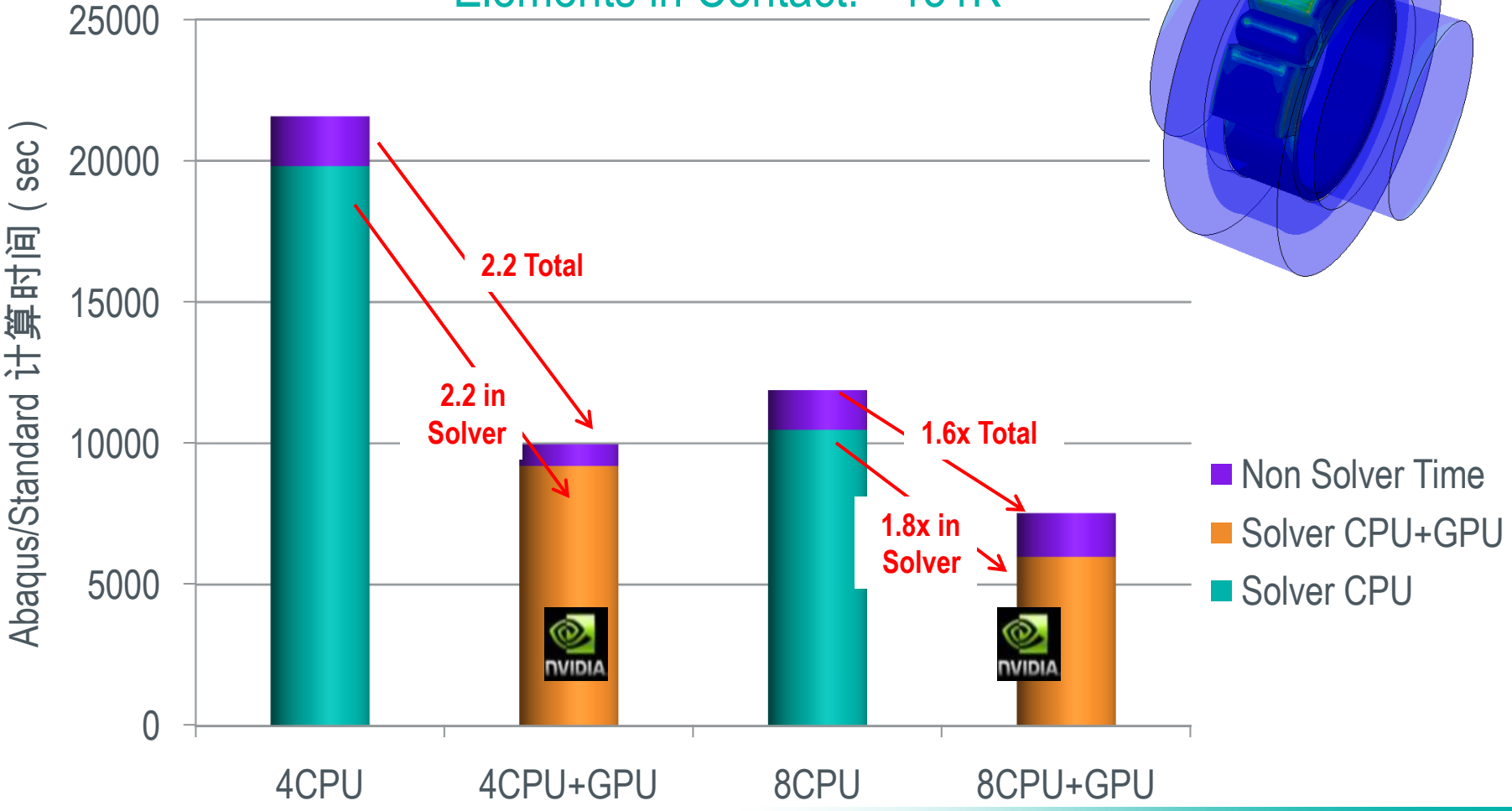
Customer benchmark (1)

