TESLA V100 PERFORMANCE GUIDE

Deep Learning and HPC Applications

JUN 2018

TESLA V100 PERFORMANCE GUIDE

Modern high performance computing (HPC) data centers are key to solving some of the world's most important scientific and engineering challenges. NVIDIA® Tesla® accelerated computing platform powers these modern data centers with the industry-leading applications to accelerate HPC and AI workloads. The Tesla V100 GPU is the engine of the modern data center, delivering breakthrough performance with fewer servers, less power consumption, and reduced networking overhead, resulting in total cost savings of 5X-10X. Each GPU-accelerated server provides the performance of dozens of commodity CPU servers, delivering a dramatic boost in application throughput. Improved performance and time-to-solution can also have significant favorable impacts on revenue and productivity.

Every HPC data center can benefit from the Tesla platform. Over 550 HPC applications in a broad range of domains are optimized for GPUs, including all 15 of the top 15 HPC applications and every major deep learning framework.

RESEARCH DOMAINS WITH GPU-ACCELERATED APPLICATIONS INCLUDE:

DEEP LEARNING

MOLECULAR DYNAMICS

QUANTUM CHEMISTRY

PHYSICS

GEOSCIENCE

ENGINEERING

COMPUTATIONAL FINANCE

HPC BENCHMARKS

Over 550 HPC applications and all deep learning frameworks are GPU-accelerated.

> To get the latest catalog of GPU-accelerated applications visit: **www.nvidia.com/teslaapps**

> To get up and running fast on GPUs with a simple set of instructions for a wide range of accelerated applications visit: **www.nvidia.com/gpu-ready-apps**

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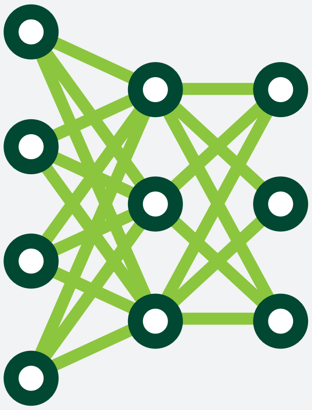
DEEP LEARNING



Deep Learning is solving important scientific, enterprise, and consumer problems that seemed beyond our reach just a few years back. Every major deep learning framework is optimized for NVIDIA GPUs, enabling data scientists and researchers to leverage artificial intelligence for their work. When running deep learning training and inference frameworks, a data center with Tesla V100 GPUs can save over 90% in server and infrastructure acquisition costs.

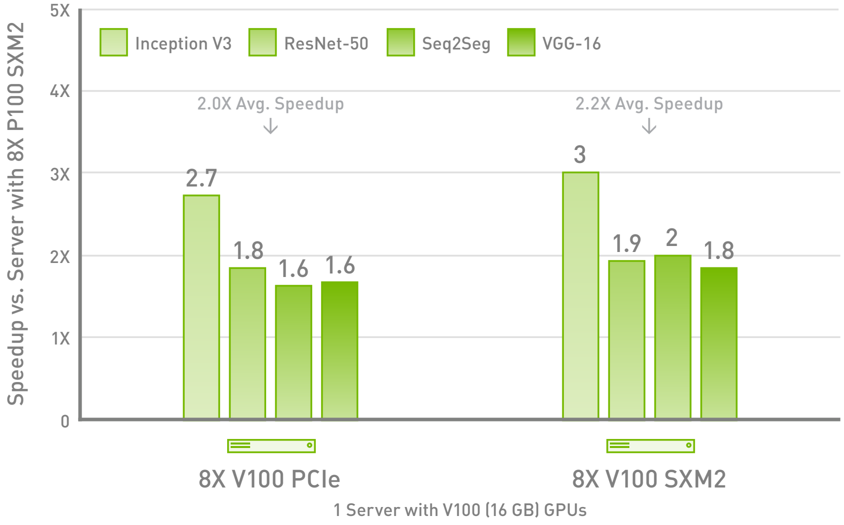
KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR DEEP LEARNING TRAINING

- Caffe, TensorFlow, and CNTK are up to 3x faster with Tesla V100 compared to P100
- 100% of the top deep learning frameworks are GPU-accelerated
- Up to 125 TFLOPS of TensorFlow operations per GPU
- Up to 32 GB of memory capacity per GPU
- Up to 900 GB/s memory bandwidth per GPU

View all related applications at:
www.nvidia.com/deep-learning-apps

Caffe2 Deep Learning Framework

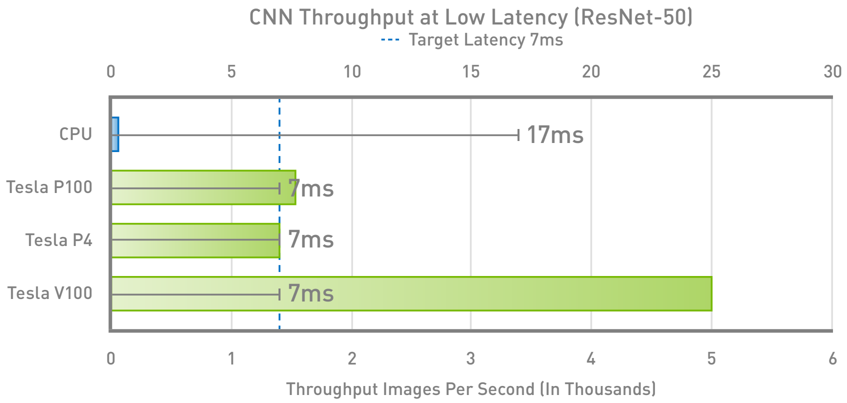
Training on 8X V100 GPU Server vs 8X P100 GPU Server



CPU Server: Dual Xeon E5-2698 v4 @ 3.6GHz, GPU servers as shown | Ubuntu 14.04.5 | NVIDIA CUDA® Version: 9.0.176 | NCCL 2.0.5 | CuDNN 7.0.2.43 | Driver 384.66 | Data set: ImageNet | Batch sizes: Inception V3 and ResNet-50 64 for P100 SXM2 for P100 SXM2 and 128 for Tesla V100, Seq2Seq 192, VGG16 96

NVIDIA TENSORRT 3

Massive Throughput and Amazing Efficiency at Low Latency



CPU throughput based on measured-inference-throughput performance on Broadwell-based Xeon E2690 v4 CPU and doubled to reflect Intel's stated claim that Xeon Scalable Processor will deliver 2X the performance of Broadwell-based Xeon CPUs on deep learning inference.

