Driving Virtual Product Development in Industry 4.0

GLOBAL PRODUCT DATA
INTEROPERABILITY
SUMMIT
2017

ELYSIUM Parker Aerospace NORTHROP GRUMMAN BOEING

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Background on the Speaker

CURRENT ROLE

Martin Feyereisen is an HPC technologist at Dell EMC. He is focused on technology infusion into the virtual product development market vertical. His primary interest is Computer Aided Engineering(CAE). Martin spends most of his work time playing on Supercomputers.

EDUCATION

Ph.D. Chemistry – *University of Minnesota*   1990

EXPERIENCE

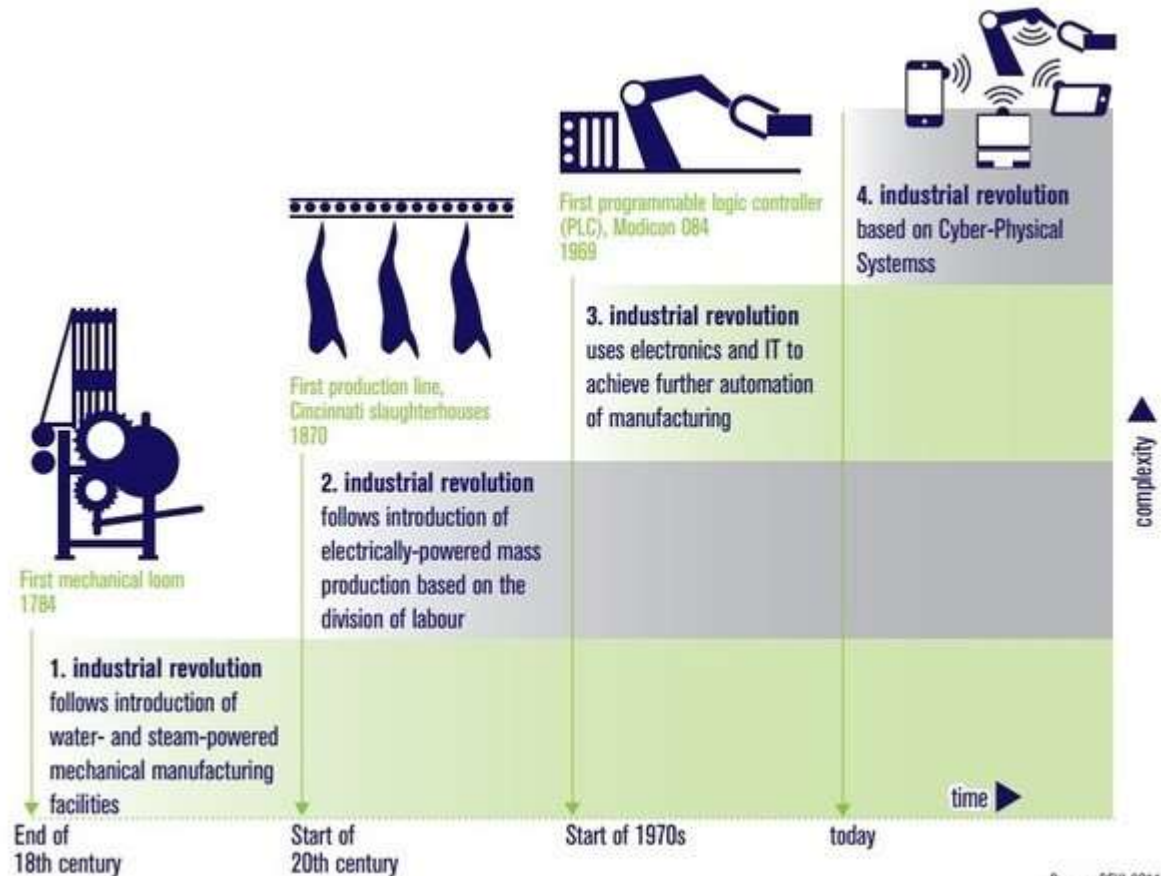|	
Dell	2015 – Present
Lenovo	2014 – 2015
IBM	1999 – 2014
Cray Research/SGI	1992 – 1999
Pacific Northwest National Laboratory	1991 – 1992

HOBBIES

Woodworking (ask to see his right index finger!)

Triathloning

Industry 4.0

4. industrial revolution based on Cyber-Physical Systemss

First programmable logic controller (PLC), Modicon 084 1969

3. industrial revolution uses electronics and IT to achieve further automation of manufacturing

First production line, Cincinnati slaughterhouses 1870

2. industrial revolution follows introduction of electrically-powered mass production based on the division of labour

First mechanical loom 1784

1. industrial revolution follows introduction of water- and steam-powered mechanical manufacturing facilities

complexity

time

| End of 18th century | Start of 20th century | Start of 1970s | today |

Source: DFKI 2011

HPC Adoption is Required to Spur Innovation and Economic Development

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Digital Manufacturing example

"**Democratizing** the use of high fidelity software and appropriate computing tools for all U.S. manufacturers will increase U.S. economic competitiveness globally."
The Honorable Aneesh Chopra, former Chief Technology Officer to President Obama

|	
300,000	Approximate number of manufacturers in the United States
95%	Of which are categorized as small or medium (1-500 employees)
200%	More jobs are provided by small and medium manufacturers than large ones.
98%	Of all products will be developed and manufactured digitally by 2020
94%	Of all small and medium manufacturers **have not yet adopted high performance digital manufacturing**

Source: National Center for Manufacturing Sciences, Digital Manufacturing Initiative (www.ncms.org)

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What is Computer-aided Engineering?

Computer-aided Engineering (CAE) or Digital Manufacturing is the broad usage of computer software to aid in engineering analysis tasks. It includes Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), Multibody dynamics (MBD) and optimization.