Contact problem: ~1.5M DOF

Elements in Contact: ~151K





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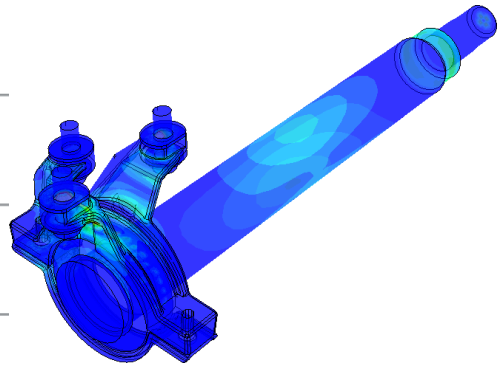
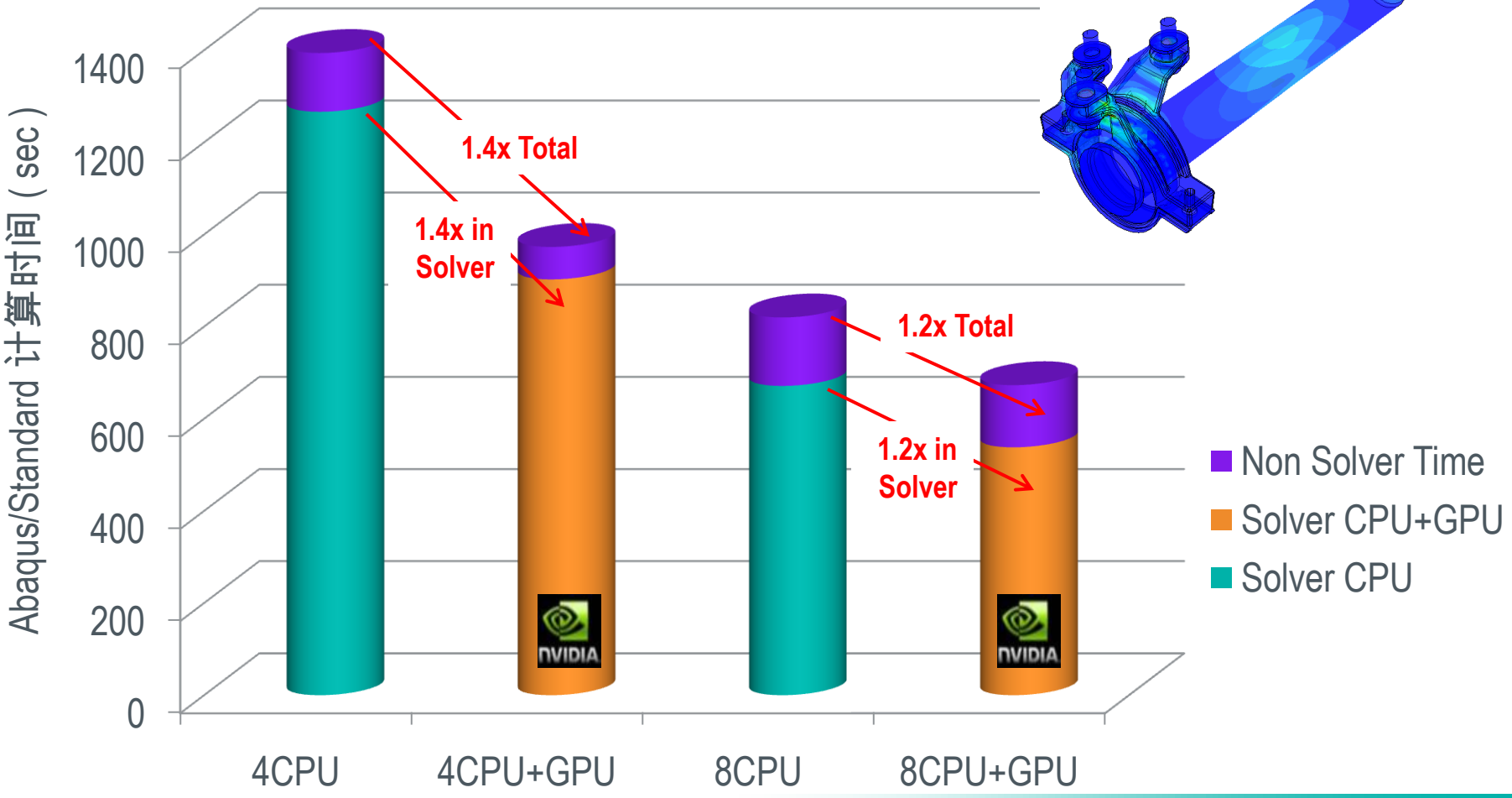
Customer benchmark (2)

