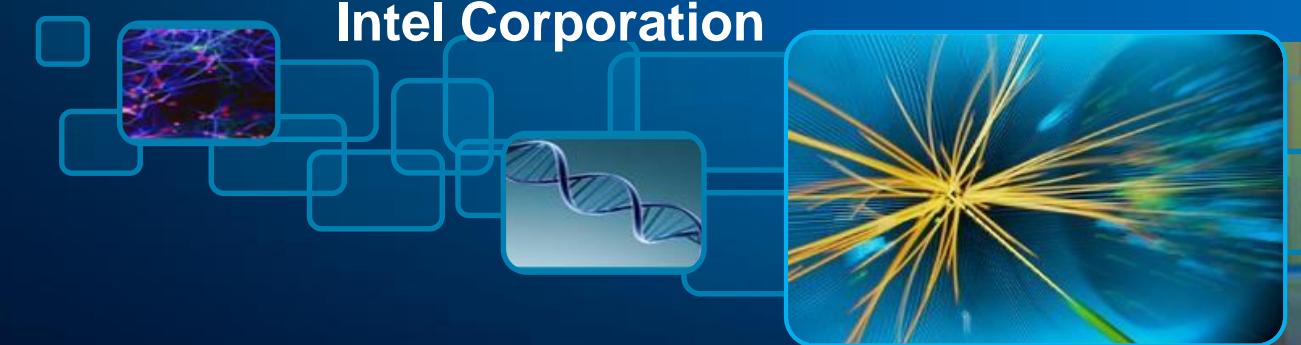




Future of Compute is Big Data

Mark Seager
Intel Fellow,
CTO for HPC Ecosystem
Intel Corporation



Traditional HPC is scientific simulation

First ever Nobel prize for HPC takes the experiment into cyberspace

Chemical reactions occur at lightning speed; electrons jump between atoms hidden from the prying eyes of scientists. The Nobel Laureates in Chemistry 2013 have made it possible to map the mysterious ways of chemistry by using computers. Detailed knowledge of chemical processes makes it possible to optimize catalysts, drugs and solar cells.

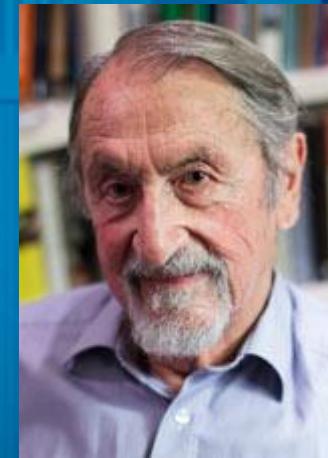
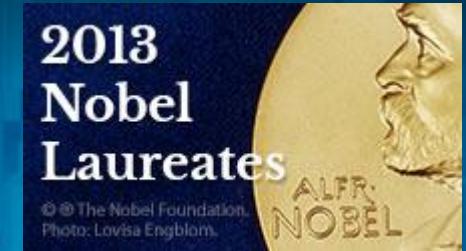
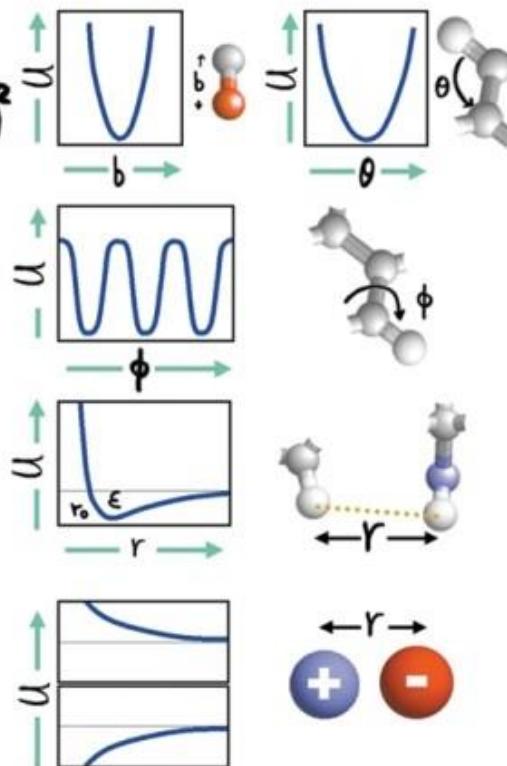
Spanning multiple scales by combining quantum mechanics and molecular dynamics

$$U = \sum_{\text{All Bonds}} \frac{1}{2} K_b (b - b_0)^2 + \sum_{\text{All Angles}} \frac{1}{2} K_\theta (\theta - \theta_0)^2$$

$$+ \sum_{\text{All Torsion Angles}} K_\phi [1 - \cos(n\phi + \delta)]$$

$$+ \sum_{\text{All nonbonded pairs}} \epsilon \left[\left(\frac{r_0}{r} \right)^12 - 2 \left(\frac{r_0}{r} \right)^6 \right]$$

$$+ \sum_{\text{All partial charges}} 332 q_i q_j / r$$



Martin Karplus Michael Levitt Arieh Warshel

The Nobel Prize in Chemistry 2013 was awarded jointly to Martin Karplus, Michael Levitt and Arieh Warshel "for the development of multi-scale models for complex chemical systems".



Other emerging technical computing usage models are driven by Big Data

Government & Research

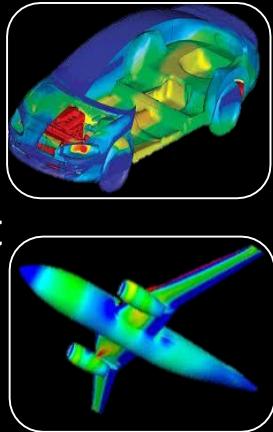


"My goal is simple. It is complete understanding of the universe, why it is as it is, and why it exists at all"

Stephen Hawking

Commerce & Industry

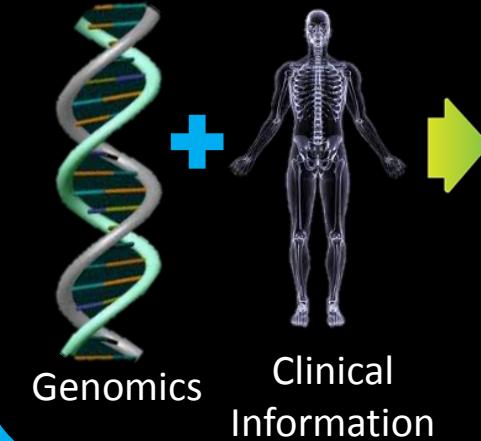
Better Products
Digital Twin
Faster Time to Market
Reduced R&D
New Business Models
Data Services