CAE compliments **Computer-aided Design (CAD)** — the use of a computer for drafting and modeling designs, and **Computer-aided Manufacturing (CAM)** — the use of computers for managing manufacturing processes.
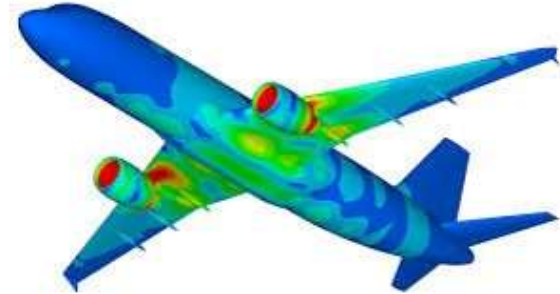
Why HPC in manufacturing segments?

Virtual prototyping
- Faster than physical prototyping / testing
- Well suited for global market requirements
- Allow for "what if's" not possible with physical development/testing

Virtual manufacturing
- Improved time to market
- Reduced tooling costs

Product lifecycle management
- Service and warranty projection
- Critical for continued engineering change orders

Being fast to market with something that is better – **while driving the bottom line**.

Digital manufacturing pain points

Major stumbling blocks to HPC adoption can include:

- Time and resources needed to deploy and manage HPC environments. IT support for Linux-based HPC clusters is often limited.

- Wide range of CAE ISV applications (and versions) in use, creating support issues

- Cost of HPC clusters and CAE ISV software applications

- Paradox of I/T consolidation with disaster recovery preparedness

- Geographically distributed engineers and I/T

- Legacy I/T infrastructure (storage, campus network, datacenter, etc.)

Our approach starts with the customer's requirements

Dell EMC provides full ecosystem solutions to address the unique workflow requirements of manufacturing

Full turnkey managed cluster solutions that include hardware development, deployment and lifecycle support and management:

- End-to-end planning, design and deployment

- Full lifecycle solutions for HPC clusters running applications such as ANSYS Fluent, ANSYS Mechanical, LSTC LS-DYNA and CD-adapco StarCCM+

- Worry-free, world-class HPC management through Dell EMC **R**emote **C**luster **M**anagement (RCM)

Digital Manufacturing workloads

CAE cluster for departmental use
Typically migration off of Windows based workstations
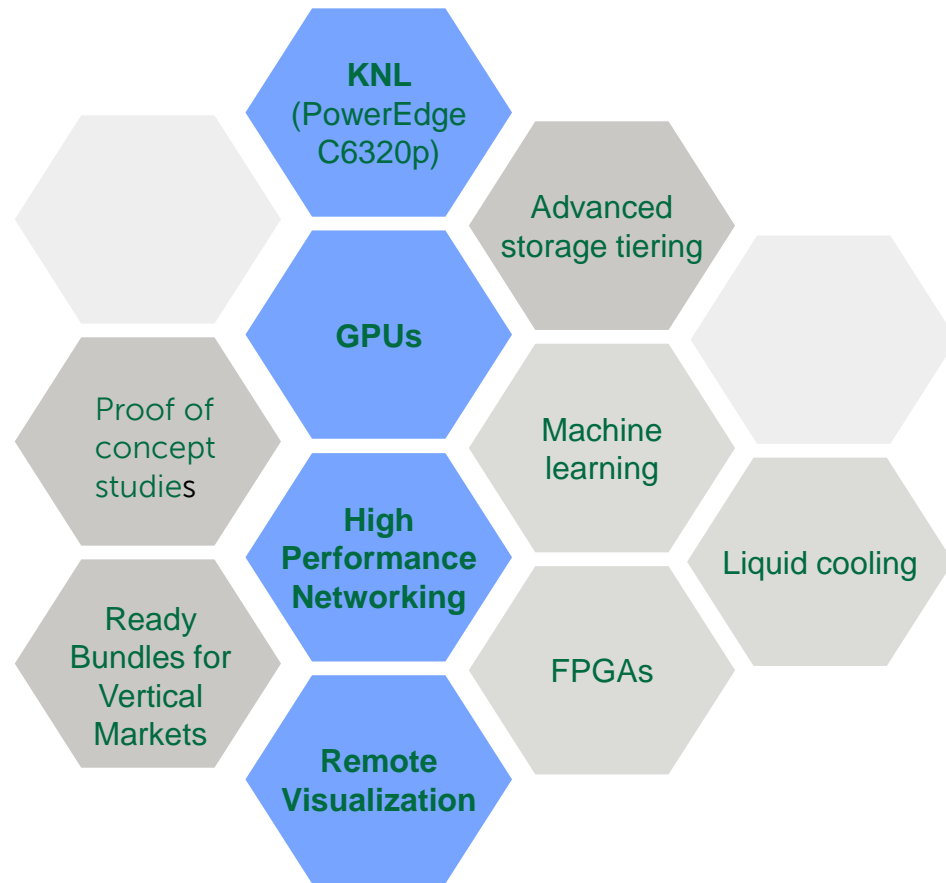
HPC cluster for divisional use
Several users with comprehensive HPC infrastructure

Technology trends & Dell EMC Innovation

Dell EMC continues to build the HPC expertise needed to design, develop, deploy, and support HPC solutions that integrate Dell EMC innovations with community standards.

KNL
(PowerEdge C6320p)

Advanced storage tiering

GPUs

Proof of concept studies

Machine learning

High Performance Networking

Liquid cooling

Ready Bundles for Vertical Markets

FPGAs

Remote Visualization

Dell EMC Ready Solutions Portfolio

Ready Nodes

Tested and validated single node optimized for a given use case or workload

vSAN
ScaleIO
SAP HANA
SAP HANA Edge
MSFT Storage Spaces*

Ready Bundles

Tested and validated multi-component bundles, optimized for a given use case or workload

HPC   Virtualization
Hadoop Clusters   Microsoft SQL / Exchange
Red Hat OpenStack Bundle for SAP Landscape
SAP HANA   Oracle

Ready Systems

Tested and validated Engineered Systems for a given use case or workload
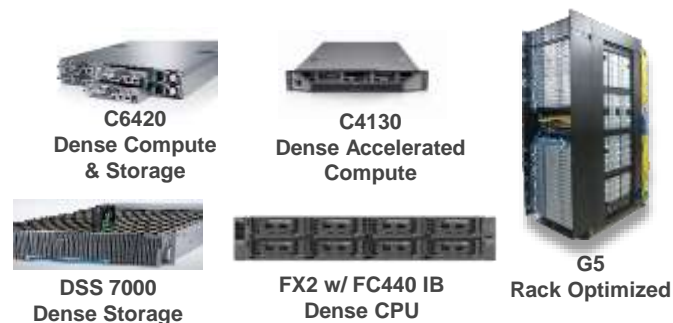
Oracle
SAP HANA
Splunk
Microsoft SQL

What does an HPC system look like?