Bolt load problem: ~1.1M DOF





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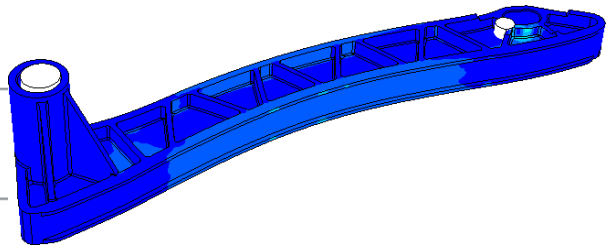
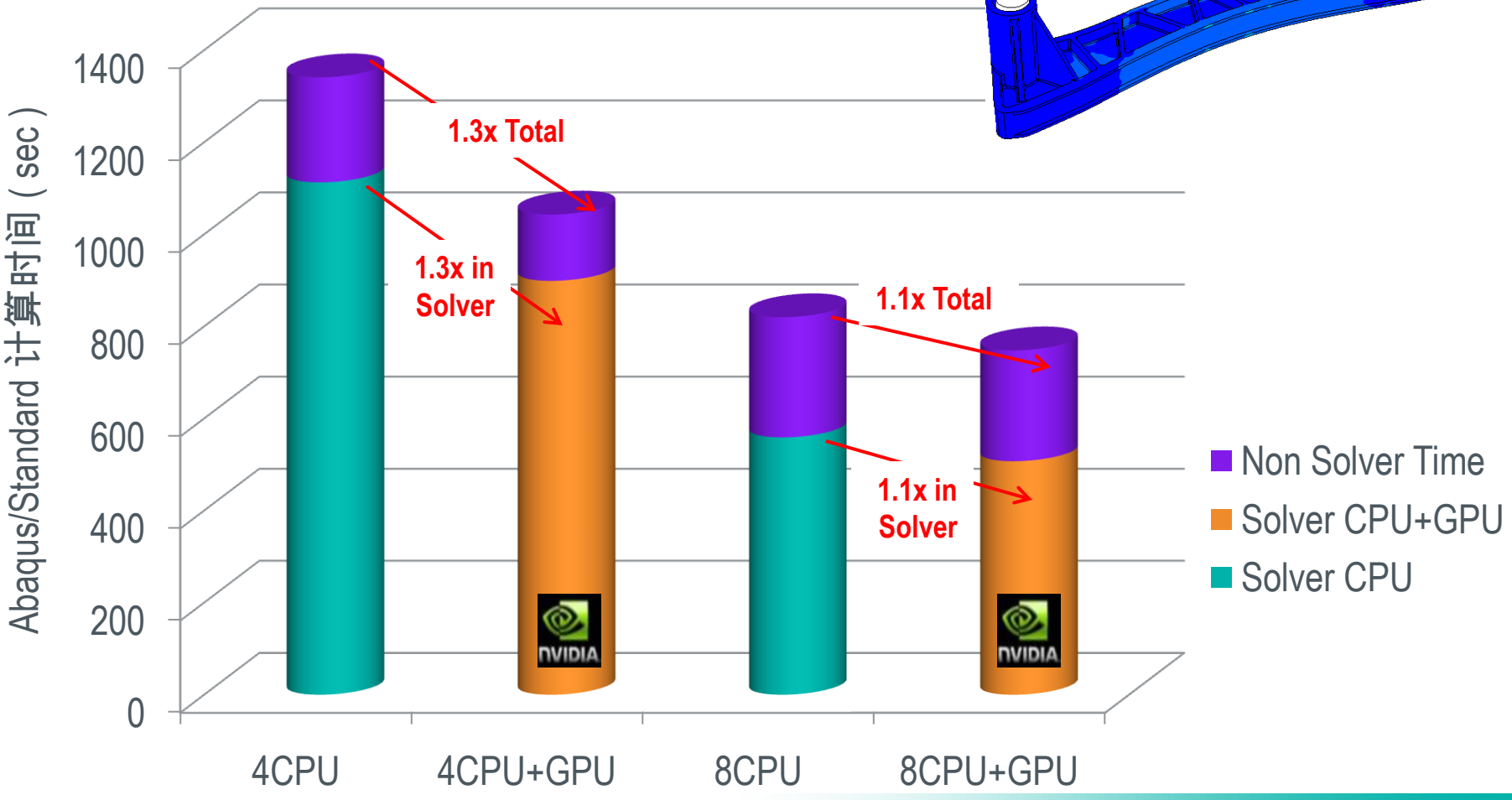
Customer benchmark (3)