Basic Science

Business Transformation

New Users & New Uses

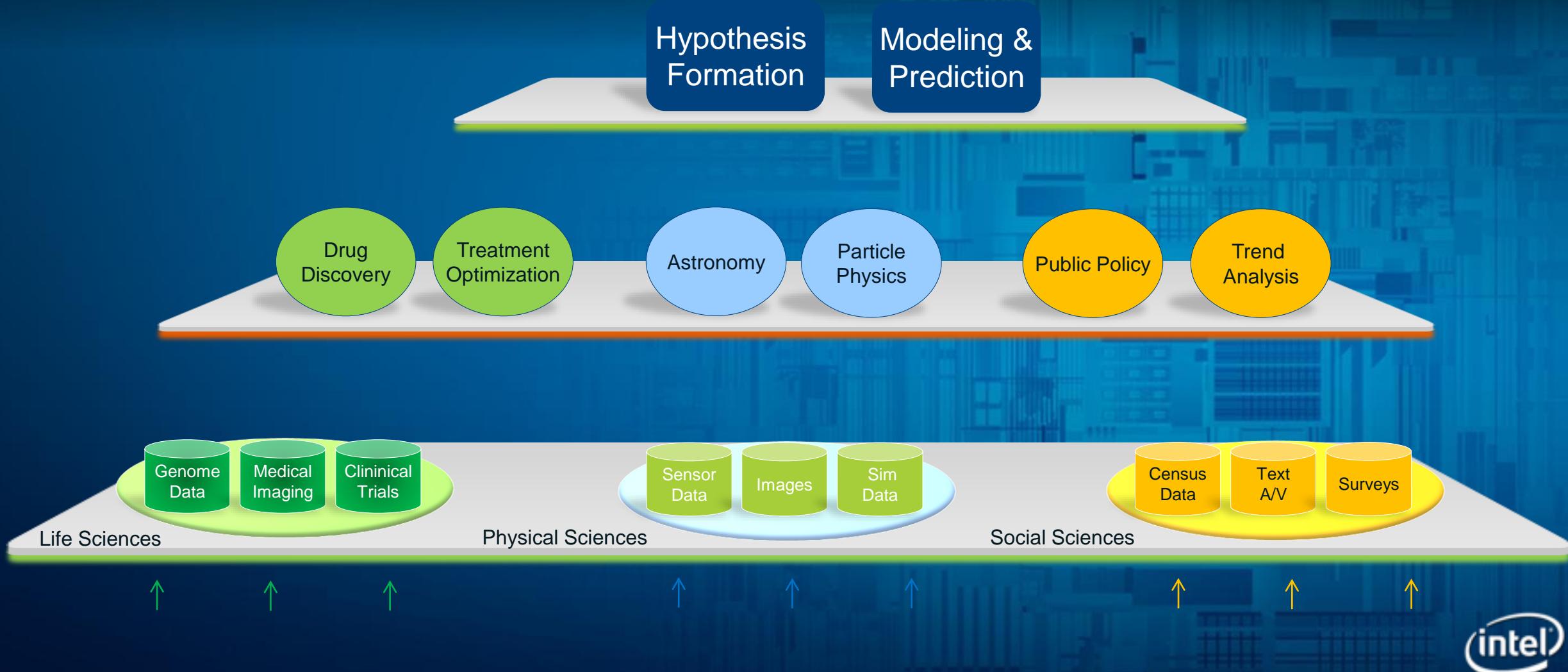


Data-Driven Discovery

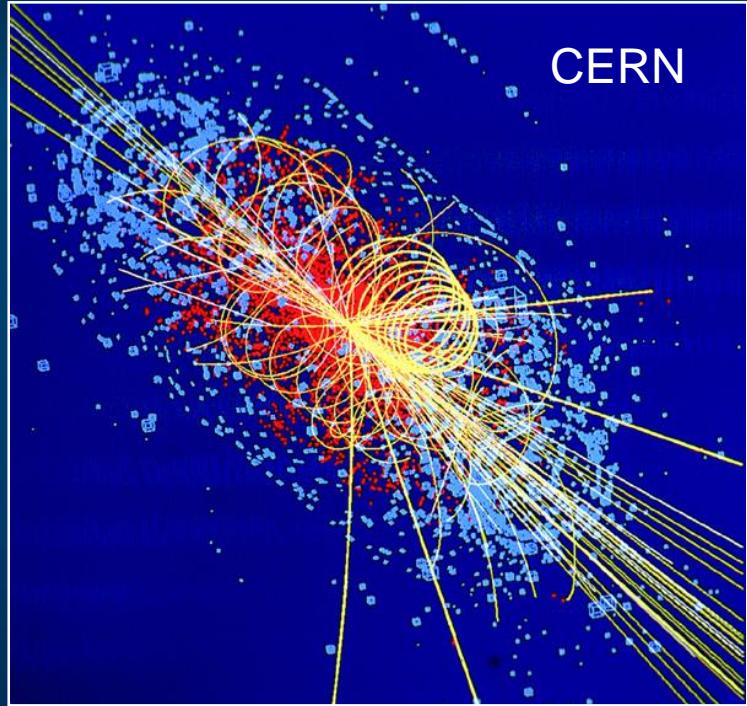
Transform data into useful knowledge



Data-Driven Discovery

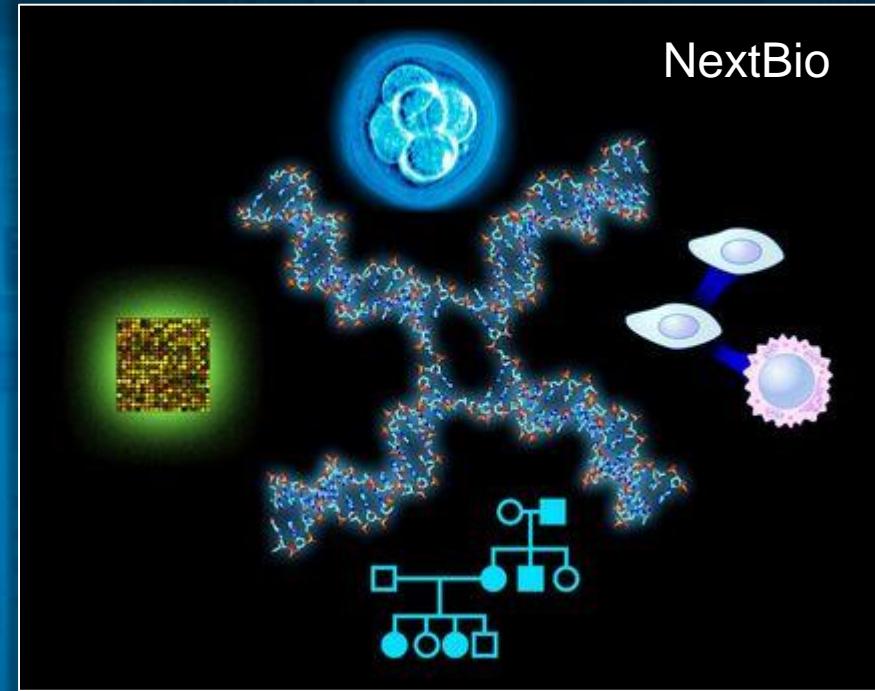


Data-Driven Discovery in Science



600 million collisions / sec

Detecting 1 in 1 trillion events to
help find the Higgs Boson

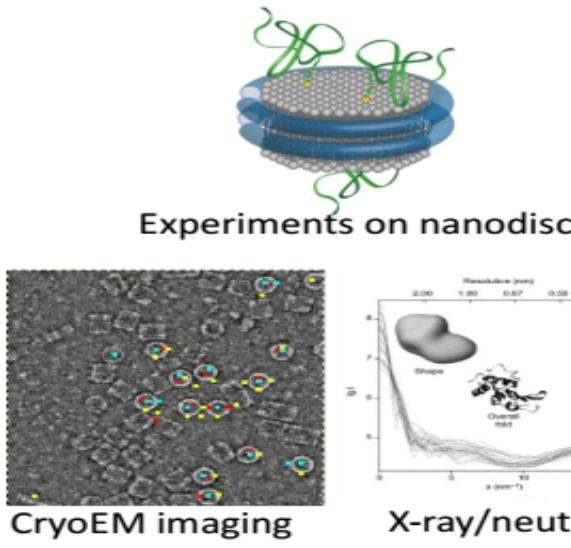


1 human genome = 1 petabyte

Finding patterns in clinical and genome
data at scale can cure cancer and other
diseases

Project Moonshot for Cancer: Predictive Oncology Pilot 2

RAS activation experiments at NCI/FNL



New adaptive sampling molecular dynamics simulation codes

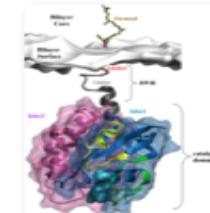