Outside Network

Master Node

Compute Nodes

High-speed
Network
(IB, OPA)

Management
Network
(GigE)

Storage
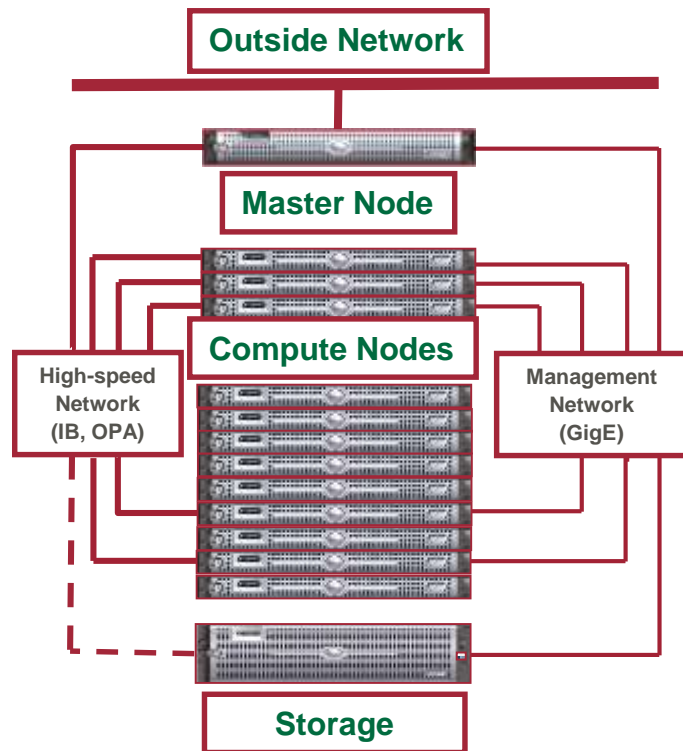
Flexible servers for HPC systems match to diverse workloads

C6420
Dense Compute & Storage

C4130
Dense Accelerated Compute

G5
Rack Optimized

DSS 7000
Dense Storage

FX2 w/ FC440 IB Dense CPU

R440

R640

R740

R740+GPU

R940

Compute node questions & best practices
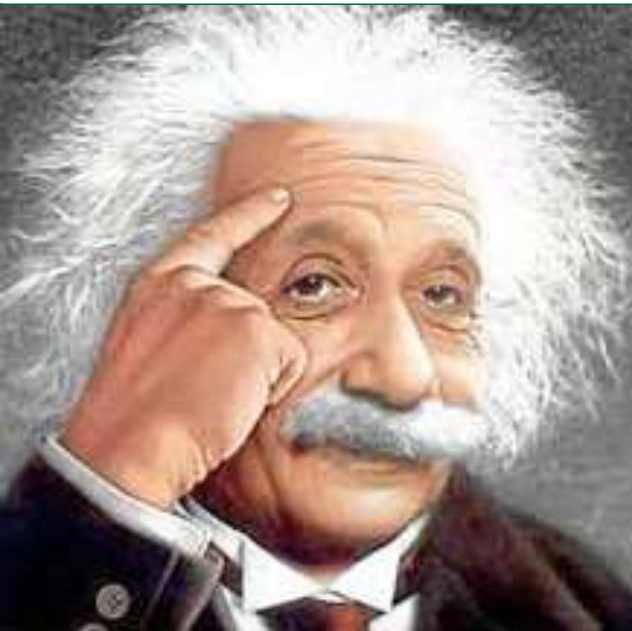
Memory
- Are the memory DIMM's equally spread across all memory channels?
- No mixing of different rank types

Scratch Space
- Diskless nodes?
- How much scratch storage do you see yourself needing?

Networking
If InfiniBand or Omni-Path are used there should not be any Cable Management Arms.

HPC BIOS
is required on compute nodes.

Management Software
- iDRAC — Basic/Express is the only level required for compute nodes.
- Shared LOM (SHLOM) is required unless providing a separate Out-of-Band network.

Power Supply
- Do the power plugs match the PDU receptacles?
- Redundant power is not necessary on the compute nodes for large systems.

Operating System
- Is the customer going to provide their own license, or is it open source?
- Are all the relevant SKU's to quote the OS on the quote?

Support Level
- Minimum required for diskless compute nodes is Basic NBD + HPC Compute Node Support
- Minimum for compute nodes with disks is ProSupport NBD

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Dell EMC testing for CAE Workloads