Small-slide contact problem: ~0.8M DOF





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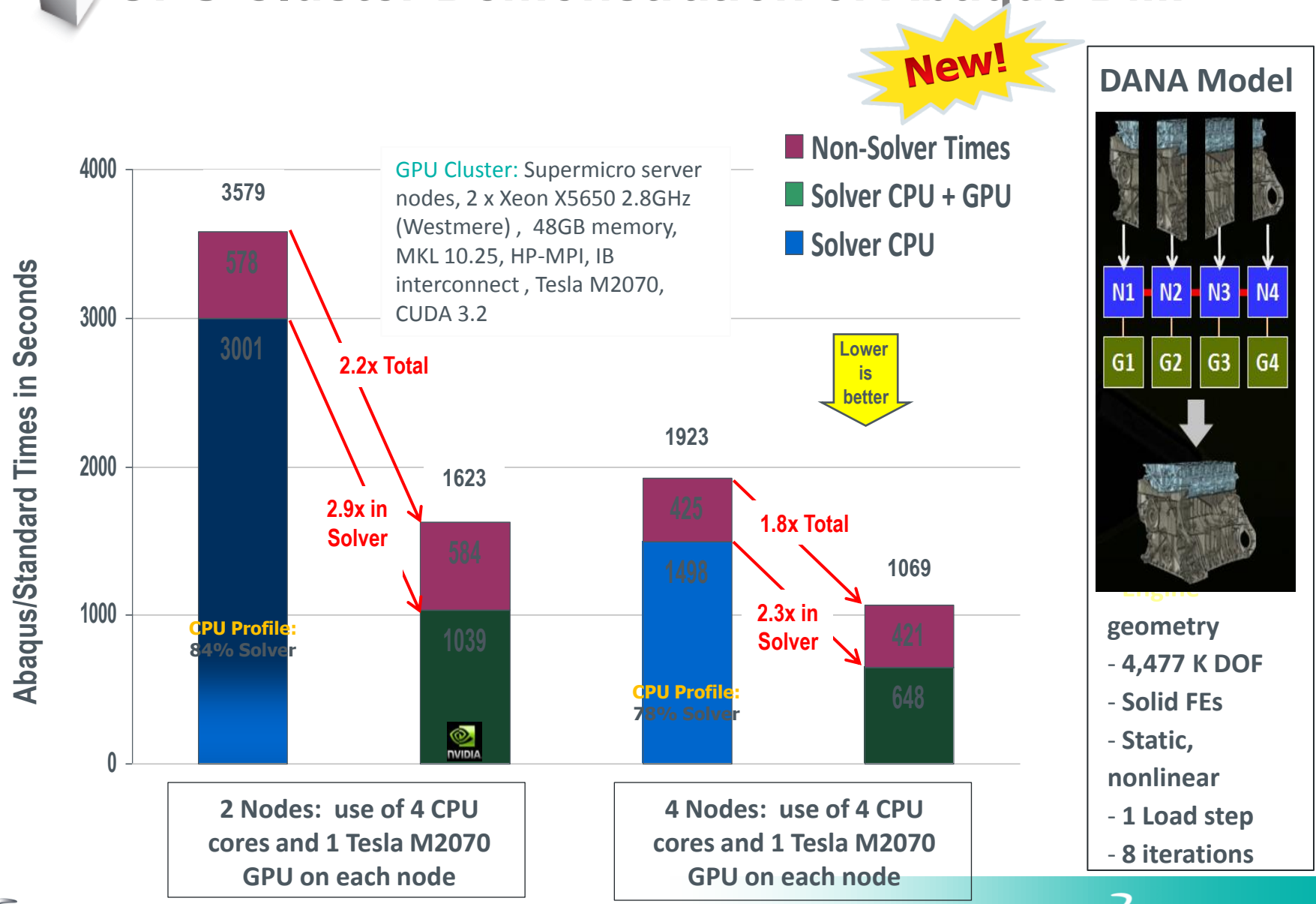
GPU Cluster Demonstration of Abaqus DMP