CAFFE2
A popular, GPU-accelerated Deep Learning framework developed at UC Berkeley and Facebook

VERSION
1.0

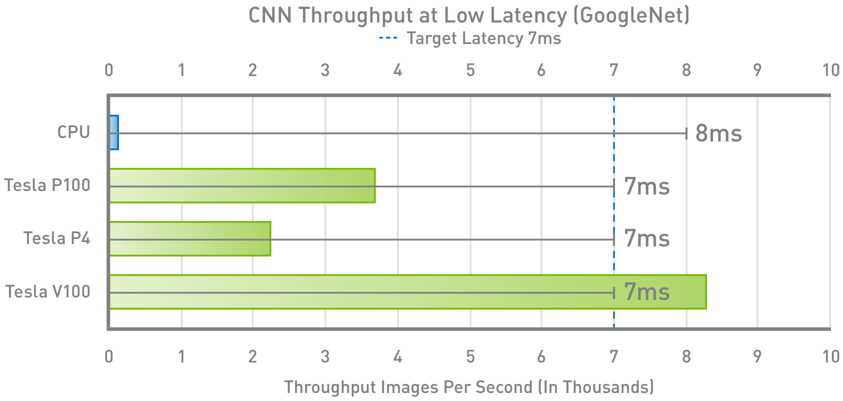
ACCELERATED FEATURES
Full framework accelerated

SCALABILITY
Multi-GPU

MORE INFORMATION
research.fb.com/downloads/caffe2

NVIDIA TENSORRT 3

Massive Throughput and Amazing Efficiency at Low Latency



CPU throughput based on measured-inference-throughput performance on Broadwell-based Xeon E2690 v4 CPU and doubled to reflect Intel's stated claim that Xeon Scalable Processor will deliver 2X the performance of Broadwell-based Xeon CPUs on deep learning inference.

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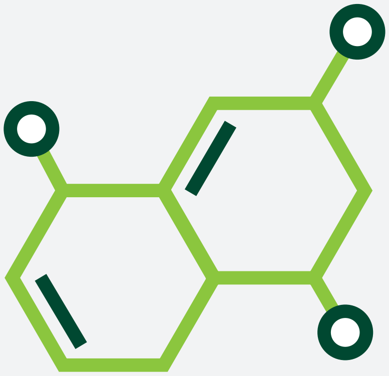
MOLECULAR DYNAMICS



Molecular Dynamics (MD) represents a large share of the workload in an HPC data center. 100% of the top MD applications are GPU-accelerated, enabling scientists to run simulations they couldn't perform before with traditional CPU-only versions of these applications. When running MD applications, a data center with Tesla V100 GPUs can save over 90% in server and infrastructure acquisition costs.

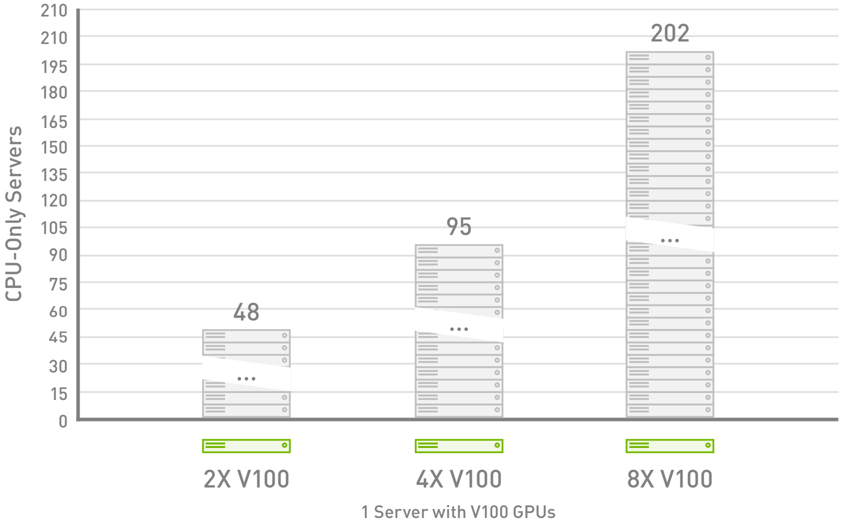
KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR MD

- Servers with V100 replace over 202 CPU servers for applications such as Amber and HOOMD-blue
- 100% of the top MD applications are GPU-accelerated
- Key math libraries like FFT and BLAS
- Up to 15.7 TFLOPS of single precision performance per GPU
- Up to 32 GB of memory capacity per GPU
- Up to 900 GB/s of memory bandwidth per GPU

View all related applications at:
www.nvidia.com/molecular-dynamics-apps

AMBER Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU servers: same CPU server with NVIDIA® Tesla® V100 PCIe or V100 SXM2 on 8X V100 config | NVIDIA CUDA® version: CUDA 9.0.176 | Dataset: PME-Cellulose_NVE | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