Adaptive time stepping



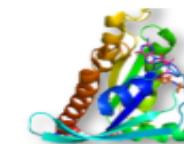
Adaptive spatial resolution

Predictive simulation and analysis of RAS activation

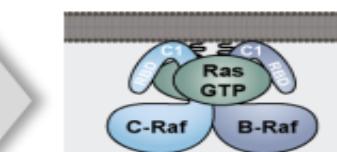
Granular RAS membrane interaction simulations



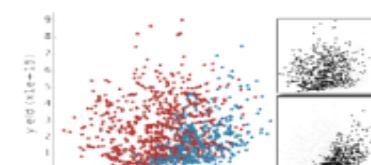
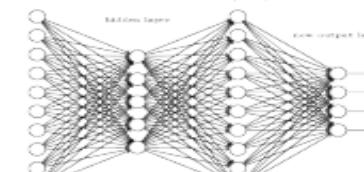
Atomic resolution sim of RAS-RAF interaction



Inhibitor target discovery



Machine learning guided dynamic validation



Convergence of Driving Forces

Intelligent Devices



19B
Connected devices
by 2016¹

Cloud



\$200B
Cloud services
In 2016²

HPC



2X
Annual growth in
supercomputing
FLOPS³

Big Data



15PB
Data collected in
1 year at CERN⁴

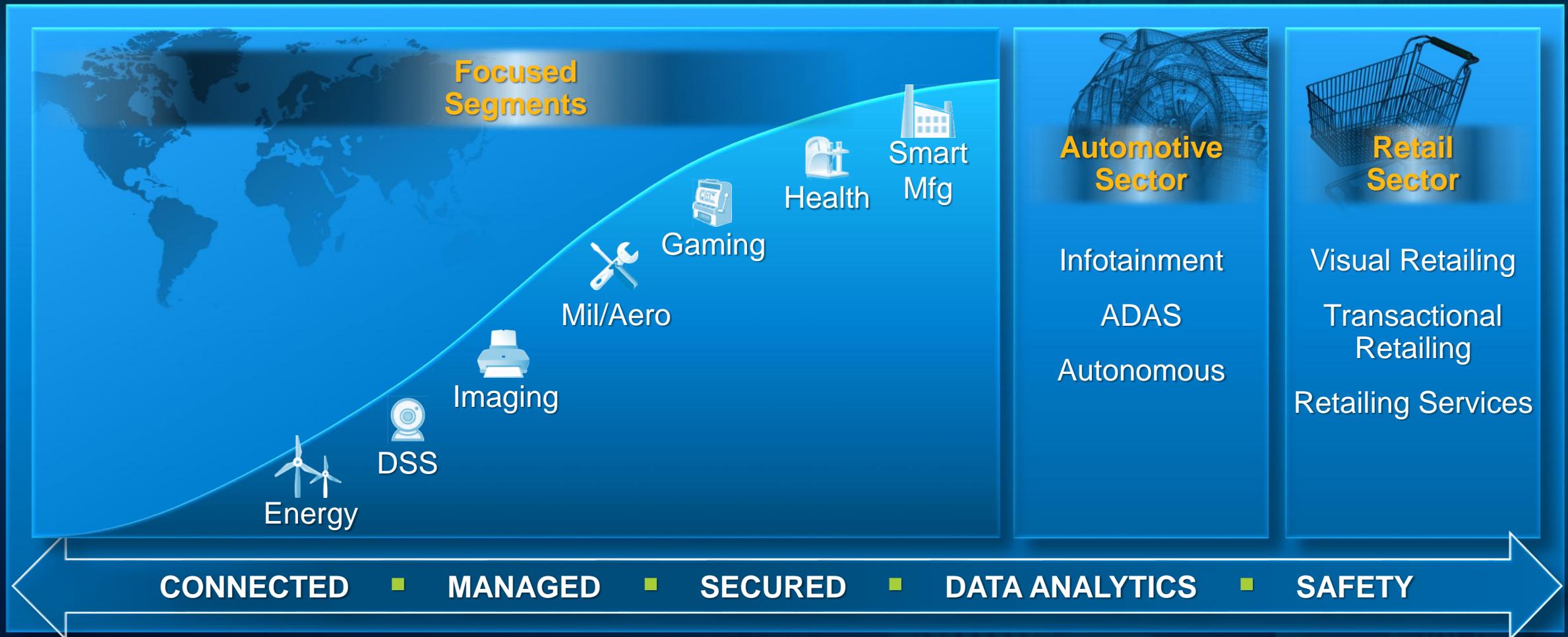
1 Source: Cisco® Visual Networking Index (VNI) Forecast (2011-2016)