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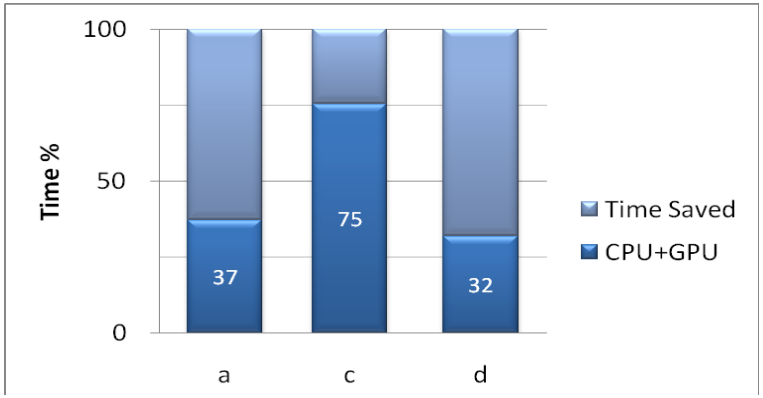
Benchmark (SCC)

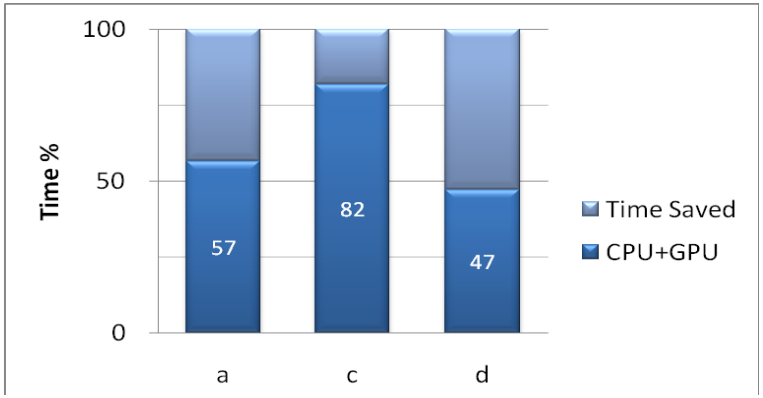
Case	问题描述	力学问题分类	单元类型	DOFs
a	悬臂梁	静力学	C3D8R	0.7M
c	斜板受压	材料非线性	S8R5	1.0M
d	实体碰撞	接触	C3D8R	0.6M

上海超级计算中心
Shanghai Supercomputer Center

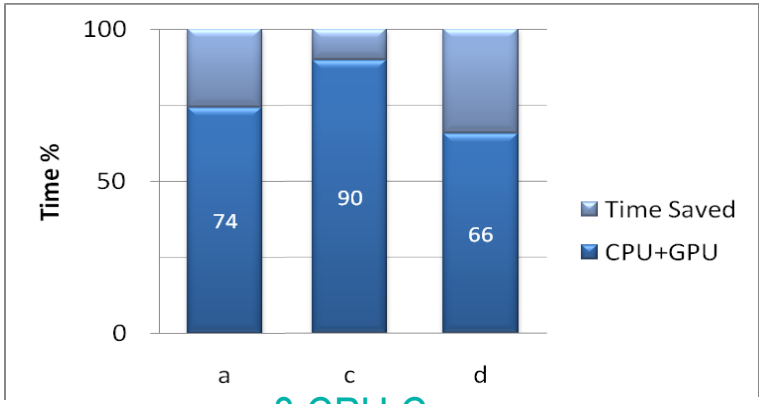
2～16 CPU Core
+ Tesla 2070 GPU



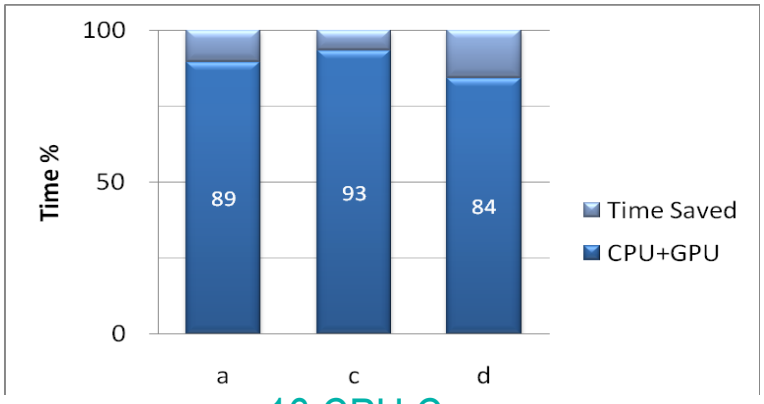
2 CPU Core



4 CPU Core



8 CPU Core



16 CPU Core

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Future work

- Unsymmetric solver
- Multiple GPGPU
- Applications outside of the direct sparse solver (AMS, Linear dynamics, etc)