AMBER
Suite of programs to simulate molecular dynamics on biomolecule

VERSION
16.12

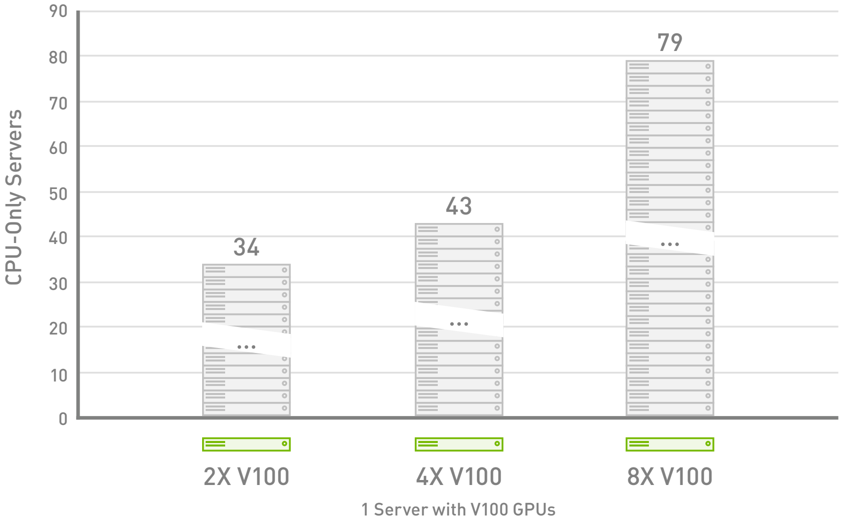
ACCELERATED FEATURES
PMEMD explicit solvent and GB; explicit and implicit solvent, REMD, aMD

SCALABILITY
Multi-GPU and Single-Node

MORE INFORMATION
http://ambermd.org/gpus

HOOMD-blue Performance Equivalency

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon E5-2690 v4 @ 2.6 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe or V100 SXM2 on 8X V100 config | NVIDIA CUDA® Version: 9.0.145 | Dataset: Microsphere | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

HOOMD-BLUE
Particle dynamics package written grounds up for GPUs

VERSION
2.2.2

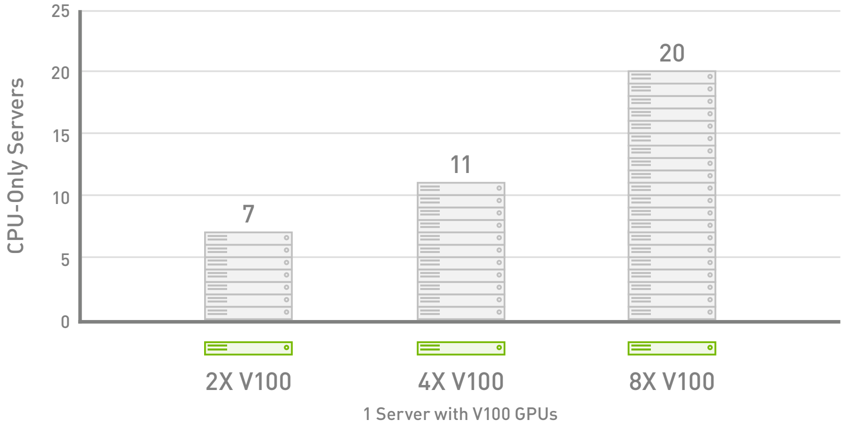
ACCELERATED FEATURES
CPU and GPU versions available

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
http://codeblue.umich.edu/hoomd-blue/index.html

LAMMPS Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Gold 6140 @ 2.30GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe or V100 SXM2 on 8X V100 config | NVIDIA CUDA® Version: 9.0.176 | Dataset: atomic-fluid Lennard-Jones 2.5 cutoff | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

LAMMPS
Classical molecular dynamics package

VERSION
2018

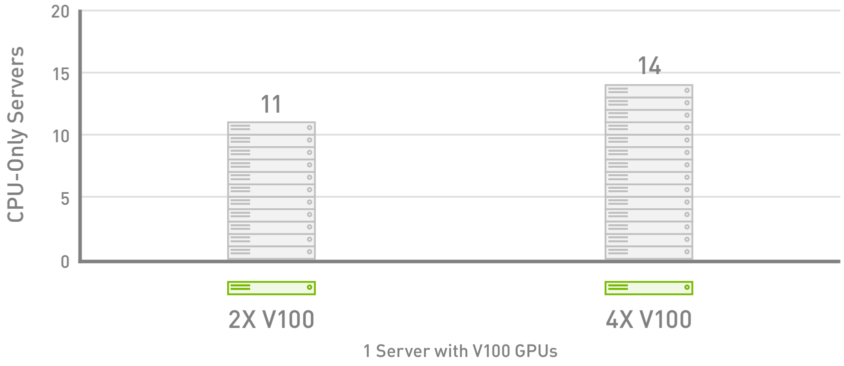
ACCELERATED FEATURES
Lennard-Jones, Gay-Berne, Tersoff, many more potentials

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
http://lammps.sandia.gov/index.html

NAMD Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.176 | Dataset: STMV | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

NAMD
Designed for high-performance simulation of large molecular systems

VERSION
2.13

ACCELERATED FEATURES
Full electrostatics with PME and most simulation features

SCALABILITY
Up to 100M atom capable, multi-GPU, scales to 2x Tesla P100

MORE INFORMATION
http://www.ks.uiuc.edu/Research/namd

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QUANTUM CHEMISTRY

Quantum chemistry (QC) simulations are key to the discovery of new drugs and materials and consume a large part of the HPC data center's workload. 60% of the top QC applications are accelerated with GPUs today. When running QC applications, a data center's workload with Tesla V100 GPUs can save over 60% in server and infrastructure acquisition costs.