Extensive overall testing of Dell EMC solution options to validate Ready Bundle Solution
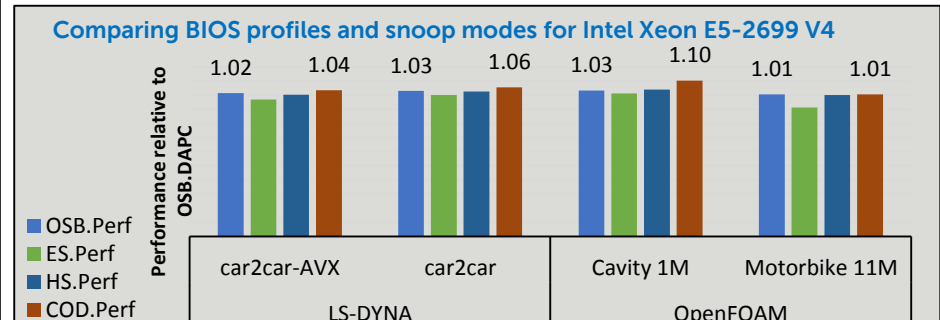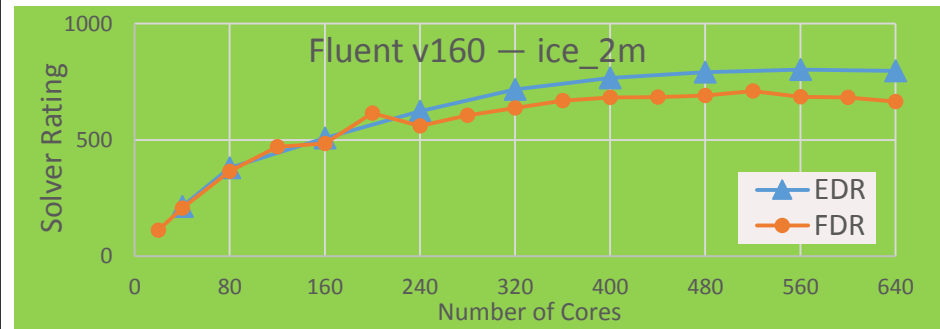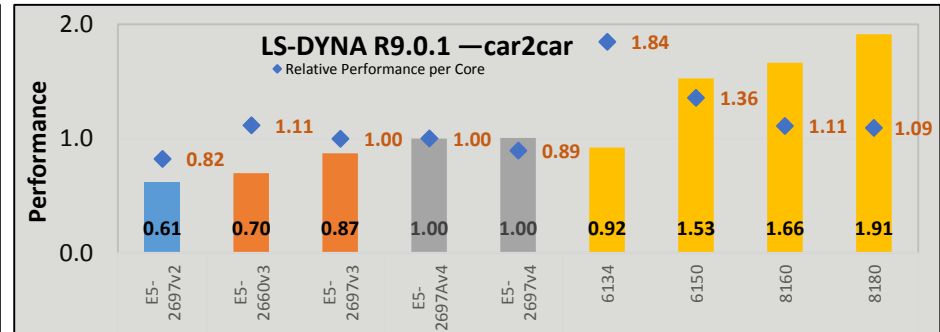
Processor Testing
- Validate both overall system throughput and single core processor performance for multiple ISV licensing scenarios
- Cost and environmental considerations

Network Testing
- Performance on variety of workloads with a variety of network choices
- ISV application validation
- Overall system maintainability and expandability
- Compatibility with various HPC storage solutions

BIOS Testing
- Testing on multiple systems with multiple HPC workloads
- Result in SKU orderable "HPC BIOS" enabling uniform performance expectation 'out of the box'

LS-DYNA R9.0.1 —car2car
Relative Performance per Core

	E5-2697v2	E5-2660v3	E5-2697v3	E5-2697Av4	E5-2697v4	6134	6150	8160	8180
Relative Perf/Core	0.82	1.11	1.00	1.00	0.89		1.36	1.11	1.09
Performance	0.61	0.70	0.87	1.00	1.00	0.92	1.53	1.66	1.91

(1.84 shown above 6134)

Fluent v160 — ice_2m
EDR / FDR, Solver Rating vs Number of Cores

Comparing BIOS profiles and snoop modes for Intel Xeon E5-2699 V4

Performance relative to OSB.DAPC

	car2car-AVX	car2car	Cavity 1M	Motorbike 11M
	1.02 1.04	1.03 1.06	1.03 1.10	1.01 1.01

- OSB.Perf
- ES.Perf
- HS.Perf
- COD.Perf

LS-DYNA | OpenFOAM

Leveraging Industrial Partnerships for CAE Workload Optimization

Business need

The NCSA Private Sector Program sought to build a readily accessible, high-performance computing (HPC) system to help manufacturing and engineering companies increase their competitiveness.

Solution

The organization manages several supercomputing resources, including the iForge HPC cluster based on Dell and Intel technologies, to help solve industry's most demanding engineering and science problems.

Benefits

- Helps industry customers solve finite element analysis and computational fluid dynamics problems with its HPC cluster
- Large memory nodes perform 53 percent faster on demanding simulations
- Provides benchmarking so users can predict performance and scalability benefits of larger software licenses
- Maintains high reliability and availability
- Performs live upgrades without disrupting partner projects

"iForge is the most reliable HPC system NCSA has ever had, and a big part of that is the technologies we're getting from Dell and Intel. That gives us the confidence to upgrade faster than we would otherwise."

Evan Burness,
Program Manager for the Private Sector Program
National Center for Supercomputing Applications

Dell EMC Ready Bundle for HPC *Digital Manufacturing*

ISV Applications
Dell Pro Support, Pro Support Plus, Deployment Services
Bright Cluster Manager

HPC storage offerings   D&LLEMC Seagate DataDirect NETWORKS

HPC networking offerings   D&LLEMC   Mellanox

Explicit Solver Building Blocks	Implicit Solver Building Blocks
Basic Building Blocks	HPC Management Building Blocks
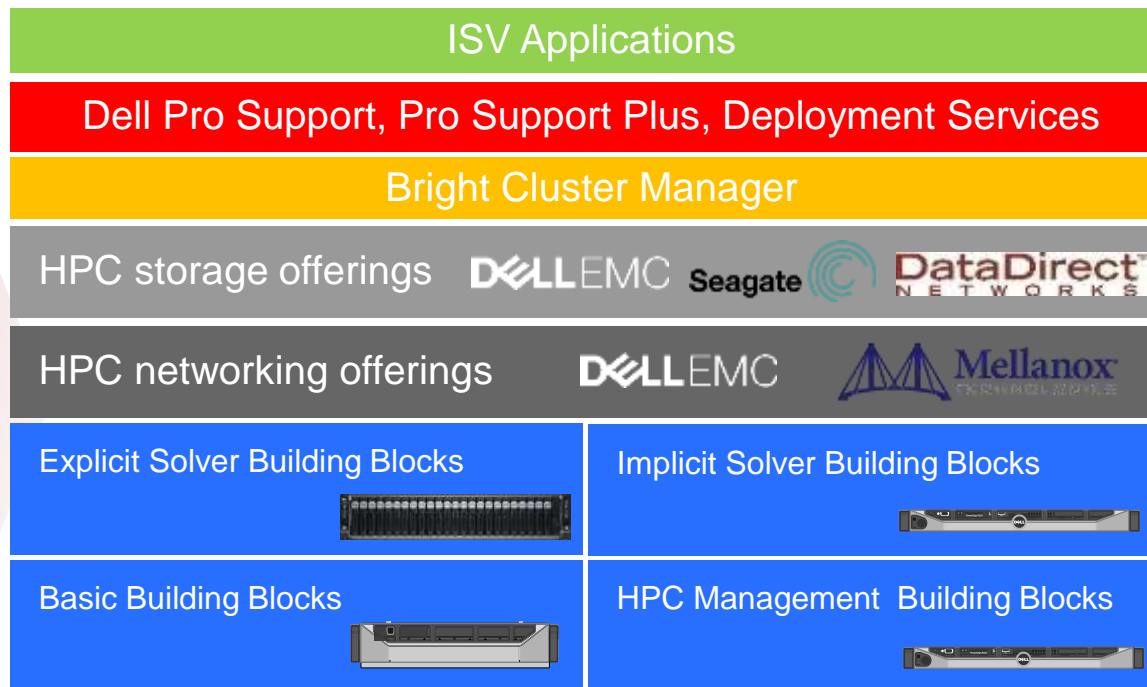
Key takeaways