2 Source: Gartner Worldwide IT Spending Forecast, 2Q12 Update

3 Source: Top 500 list: Top 10 change from November 2007 to November 2012

4 Source: CERN

Intelligent Devices - New Era of Computing Enabling an Industry of Pervasive Computing



INTEL GIVING SIGHT TO MACHINES IN THE AI AGE

THROUGH INNOVATION & ACQUISITION

CAPABILITIES

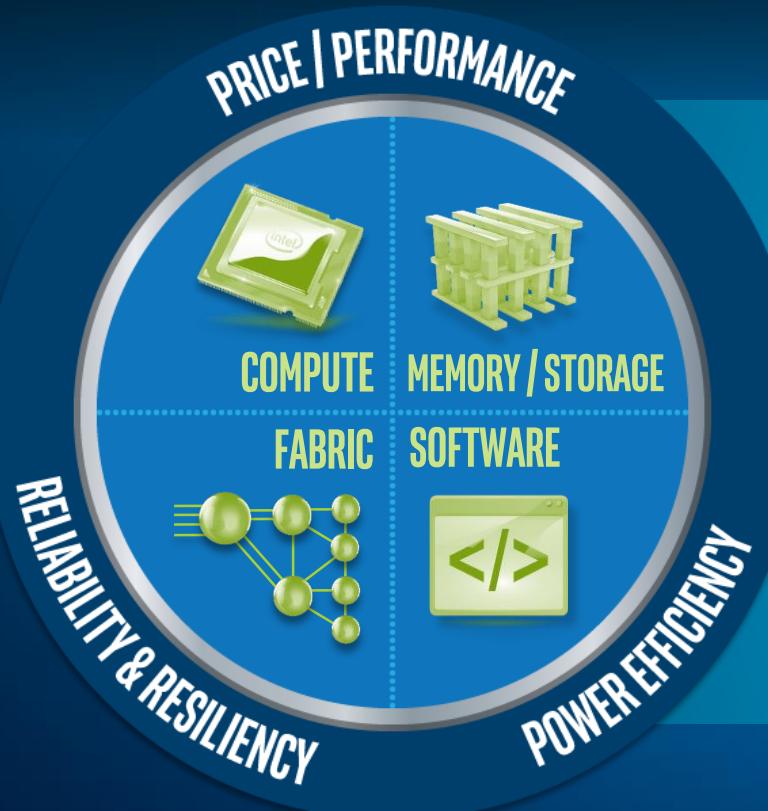
- MACHINE & DEEP LEARNING
- COGNITIVE COMPUTING
- PROGRAMMABLE SOLUTIONS
- intel REALSENSE™
DEPTH SENSING
- Movidius**
COMPUTER VISION & DEEP LEARNING
- COMPUTER VISION,
TOOLS & STANDARDS
- COLLISION AVOIDANCE
& NAVIGATION

EXPERIENCES



Intel® Scalable System Framework

A Holistic Solution for All HPC Needs



Intel® Xeon® Processors
Intel® Xeon Phi™ Processors
Intel® FPGAs and Server Solutions

Intel® Solutions for Lustre*
Intel® Optane™ Technology
3D XPoint™ Technology
Intel® SSDs

Intel® Omni-Path Architecture
Intel® Silicon Photonics
Intel® Ethernet

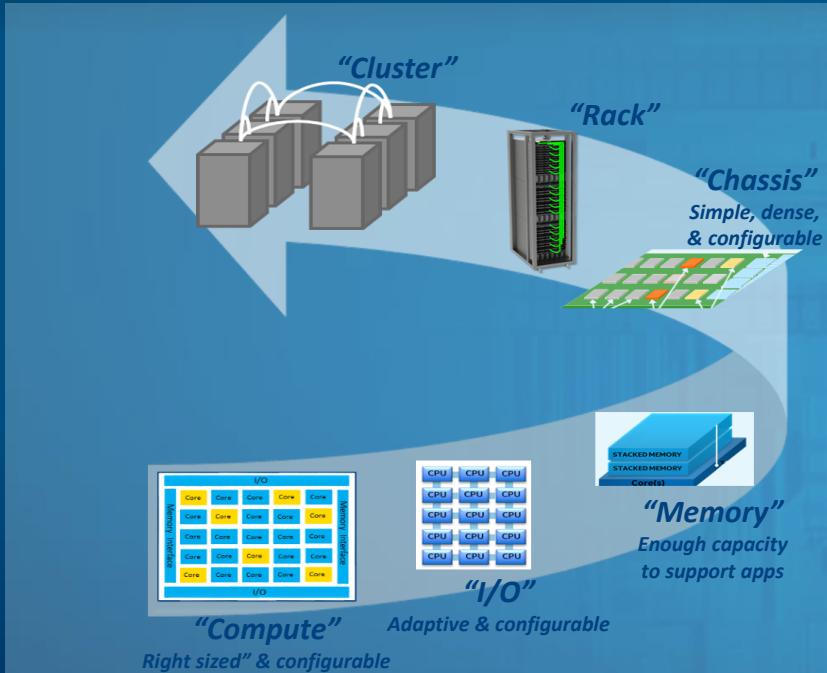
Intel® HPC Orchestrator
Intel® Software Tools
Intel® Cluster Ready Program
Intel Supported SDVis