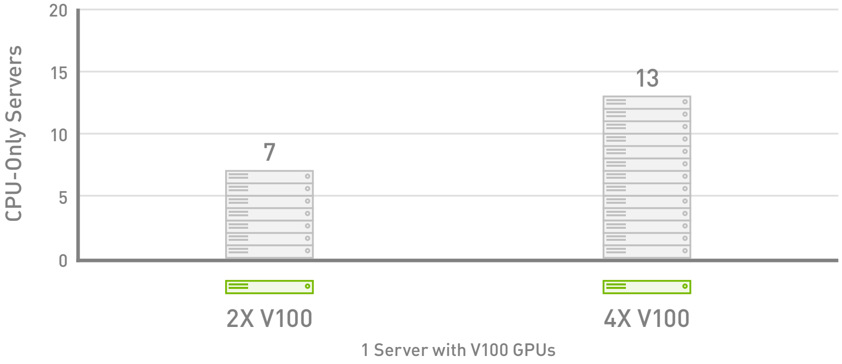
KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR QC

- Servers with V100 replace up to 13 CPU servers for applications such as Quantum Espresso
- 60% of the top QC applications are GPU-accelerated
- Key math libraries like FFT and BLAS
- Up to 7.8 TFLOPS per second of double precision performance per GPU
- Up to 32 GB of memory capacity per GPU
- Up to 900 GB/s of memory bandwidth per GPU

View all related applications at:
www.nvidia.com/quantum-chemistry-apps

Quantum Espresso Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.176 | Dataset: AUSURF112-jR | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

QUANTUM ESPRESSO

An open-source suite of computer codes for electronic structure calculations and materials modeling at the nanoscale

VERSION

6.2.1

ACCELERATED FEATURES

Linear algebra (matix multiply), explicit computational kernels, 3D FFTs

SCALABILITY

Multi-GPU and Multi-Node

MORE INFORMATION

http://www.quantum-espresso.org

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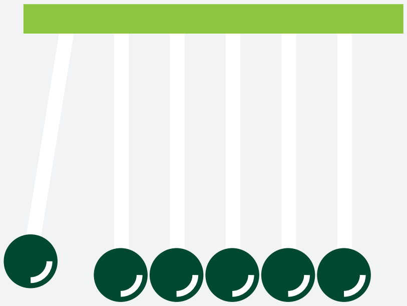
PHYSICS



From fusion energy to high energy particles, physics simulations span a wide range of applications in the HPC data center. All of the top physics applications are GPU-accelerated, enabling insights previously not possible. A data center with Tesla V100 GPUs can save over 85% in server acquisition cost when running GPU-accelerated physics applications.

KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR PHYSICS

> Servers with V100 replace up to 89 CPU servers for applications such as Chroma, GTC, MILC, and QUDA

> Most of the top physics applications are GPU-accelerated

> Up to 7.8 TFLOPS of double precision floating point performance per GPU

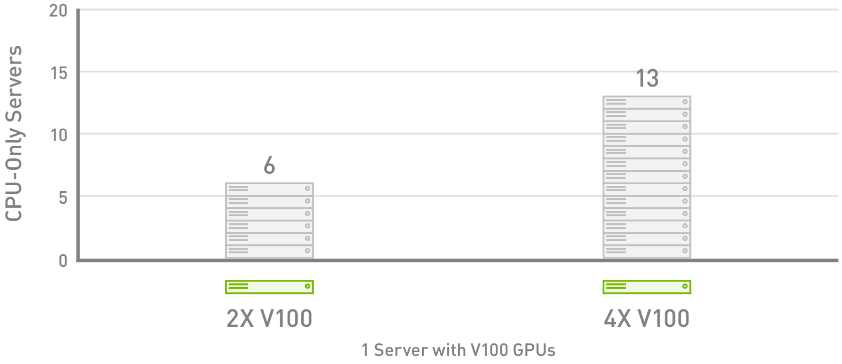
> Up to 32 GB of memory capacity per GPU

> Up to 900 GB/s memory bandwidth per GPU

View all related applications at:
www.nvidia.com/physics-apps

Chroma Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.176 | Dataset: szscl21_24_128 | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

CHROMA
Lattice quantum chromodynamics (LQCD)

VERSION
2018

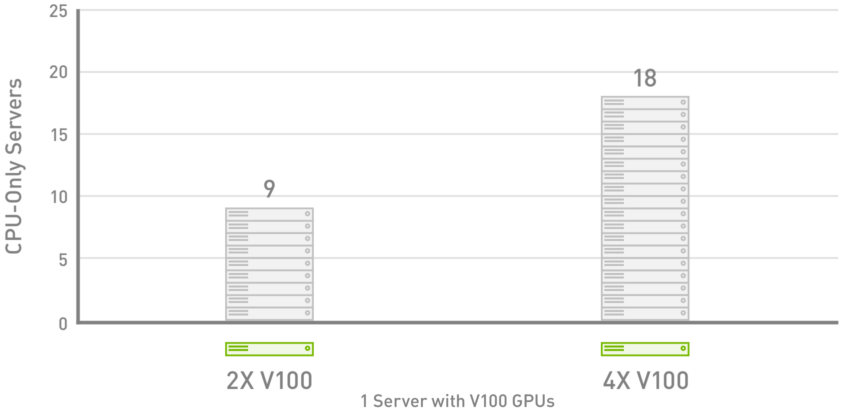
ACCELERATED FEATURES
Wilson-clover fermions, Krylov solvers,Domain-decomposition

SCALABILITY
Multi-GPU

MORE INFORMATION
http://jeffersonlab.github.io/chroma

GTC Performance Equivalence

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.176 | Dataset: mpi#proc.in | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

GTC
Used for gyrokinetic particle simulation of turbulent transport in burning plasmas

VERSION
2017

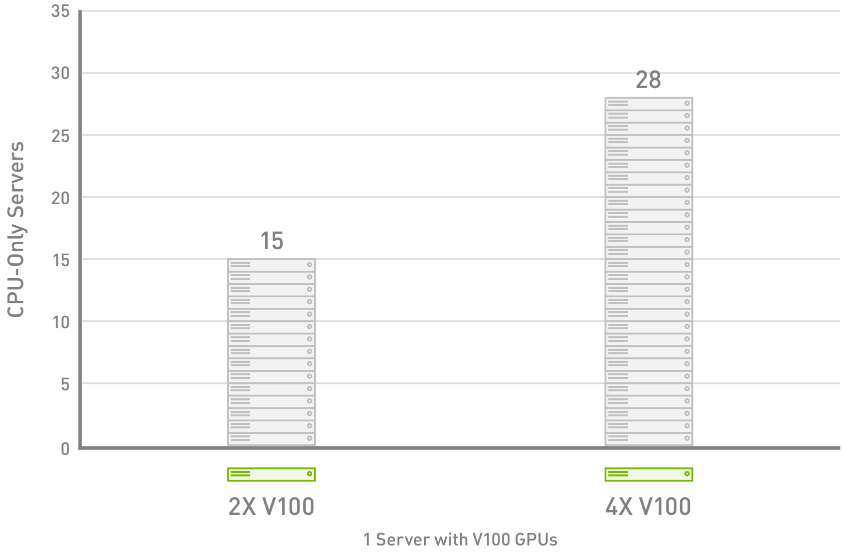
ACCELERATED FEATURES
Push, shift, collision