- Comprehensive offering that includes compute, storage , networking , unified management, monitoring and services

- Choice & flexibility at every level

- Designed to improve overall system configuration process to meet customer's unique requirements quickly

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Dell EMC Ready Bundle for HPC *Digital Manufacturing*

Basic Building Blocks

Typical use
- Windows based customers looking for a modest cluster to improve single job capacity and overall volume of jobs
- Stepping stone from Windows workstation usage to full Linux based HPC cluster environment

Typical simulation types
- Crash, stamping, safety, impact analysis, fluid flow, pump design, combustion, aerodynamics, acoustics

Typical run environment
- SMP parallel jobs on a single node and MPI parallel jobs run across two node 10GE switchless "couplet"

Reference Architecture
- PowerEdge R640
- Intel 6142
  - (32 cores per server)
  - (64 cores per couplet)
- 192GB 2667MHz DDR4 memory
- 2x400GB Mixed-use SATA SSDs
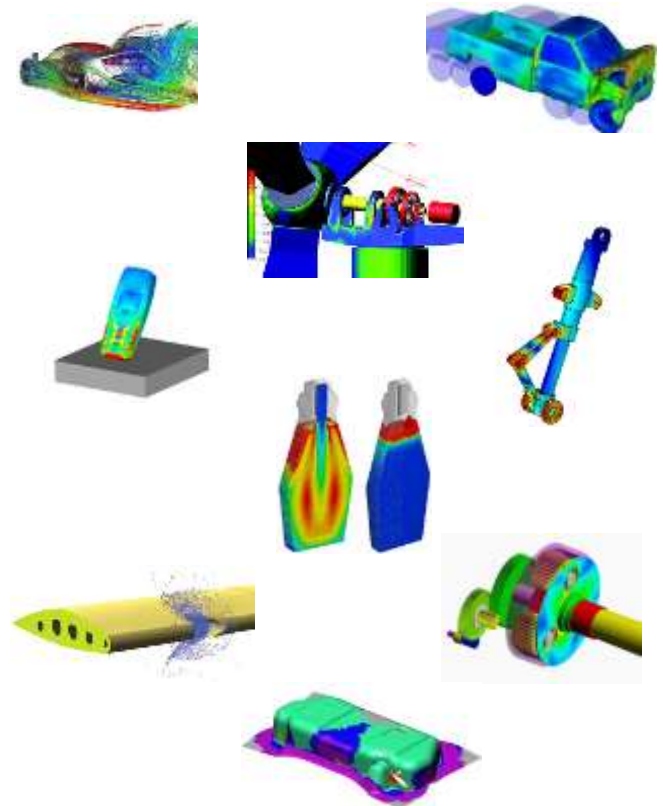
Dell EMC Ready Bundle for HPC *Digital Manufacturing*

Explicit Solver Building Blocks

Typical ISV application workloads
- CFD: Fluent, CFX, STAR-CD, STAR-CCM+, OpenFOAM, PowerFLOW
- Explicit Structures: Abaqus-Explicit, LS-DYNA, PAM-CRASH, Altair-RADIOSS

Typical simulation types
- Crash, stamping, safety, impact analysis, fluid flow, pump design, combustion, aerodynamics, acoustics

Typical run environment
- MPI parallel jobs run across 4-12 nodes
  - Typically run on a cluster with a high-speed IB, OPA, or 10GE network
- Minimal I/O to local disks during job

Reference Architecture
- PowerEdge C6420
- Intel 6162 (32 cores per server)
- 192GB 2667MHz DDR4 memory
- 2x400GB Mixed-use SATA SSDs
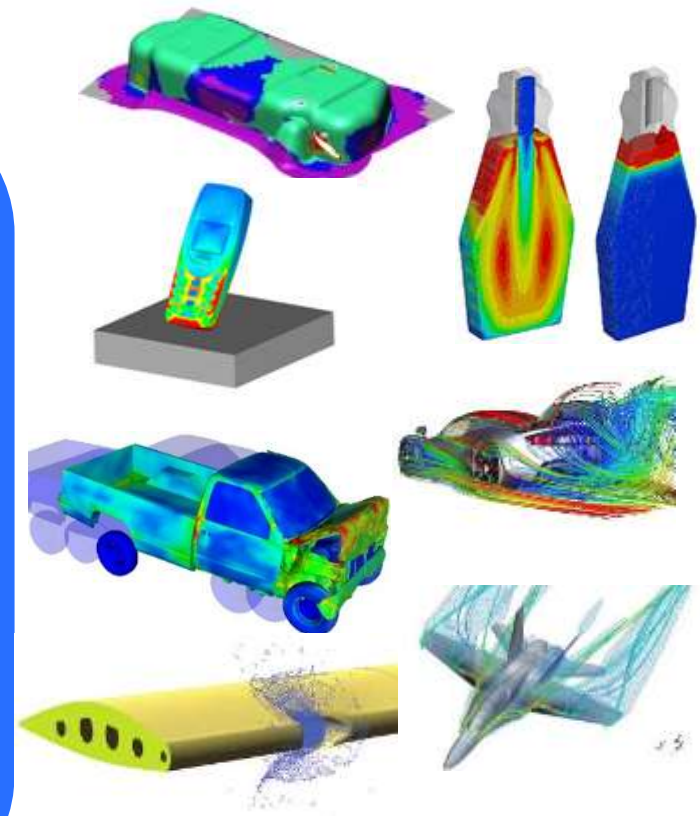
Dell EMC Ready Bundle for HPC *Digital Manufacturing*