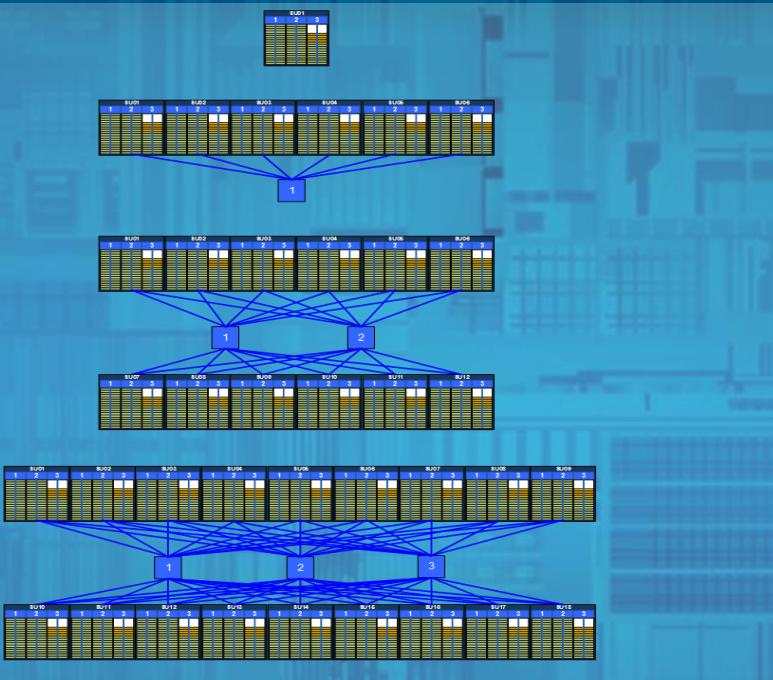
SSF: Enabling Configurability & Scalability

from components to racks to clusters

SSF Path To Exascale



SSF for Scalable Clusters



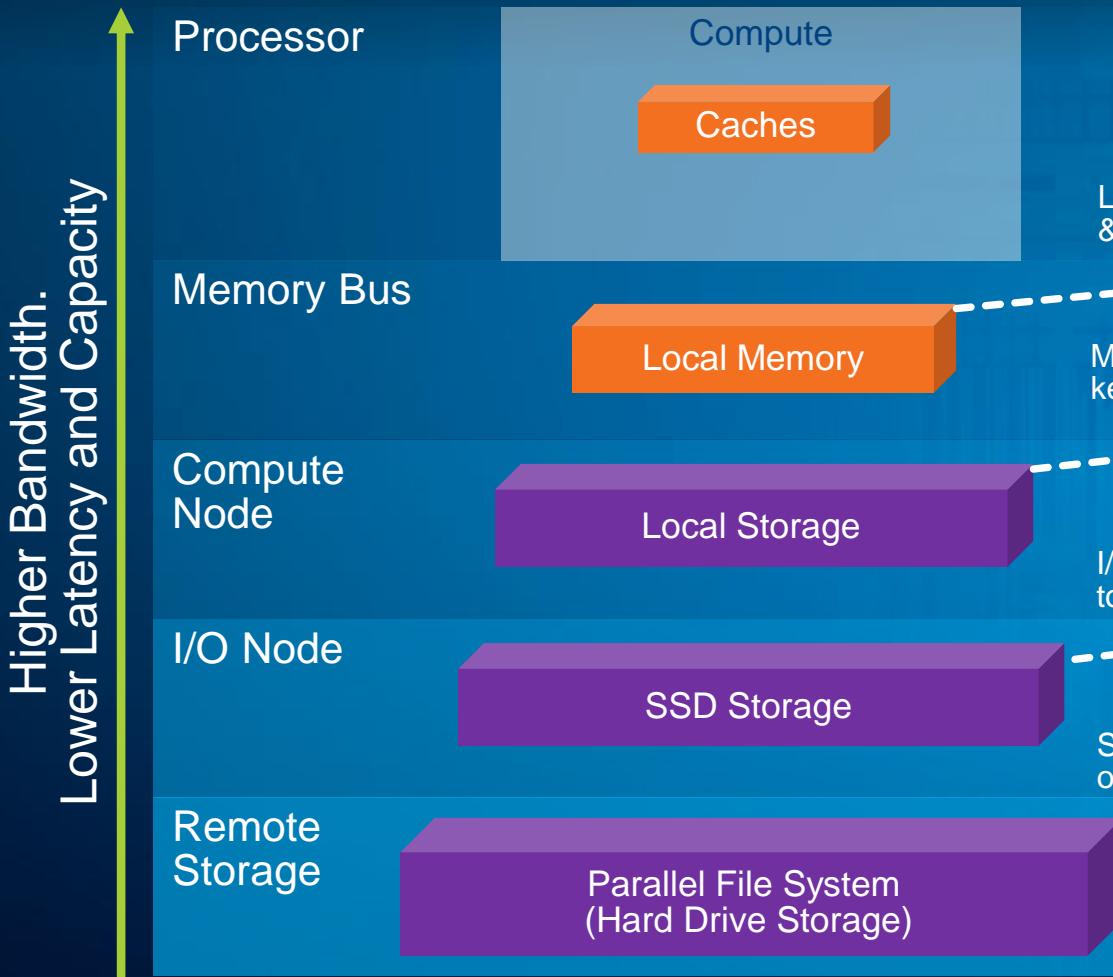
- Xeon or Xeon-Phi – based on workload needs
- Compute flexibly aggregated
- Lowest latency compute to compute interconnect

- I/O Topologies for best performance
- Configurable I/O bandwidth director switch
- Burst buffer to decouple storage from I/O