SCALABILITY
Multi-GPU

MORE INFORMATION
www.nvidia.com/gtc-p

MILC Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30GHz, GPU Servers: Dual Xeon Gold 6140 @ 2.30GHz with NVIDIA® Tesla® V100 PCIe (16 GB) | NVIDIA CUDA® Version: 9.0.176 | Dataset: MILC APEX Medium | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

MILC
Lattice quantum chromodynamics (LQCD) codes simulate how elemental particles are formed and bound by the "strong force" to create larger particles like protons and neutrons.

VERSION
2018

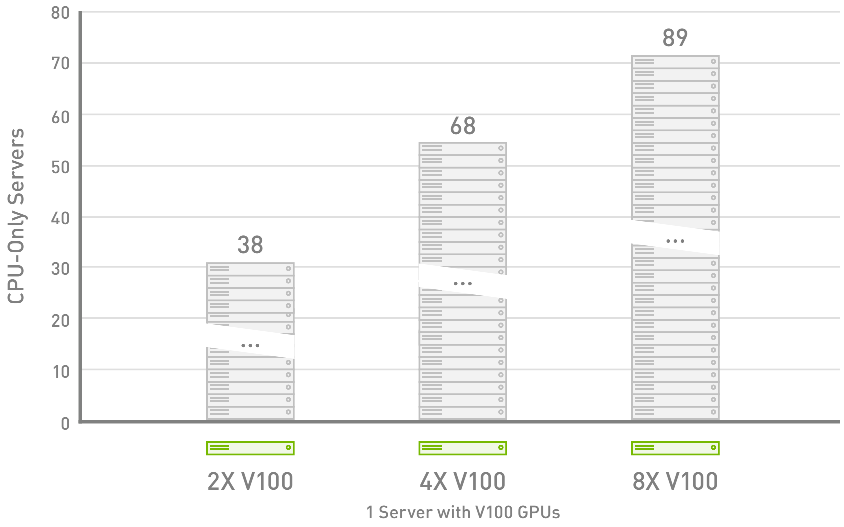
ACCELERATED FEATURES
Staggered fermions, Krylov solvers, gauge-link fattening

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
www.nvidia.com/milc

QUDA Performance Equivalence

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon E5-2690 v4 @ 2.6 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe or V100 SXM2 on 8X V100 config | NVIDIA CUDA® Version: 9.0.103 | Dataset: Dslash Wilson-Clove; Precision: Single; Gauge Compression/Recon: 12; Problem Size 32x32x32x64 | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

QUDA
A library for lattice quantum chromodynamics on GPUs

VERSION
2017

ACCELERATED FEATURES
All

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
www.nvidia.com/quda

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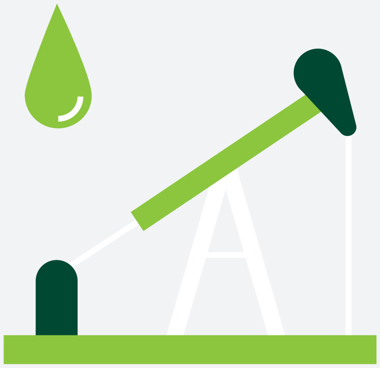
GEOSCIENCE



Geoscience simulations are key to the discovery of oil and gas and performing geological modeling. Many of the top geoscience applications are accelerated with GPUs today. When running Geoscience applications, a data center with Tesla V100 GPUs can save up to 90% in server and infrastructure acquisition costs.

KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR GEOSCIENCE

> Servers with V100 replace up to 54 CPU servers for applications such as RTM and SPECFEM3D

> Top Geoscience applications are GPU-accelerated

> Up to 15.7 TFLOPS of single precision floating point performance

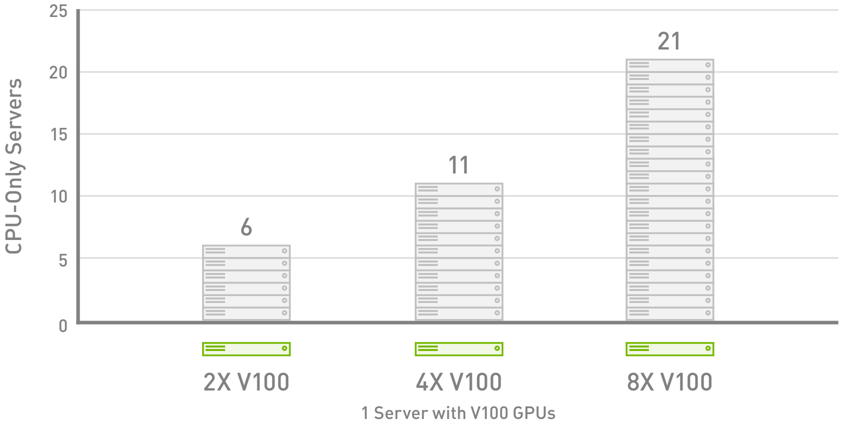
> Up to 32 GB of memory capacity per GPU

> Up to 900 GB/s memory bandwidth per GPU

View all related applications at:
www.nvidia.com/oil-and-gas-apps

RTM Performance Equivalence

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon E5-2690 v4 @ 2.6 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe or V100 SXM2 on 8X V100 config | NVIDIA CUDA® Version: 9.0.103 | Dataset: TTI RX 2pass mgpu | To arrive at CPU node equivalence, we use linear scaling to scale beyond 1 node.