Implicit Solver Building Blocks

Typical ISV application workloads
- ANSYS-Mechanical, Abaqus-Standard, MSC.Nastran, NX.Nastran, Altair-Optistruct

Typical simulation types
- Noise vibration harshness (NVH), structural integrity (linear and nonlinear), assembly

Typical run environment
- Most jobs run on a single node
- Jobs tend to require large memory to improve overall performance
- Scratch I/O to array of local disks typically preferred over shared file system

Reference Architectures
- PowerEdge R640
- Intel 6134 (24 total cores per server)
- 384GB 2667MHz DDR4 Memory
- 4x400GB Mixed-use SATA SSDs
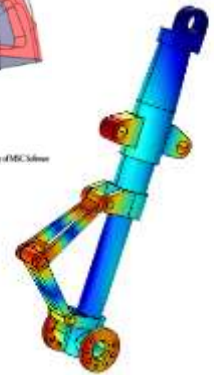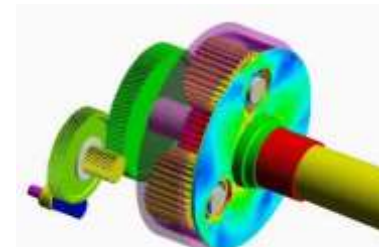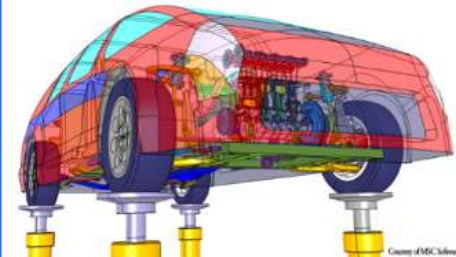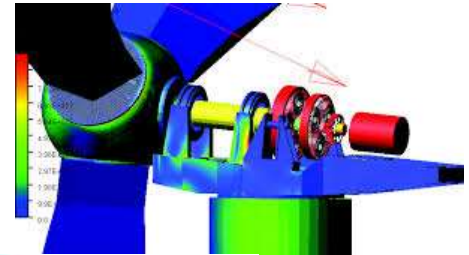
Management Building Blocks

Management software
- Bright Cluster Management (optional) The Dell EMC HPC System for Manufacturing is configured to work with all industry leading IPMI based cluster management tools
  - optimized for Dell specific hardware
- Dell-supported Remote Cluster Management Services (optional)

Management Server building blocks
- Cluster management — Typically one for modest clusters, two for larger clusters
- Cluster administration (queues, etc.) — Typically one-two for each specific task
- Login — Typically one for each 30-100 users

Reference Architecture
- PowerEdge R640
- Intel 3106 (16 cores per server)
- 192GB 2667MHz DDR4 memory
- 1 x 800GB Mixed-used SATA SSD
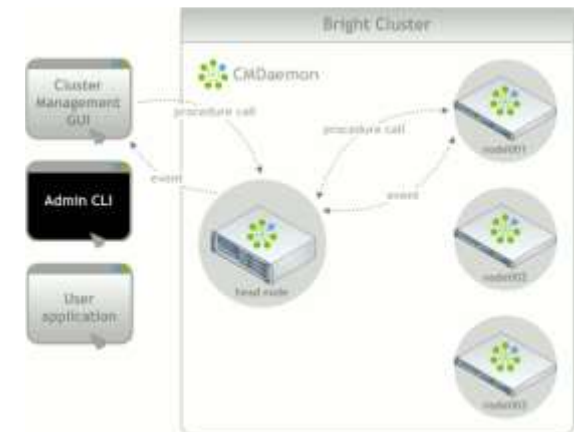
14g performance

Performance improvements for LDSYNA

- Software: MPPDYNA_9.1.2.0SP-avx2
- Benchmark: Car2Car
- Hardware:
  - 13g (Explicit Solver Building Block)
    - DellEMC PE C6320
    - E5-2697Av4 (32 cores per server)
    - 128GB 2400MHz DDR4
  - 14g (Explicit Solver Building Block)
    - DellEMC PE C6420
    - 6142 (32 cores per server)
    - 192GB 2667MHz DDR4

Observations

- 14g Ready bundle consistently outperforms 13g counterpart by about 25%
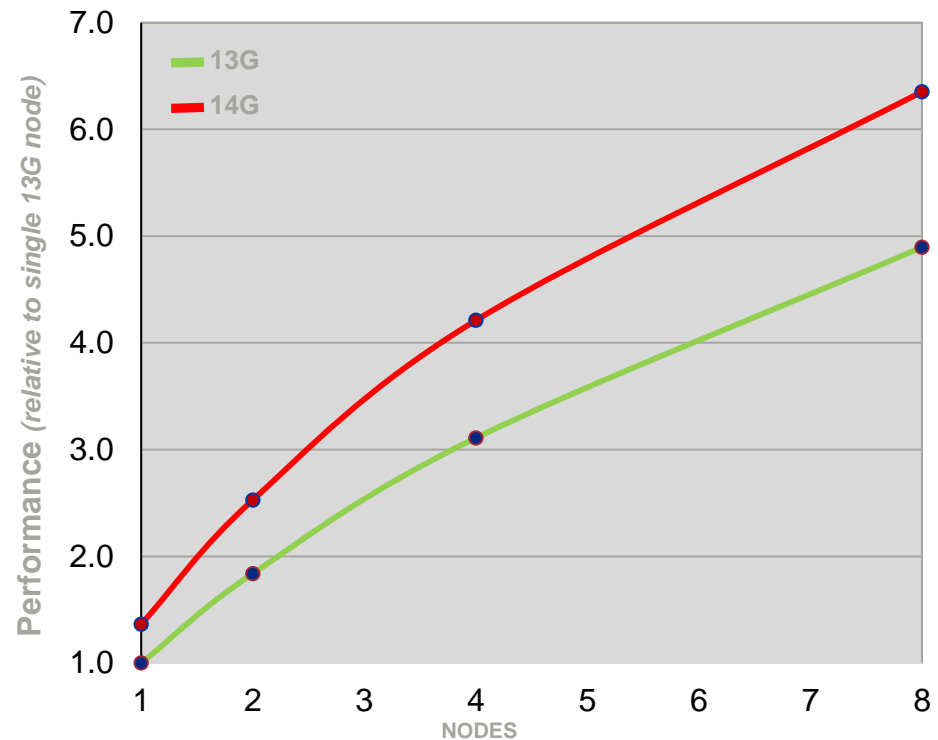
Dell EMC HPC Storage Portfolio