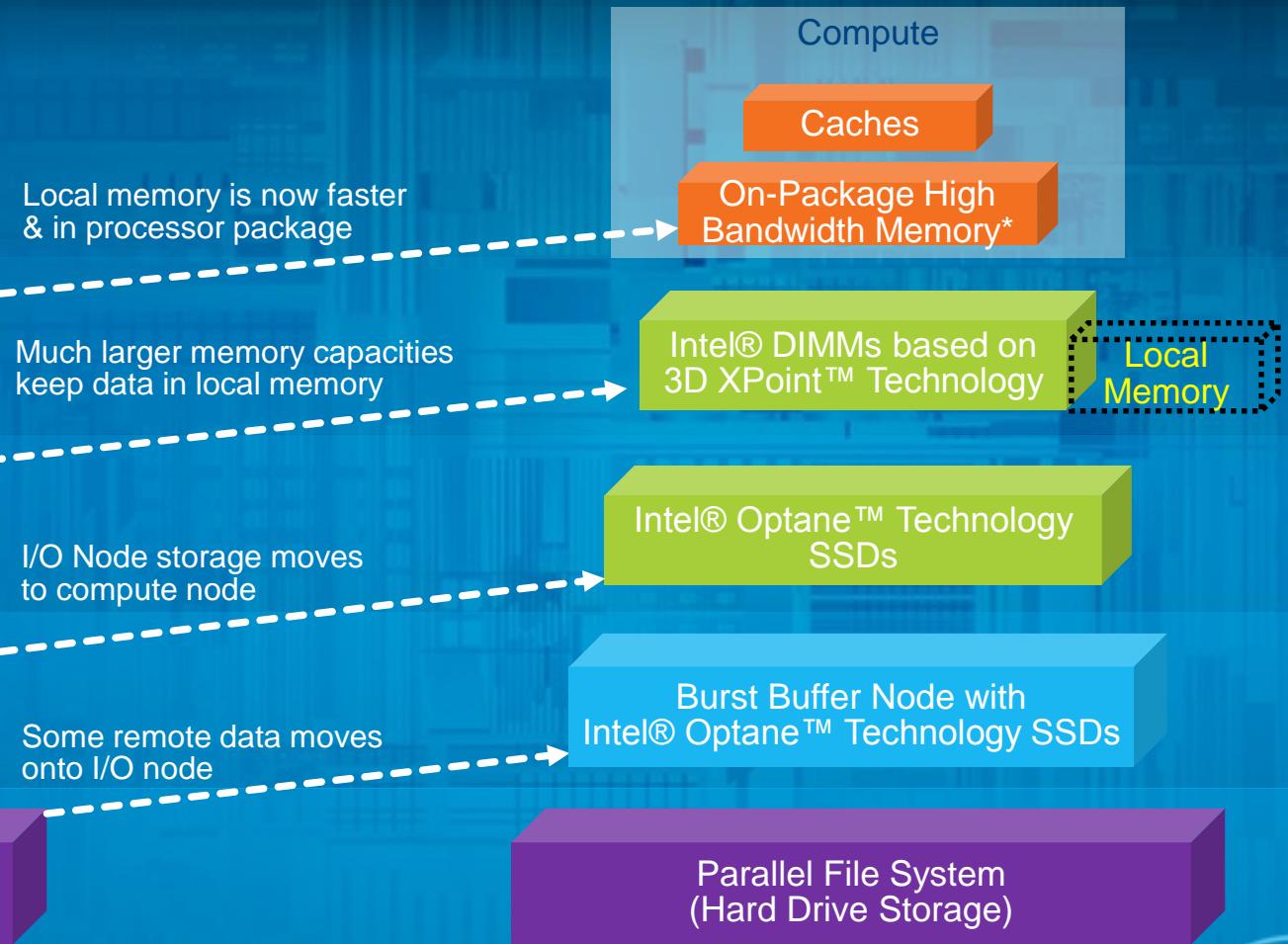
Tighter System-Level Integration

Innovative Memory-Storage Hierarchy

Today



Future



*cache, memory or hybrid mode

Bringing Memory Back Into Balance

High Bandwidth, On-Package Memory

Up to 16GB with Knights Landing

5x the Bandwidth vs DDR4¹, >400 GB/s¹

>5x More Energy Efficient vs GDDR5²

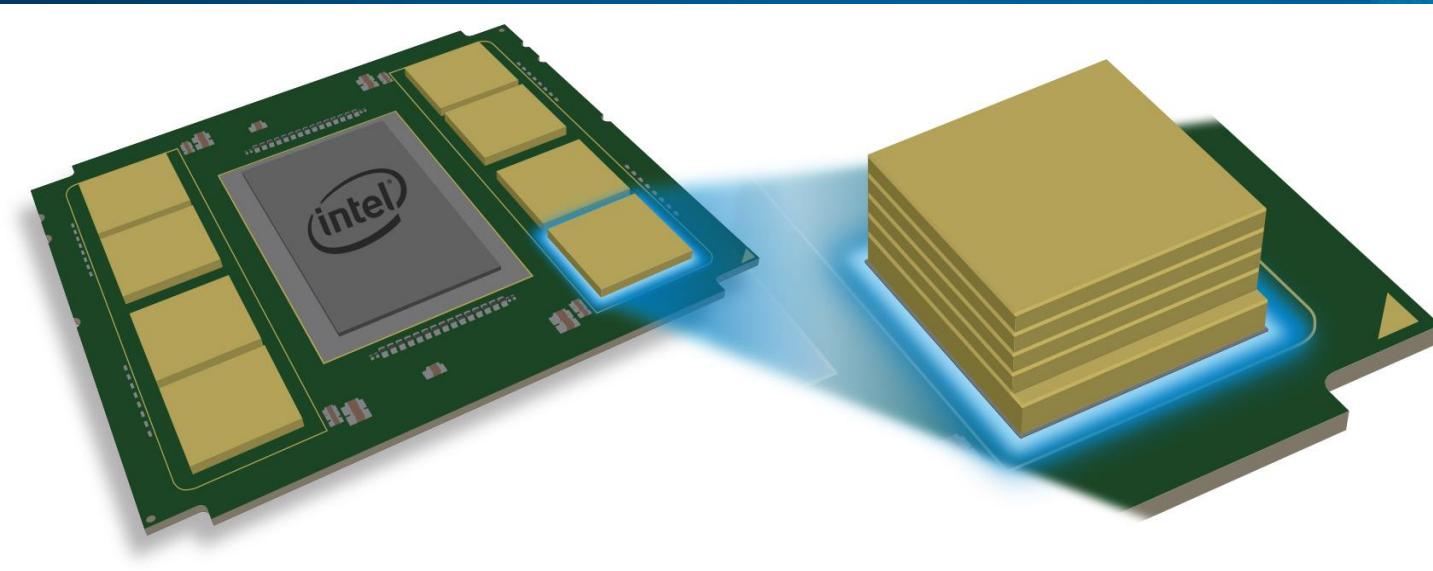
>3x More Dense vs GDDR5²

3 Modes of Operation

Flat Mode: Acts as Memory

Cache Mode: Acts as Cache

Hybrid Mode: Mix of Cache and Flat

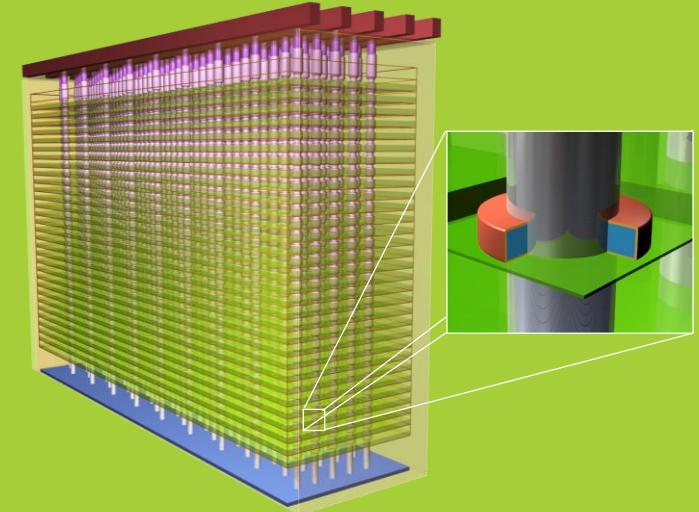


¹ Projected result based on internal Intel analysis of STREAM benchmark using a Knights Landing processor with 16GB of ultra high-bandwidth versus DDR4 memory with all channels populated.

² Projected result based on internal Intel analysis comparison of 16GB of ultra high-bandwidth memory to 16GB of GDDR5 memory used in the Intel® Xeon Phi™ coprocessor 7120P.

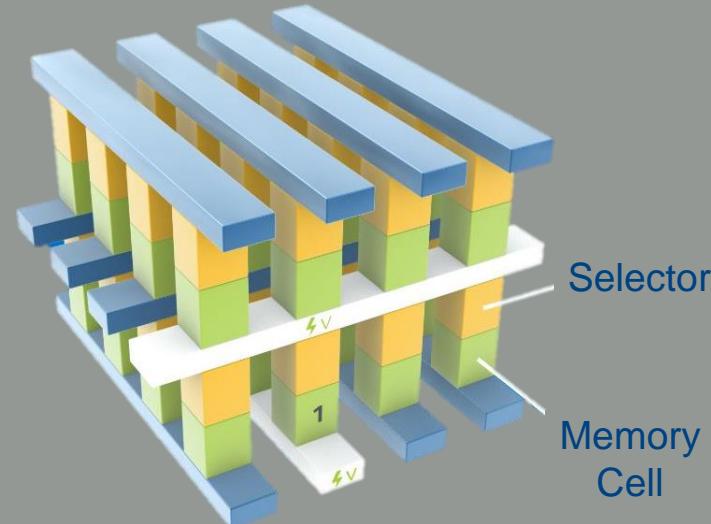
NAND Flash and 3D XPoint™ Technology

3D MLC and TLC NAND



Enabling highest capacity SSDs
at the lowest price

3D XPoint™ Technology



Enabling highest performance
SSDs and expanding use cases

3D Xpoint™ Technology

Cross Point Structure

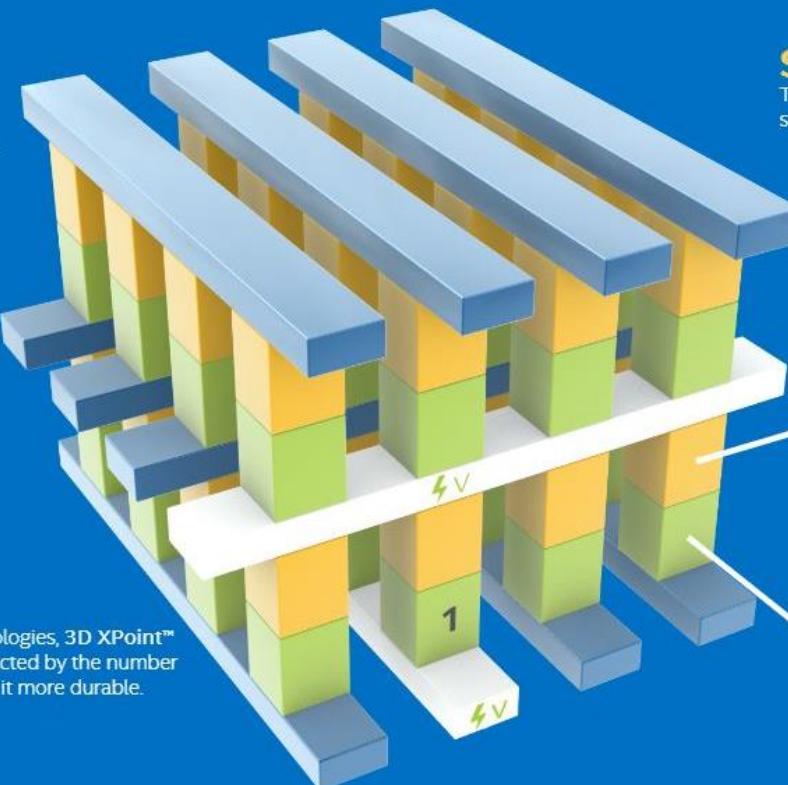
Perpendicular wires connect submicroscopic columns. An individual memory cell can be addressed by selecting its top and bottom wire.

Non-Volatile

3D XPoint™ Technology is non-volatile—which means your data doesn't go away when your power goes away—making it a great choice for storage.

High Endurance

Unlike other storage memory technologies, 3D XPoint™ Technology is not significantly impacted by the number of write cycles it can endure, making it more durable.



Stackable

These thin layers of memory can be stacked to further boost density.

Selector

Whereas DRAM requires a transistor at each memory cell—making it big and expensive—the amount of voltage sent to each 3D XPoint™ Technology selector enables its memory cell to be written to or read without requiring a transistor.

Memory Cell

Each memory cell can store a single bit of data.

Transforming the Memory Hierarchy

For the first time, there is a fast, inexpensive and non-volatile memory technology that can serve as system memory and storage.



3D XPoint™ Technology

Processor

~8x to 10x Greater Density than DRAM¹

3D XPoint™ Technology's simple, stackable, transistor-less design packs more memory into less space, which is critical to reducing cost.