RTM
Reverse time migration (RTM) modeling is a critical component in the seismic processing workflow of oil and gas exploration

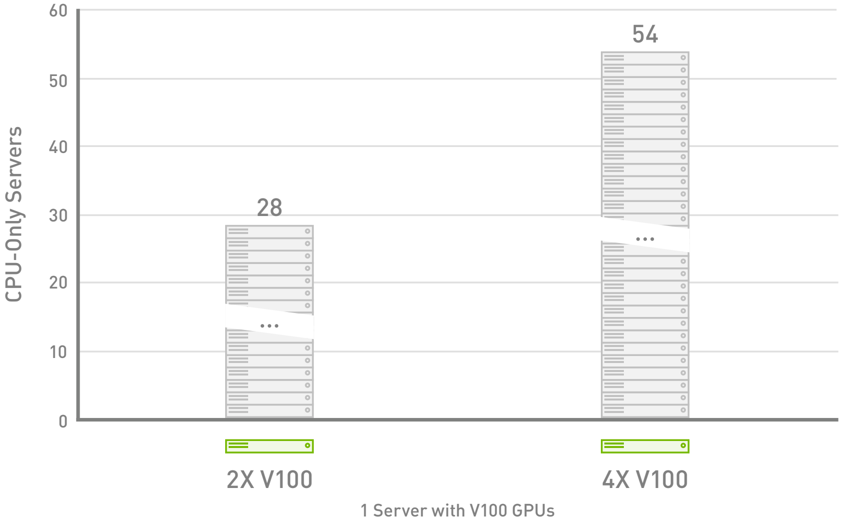
VERSION
2017

ACCELERATED FEATURES
Batch algorithm

SCALABILITY
Multi-GPU and Multi-Node

SPECFEM3D Performance Equivalence

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.176 | Dataset: four_material_simple_model | To arrive at CPU node equivalence, we use linear scaling to scale beyond 1 node.

SPECFEM3D
Simulates Seismic wave propagation

VERSION
2.0.2

SCALABILITY
Multi-GPU and Single-Node

MORE INFORMATION
https://geodynamics.org/cig/software/specfem3d_globe

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ENGINEERING

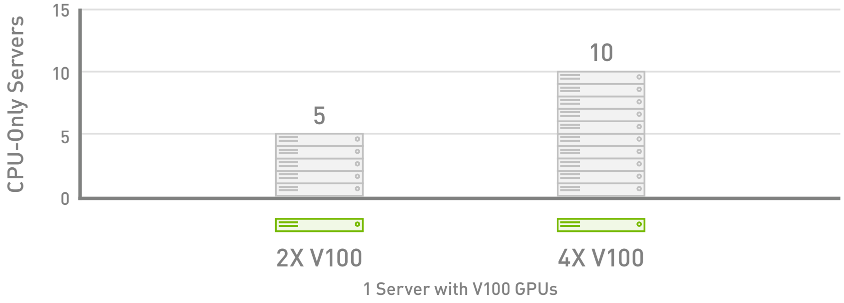
Engineering simulations are key to developing new products across industries by modeling flows, heat transfers, finite element analysis and more. Many of the top Engineering applications are accelerated with GPUs today. When running Engineering applications, a data center with NVIDIA® Tesla® V100 GPUs can save over 70% in software licensing costs and 50% in server and infrastructure acquisition costs.

KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR ENGINEERING

- Servers with Tesla V100 replace up to 10 CPU servers for applications such as SIMULIA Abaqus and ANSYS FLUENT
- The top engineering applications are GPU-accelerated
- Up to 7.8 TFLOPS of double precision floating point performance per GPU
- Up to 32 GB of memory capacity per GPU
- Up to 900 GB/s memory bandwidth per GPU

SIMULIA Abaqus Performance Equivalency

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 7.5 | Dataset: LS-EPP-Combined-WC-Mkl (RR) | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

SIMULIA ABAQUS
Simulation tool for analysis of structures

VERSION
2017

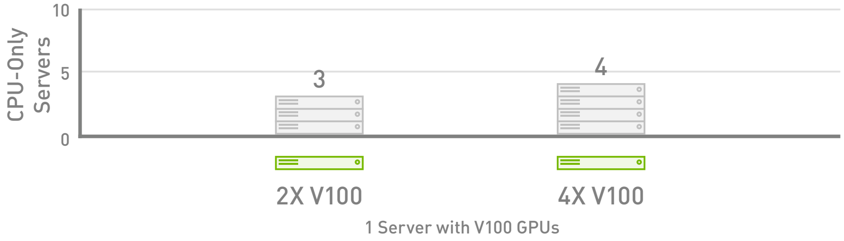
ACCELERATED FEATURES
Direct sparse solver, AMS eigensolver, steady-state dynamics solver

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
http://www.nvidia.com/simulia-abaqus

ANSYS Fluent Performance Equivalency

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30GHz , GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 6.0 | Dataset: Water Jacket | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

ANSYS FLUENT
General purpose software for the simulation of fluid dynamics

VERSION
18

ACCELERATED FEATURES
Pressure-based Coupled Solver and Radiation Heat Transfer

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
www.nvidia.com/ansys-fluent

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COMPUTATIONAL FINANCE

Computational finance applications are essential to the success of global financial service firms when performing market and counterparty risk analytics, asset pricing, and portfolio risk management analysis. This analysis requires numerical methods that are computationally intensive. And because time is money in financial analysis, several of the leading computational finance applications are GPU-accelerated. Computational finance applications using Tesla V100 GPUs can improve performance by over 50X and save up to 80% in server and infrastructure acquisition costs.

KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR COMPUTATIONAL FINANCE

> Servers with V100 outperform CPU servers by nearly 9X based on STAC-A2 benchmark results

> Top Computational Finance applications are GPU-accelerated

> Up to 7.8 TFLOPS per second of double precision performance per GPU

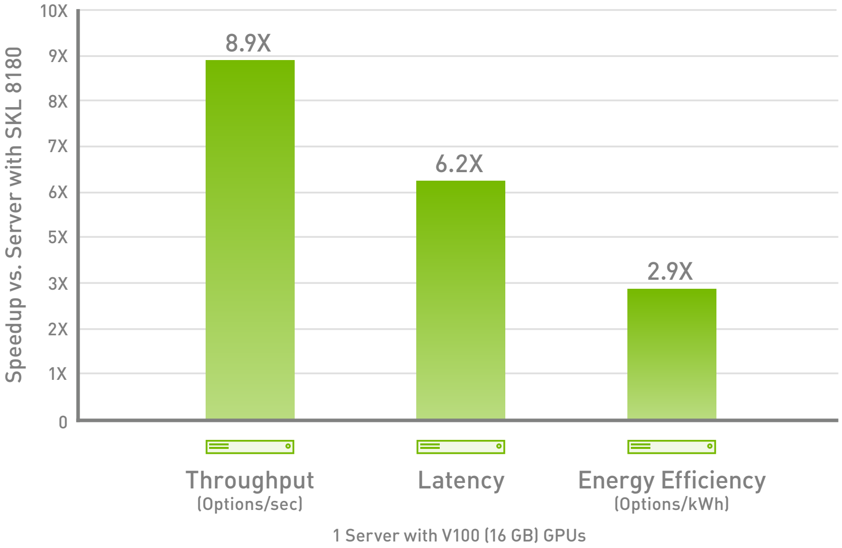
> Up to 32 GB of memory capacity per GPU

> Up to 900 GB/s memory bandwidth per GPU

View all related applications at:
www.nvidia.com/en-us/data-center/gpu-accelerated-applications/catalog

STAC-A2 Benchmark Performance Results

8X V100 GPU Server vs Dual Skylake Platinum 8180 Sever



System Configuration: GPU Server SUT ID: NVDA171020 | STAC-A2 Pack for CUDA (Rev D) | GPU Server: 8X NVIDIA® Tesla® V100 (Volta) GPU, 2X Intel® Xeon E5-2680 v4 @ 2.4 GHz | CUDA Version 9.0 | Compared to: CPU Server SUT ID: INTC170920, | STAC-A2 Pack for Intel Composer XE (Rev K) | 2X 28-Core Intel Xeon Platinum 8180 @ 2.5GHz "Throughput" is STAC-A2.β2.HPORTFOLIO.SPEED, "Latency" is STAC-A2.β2.GREEKS.WARM, and "Energy Efficiency" is STAC-A2.β2.ENERG_EFF.|"STAC" and all STAC names are trademarks or registered trademarks of the Securities Technology Analysis Center, LLC.

STAC-A2
Financial risk management benchmark created by leading global banks working with the Securities Technology Analysis Center (STAC) used to assess financial compute solutions

VERSION
STAC-A2 (Beta 2)

ACCELERATED FEATURES
Full framework accelerated

SCALABILITY
Multi-GPU

MORE INFORMATION
www.STACresearch.com/nvidia

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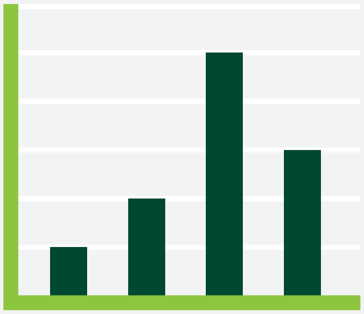
HPC BENCHMARKS



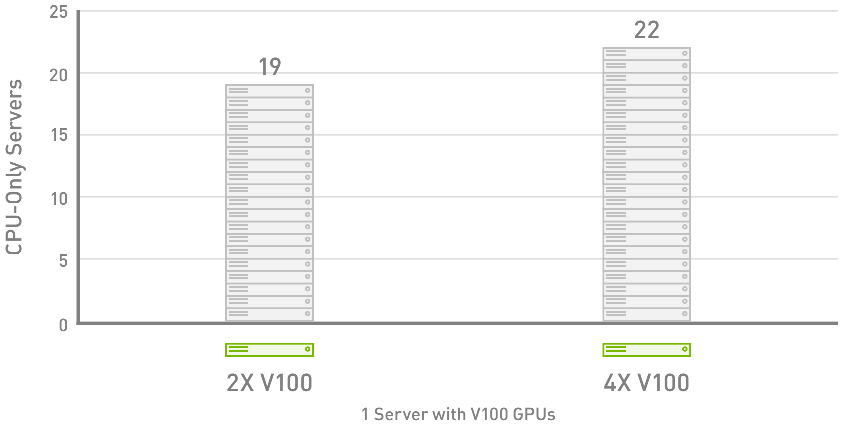
Benchmarks provide an approximation of how a system will perform at production-scale and help to assess the relative performance of different systems. The top benchmarks have GPU-accelerated versions and can help you understand the benefits of running GPUs in your data center.

KEY FEATURES OF THE TESLA PLATFORM AND V100 FOR BENCHMARKING

- Servers with Tesla V100 replace up to 23 CPU servers for benchmarks such as Cloverleaf, MiniFE, Linpack, and HPCG
- The top benchmarks are GPU-accelerated
- Up to 7.8 TFLOPS of double precision floating point performance per GPU
- Up to 32 GB of memory capacity per GPU
- Up to 900 GB/s memory bandwidth per GPU

Cloverleaf Performance Equivalency

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon E5-2690 v4 @ 2.6GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.103 | Dataset: bm32 | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