ScaleIO

Software-defined scale-out SAN that uses existing hardware to turn existing DAS storage into shared block storage
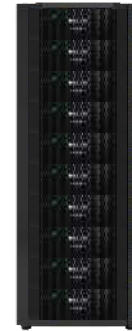
HPC NFS Storage

High availability storage system with up to 480TB of raw storage capacity

Red Hat HA software stack

HPC Lustre Storage

Lustre storage system with up to 960TB raw storage per object storage server pair and up to 14.9GB/s of write and 16.8GB/s of read throughput

Isilon

Scale-out NAS storage to store, protect and analyze unstructured data

Unity

- All-Flash scales up to 6PB
- Unity Hybrid Flash combines SSD and HDD
- Unity VSA has up to 50TB of unified storage

Elastic Cloud Storage (ECS)

All the benefits of a public cloud while keeping cost under control

Software and hybrid	High performance and flash	Cloud

powerful **performance | efficiency | scalability**

Additional options: http://i.dell.com/sites/doccontent/shared-content/data-sheets/en/Documents/Dell_Storage_Family_Portfolio.pdf

Dell Precision Portfolio

**Dell Canvas:
The "do" surface to
compliment your
"view" surface**

**3000 Series
(35x0)**

Thin and light +
powerful and
affordable

**5000 Series
(55x0)**

The thinnest,
lightest and
smallest
workstations in the
world

**7000 Series
(75x0 & 77x0*)**

The most powerful
15" and 17" inch
mobile workstations

**3000 Series
(3620 & 3420)**

Professional
performance meets
affordability

**5000 Series
(5810* & 5720* AIO)**

Big power
in a compact,
innovative
design

**7000 Series
(7810*& 7910*)**

The most
powerful and
scalable
workstations

**Rack 7000 Series
(7910)**

Ultimate
workstation
performance
and security for 1:1 or
1:many

Mobile	Towers & AIO	Rack

powerful **performance |** innovative **design |** ISV **certified**

*VR-enabled

backed by Dell ProSupport™ Plus

Dell EMC Ready Bundle for HPC

Faster time-to-results, better throughput and utilization

- EAL3+ security certification and SELinux support
- Policy-driven, topology-aware scheduling
- Accelerator/co-processor scheduling
- Green Provisioning™ for power management
- Cgroups and fairshare available
- Proven to run millions of jobs per day
- Backfill, sharing, and shrink-to-fit jobs maximize usage
- Extensible plugin framework
- Open architecture to implement virtually any policy
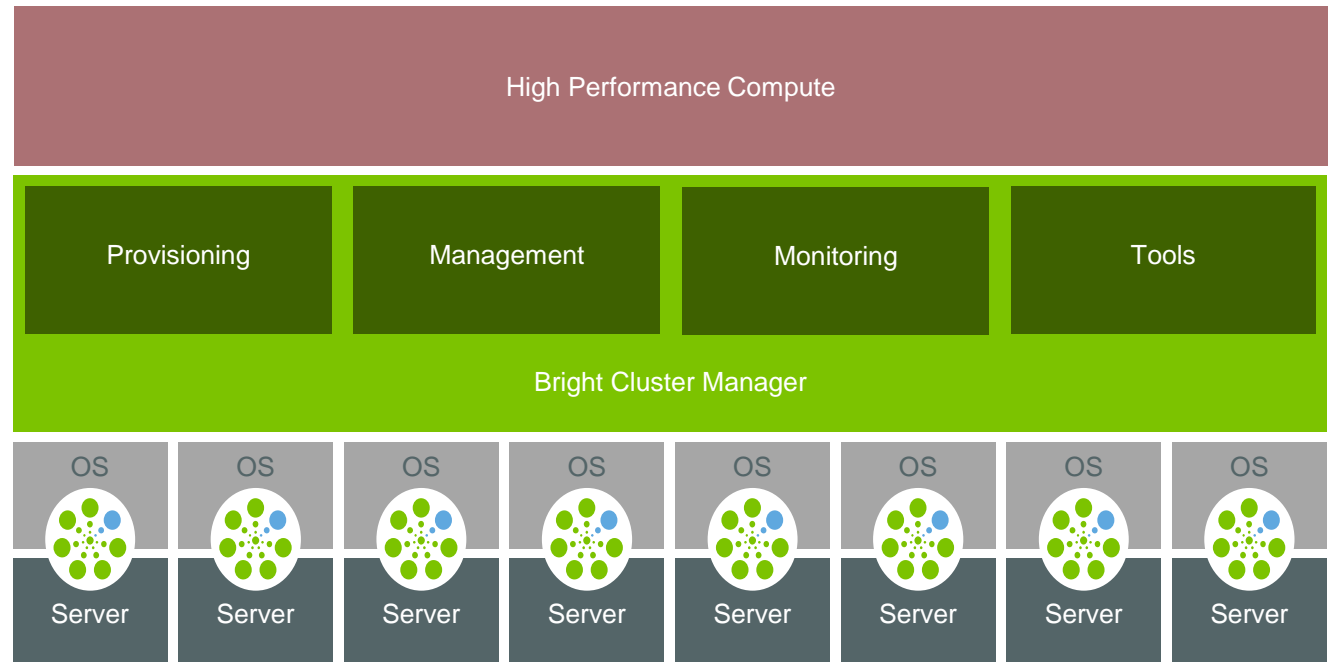
△ Altair | PBS Professional®