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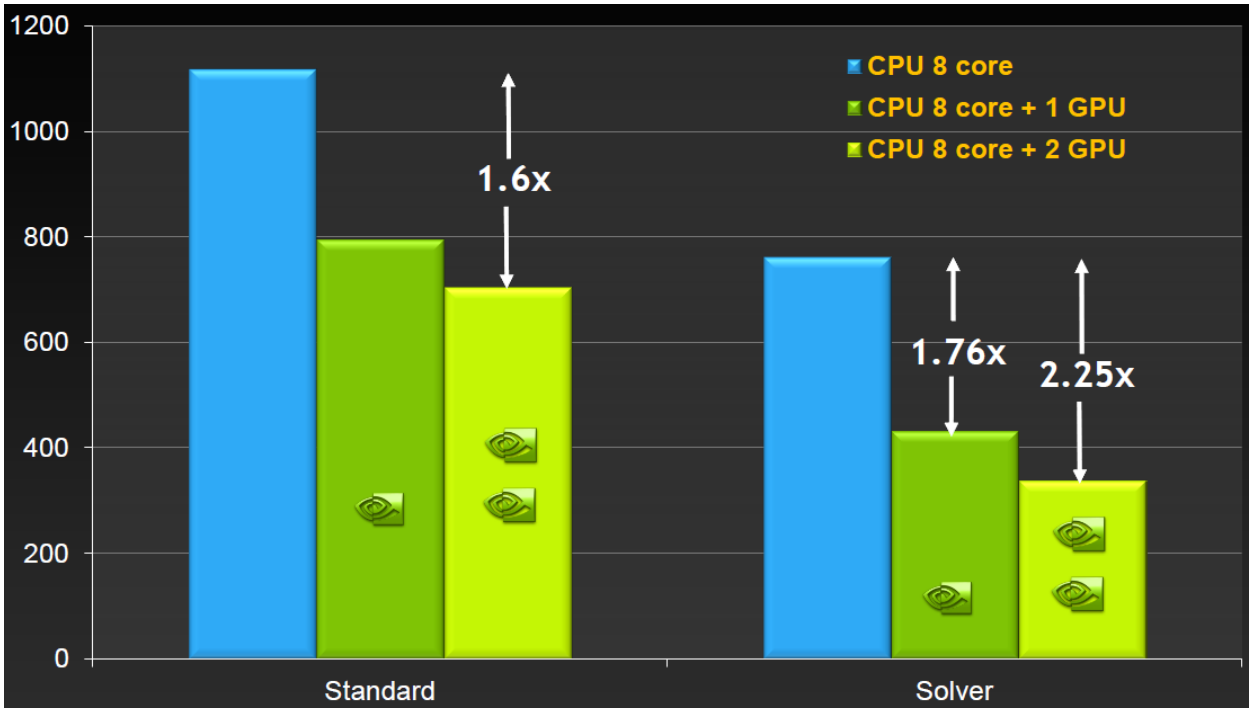
Multiple GPGPUs — Abaqus 6.12 Beta



HP Z800 Workstation, 2× Xeon X5550 2.67 GHz CPUs, 48GB memory; Tesla C2075 & Quadro 6000 GPUs

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SIMULIA and NVIDIA Collaboration Focus

- **Abaqus/Standard:** GPU acceleration of the direct solver for Linux and Windows – Full support announced for 6.11 release in May 2011
- **Abaqus/Explicit:** GPU R&D evaluation for future release
- **Abaqus/CFD:** GPU evaluation of implicit iterative solvers
- **Abaqus/CAE:** Development of graphics acceleration for pre- and post-processing with OpenGL and use of Quadro GPUs

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Thanks for your attention!

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