CLOVERLEAF
Benchmark – Mini-App Hydrodynamics

VERSION
1.3

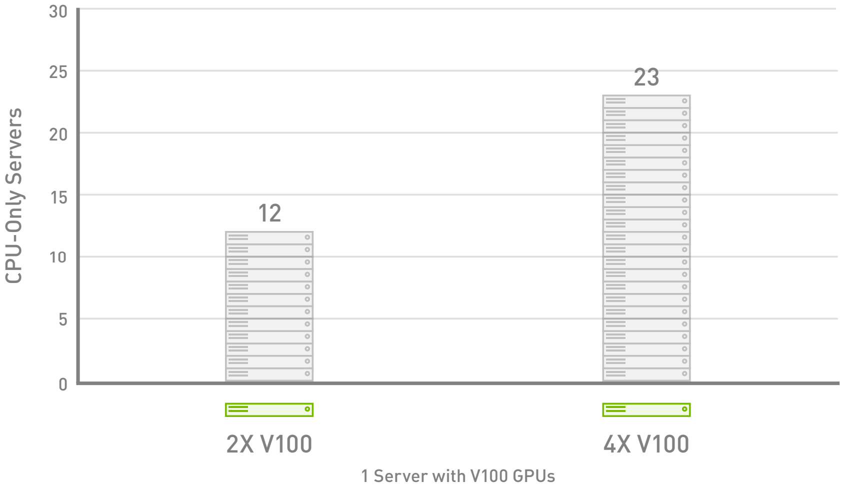
ACCELERATED FEATURES
Lagrangian-Eulerian explicit hydrodynamics mini-application

SCALABILITY
Multi-Node (MPI)

MORE INFORMATION
http://uk-mac.github.io/CloverLeaf

HPCG Performance Equivalency

Single GPU Server vs Multiple Broadwell CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.103 | Dataset: 256x256x256 local size | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

HPCG
Exercises computational and data access patterns that closely match a broad set of important HPC applications

VERSION
3

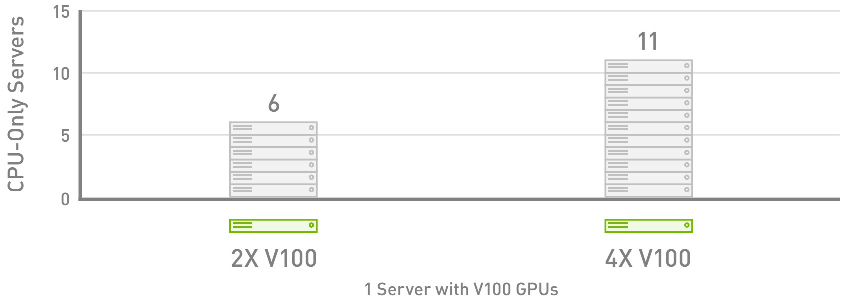
ACCELERATED FEATURES
All

SCALABILITY
Multi-GPU and Multi-Node

MORE INFORMATION
http://www.hpcg-benchmark.org/index.html

Linpack Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.103 | Dataset: HPL.dat | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

LINPACK
Benchmark – Measures floating point computing power

VERSION
2.1

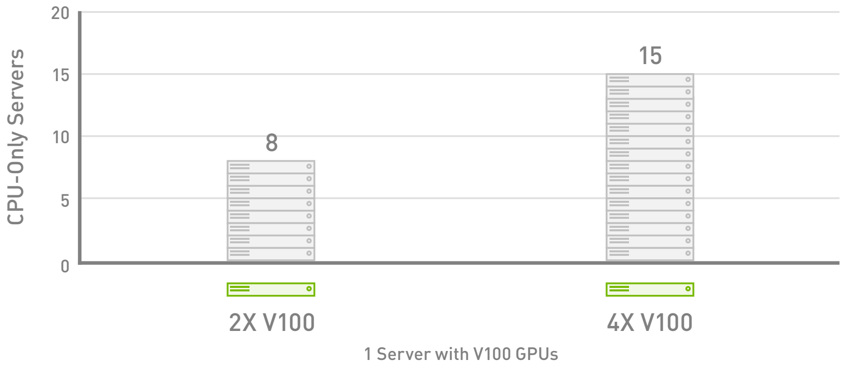
ACCELERATED FEATURES
All

SCALABILITY
Multi-Node and Multi-Node

MORE INFORMATION
www.top500.org/project/linpack

MiniFE Performance Equivalency

Single GPU Server vs Multiple Skylake CPU-Only Servers



CPU Server: Dual Xeon Gold 6140 @ 2.30 GHz, GPU Servers: Same as CPU server with NVIDIA® Tesla® V100 PCIe | NVIDIA CUDA® Version: 9.0.103 | Dataset: 350x350x350 | To arrive at CPU node equivalence, we use a measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

MINIFE
Benchmark—Mini-App Finite element analysis

VERSION
0.3

ACCELERATED FEATURES
All

SCALABILITY
Multi-GPU

MORE INFORMATION
https://mantevo.org/about/applications

TESLA V100 PRODUCT SPECIFICATIONS

	NVIDIA Tesla V100 for PCIe-Based Servers	NVIDIA Tesla V100 for NVLink-Optimized Servers
Double-Precision Performance	up to 7 TFLOPS	up to 7.8 TFLOPS
Single-Precision Performance	up to 14 TFLOPS	up to 15.7 TFLOPS
Deep Learning	up to 112 TFLOPS	up to 125 TFLOPS
NVIDIA NVLink™ Interconnect Bandwidth	-	300 GB/s
PCIe x 16 Interconnect Bandwidth	32 GB/s	32 GB/s
CoWoS HBM2 Stacked Memory Capacity	32 GB / 16 GB	32 GB / 16 GB
CoWoS HBM2 Stacked Memory Bandwidth	900 GB/s	900 GB/s

Assumptions and Disclaimers

The percentage of top applications that are GPU-accelerated is from top 50 app list in the i360 report: HPC Support for GPU Computing.

Calculation of throughput and cost savings assumes a workload profile where applications benchmarked in the domain take equal compute cycles: **http://www.intersect360.com/industry/reports.php?id=131**

The number of CPU nodes required to match single GPU node is calculated using lab performance results of the GPU node application speed-up and the Multi-CPU node scaling performance.