Dell EMC Ready Bundle for HPC

Optional: Bright Cluster Manager

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Bright software contains all of the essential functions for managing a cluster with ease including:

- Deployment & provisioning
- Dashboards, monitoring, & health-checking
- Visualization
- Workload manager integration
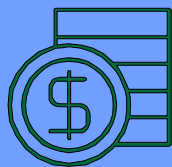- Security
- Cloud-bursting (AWS)

High Performance Compute

| Provisioning | Management | Monitoring | Tools |

Bright Cluster Manager

| OS | OS | OS | OS | OS | OS | OS | OS |
| Server | Server | Server | Server | Server | Server | Server | Server |

Dell EMC Ready Bundle for HPC

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The Problem

IT support of HPC, and the use of researchers & engineers is:

- Expensive
- Inefficient
- Ineffective

Dell Remote Cluster Management provides:

- Full service cluster administration
- Fulfill need for HPC full-time staff
- Focus on work, not administration
- Secure monitoring and reporting
- Single contact for all HPC issues
- Priced right for budget

Supports

- Schedulers & resource managers
- Remote visualization and application portals
- Storage & parallel file systems
- CAE applications and other applications

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Get exactly the help you need

Deployment Services

- Rapid integration using best practices
- HPC Factory Integration
- Flexible services customized to fit needs

Remote Cluster Management Services

- Turnkey outsource system management
- Secure remote system monitoring, administration & support
- Increased system utilization and uptime

Support Services

- 24x7 coverage
- Hardware/software
- 3rd party collaborative assistance
- Onsite services
- Dedicated TAM
- Global support in 55 languages

Dell Cloud Services

- Hybrid HPC clouds with bursting to public cloud for peak usage
- Flexible private cloud configurations

Dell Financial Services

- Flexible payment options to get more compute power for your money
- With financing, we make it easier for you to upgrade and refresh

Select, deploy, manage, support and scale your cluster

Comprehensive Data Management with DELL EMC

Business need

The challenge for Manufacturing and Engineering was to support huge volumes of information that go into every aspect of automobile design and production.

Solution

The company worked with Dell to create a Dell end-to-end infrastructure, featuring PowerEdge servers, storage, networking, data protection software and services.

Benefits

- Can support data growth for the coming years without concern over storage capacity with 20x more capacity than in the past
- Delivers easy scalability and slashes data backup times by 93%
- Guarantees operations with redundancy built into IT solution
- Keeps costs down with virtualized solution

"The deployment, with Dell products, represents an important step in keeping Nissan Motor Company on the cutting edge of technology."

Eiji Kimura,
General Manager, Manufacturing and Engineering
Department No. 2, Tochigi Plant, Nissan Motor Co., Ltd.

Migration to Hyper-Converged Solutions

Business need

Increasingly large data sets produced by the car's telemetry system, plus the proliferation of high definition video, meant that the I/O (input/output) of storage was causing bottlenecks. It could take engineers up to three minutes to open up a data set for analysis. When they only have an hour between practice sessions to fine-tune the car and are dealing with multiple data sets at any one time, every minute counts.

Solution

Williams F1 team worked with Dell to migrate its email and instant messaging to Microsoft Office 365, and install Dell XC Series web-scale hyper-converged appliances in its trackside and factory environments.

Benefits

- Hyper-converged architecture lets engineers access data in seconds instead of minutes for trackside analysis
- Simplified management frees up days of staff time to make crucial upgrades elsewhere
- Lightweight trackside infrastructure saves $150,000 on freight fees each season

"Now engineers can access the same data sets as before in around six seconds, as opposed to two to three minutes. This means they can make better informed decisions about configuring the car before a race."

Phil Cooper,
IT Infrastructure Manager, Williams

WILLIAMS F1 TEAM

Thank You!

Dell EMC Digital Manufacturing Whitepapers and blogs

Publicly available results of CAE application benchmarking on Dell systems

- **Broadwell blog series:** CAE application performance with various Broadwell processors and BIOS tuning options
  - New vs. Old: Comparing Broadwell Performance for CAE Applications Across Generations
  - Impact of Broadwell BIOS Options On CAE Applications
- **Comparing FDR and EDR InfiniBand blog series**
  - Need for Speed: Comparing FDR and EDR InfiniBand (Part 1)
  - Need for Speed: Comparing FDR and EDR InfiniBand (Part 2)
- Performance and Analysis of Manufacturing Applications on an HPC Cluster White Paper
  - Discussion of HPC system design for CAE applications
  - Results of a study on a 32-node HPC system including CAE application performance, effect of BIOS tuning and power usage
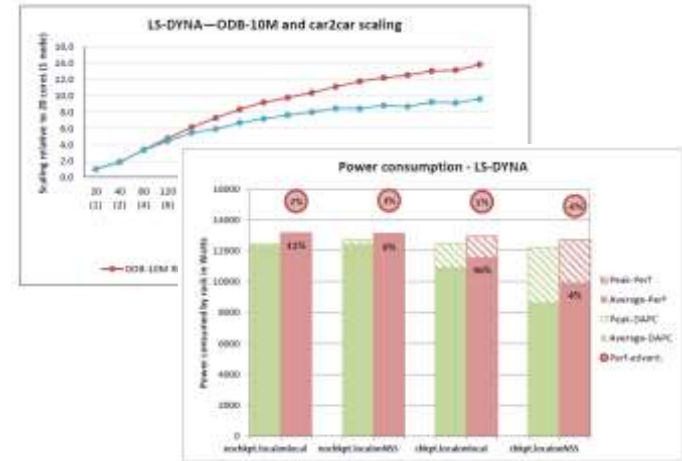
Additional component information:

PowerEdge C6320 PowerEdge C6320p PowerEdge R730
Dell Networking S3048-ON Dell Networking S4048-ON
Dell Z-series Networking
Mellanox InfiniBand Dell H-Series Networking (Intel OPA)
Dell HPC NFS Storage White Paper Dell HPC Lustre Storage solution with Intel Omni-Path (IEEL v3.0) August 2016 HPC Lustre Storage Solution with InfiniBand EDR (IEEL v3.0) White Paper (Sept 2016)

- www.hpcatdell.com
- www.dell.com/hpc