1GB



DRAM



3D XPoint™ Technology



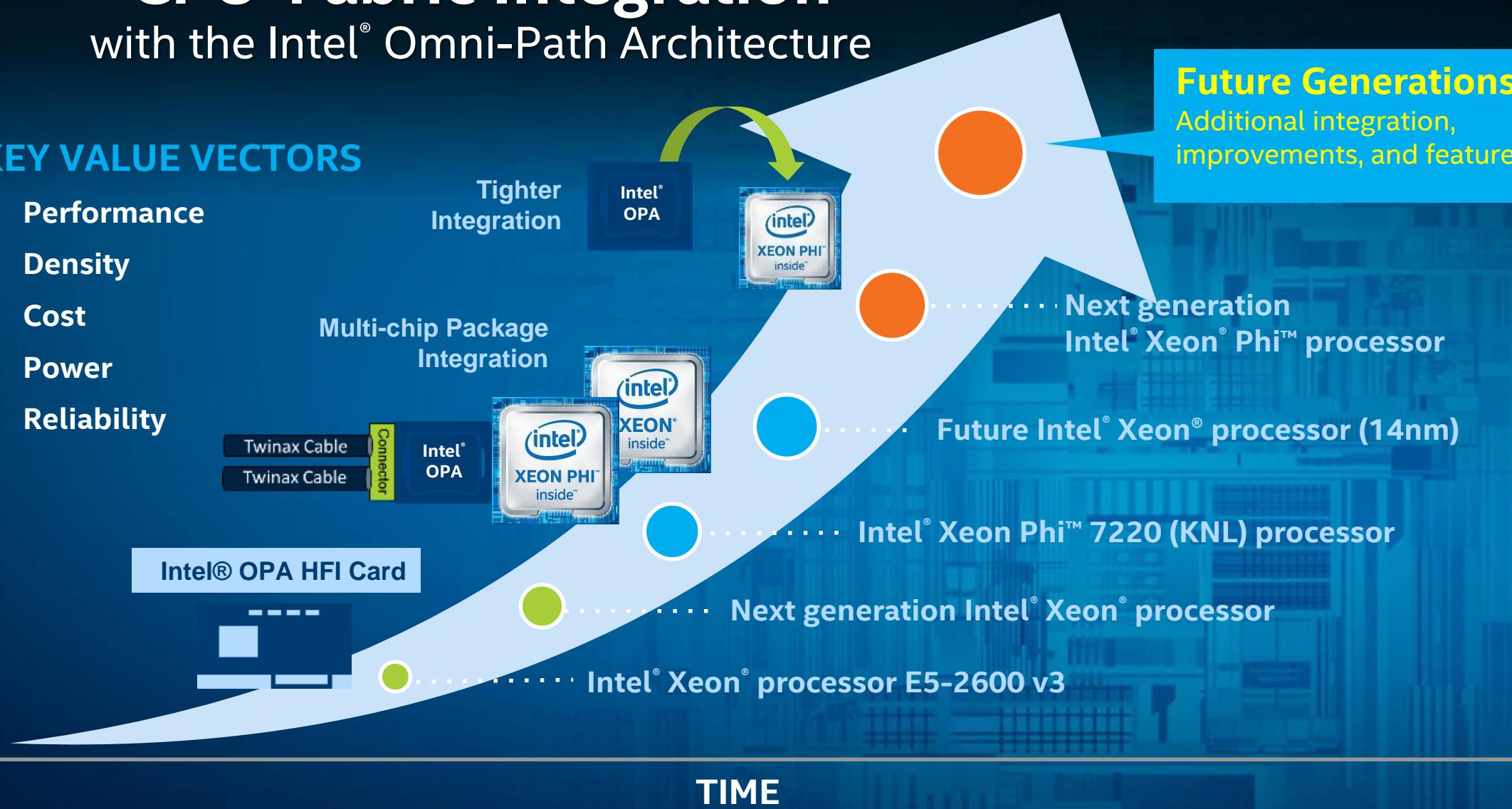
CPU-Fabric Integration

with the Intel® Omni-Path Architecture

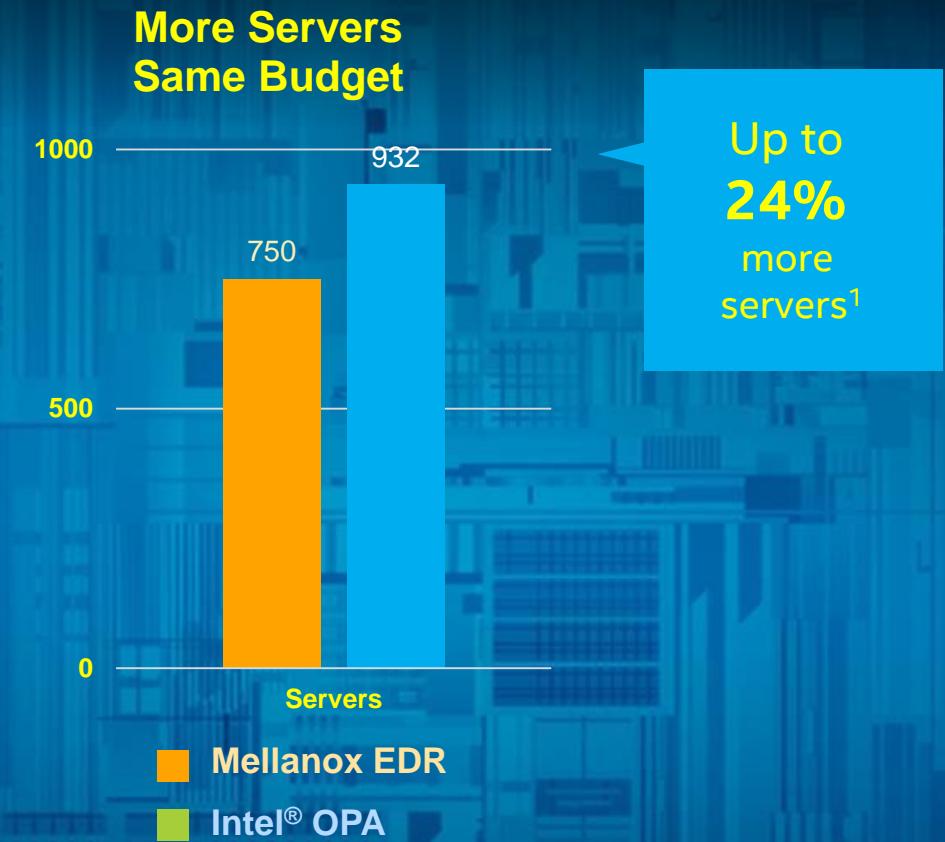
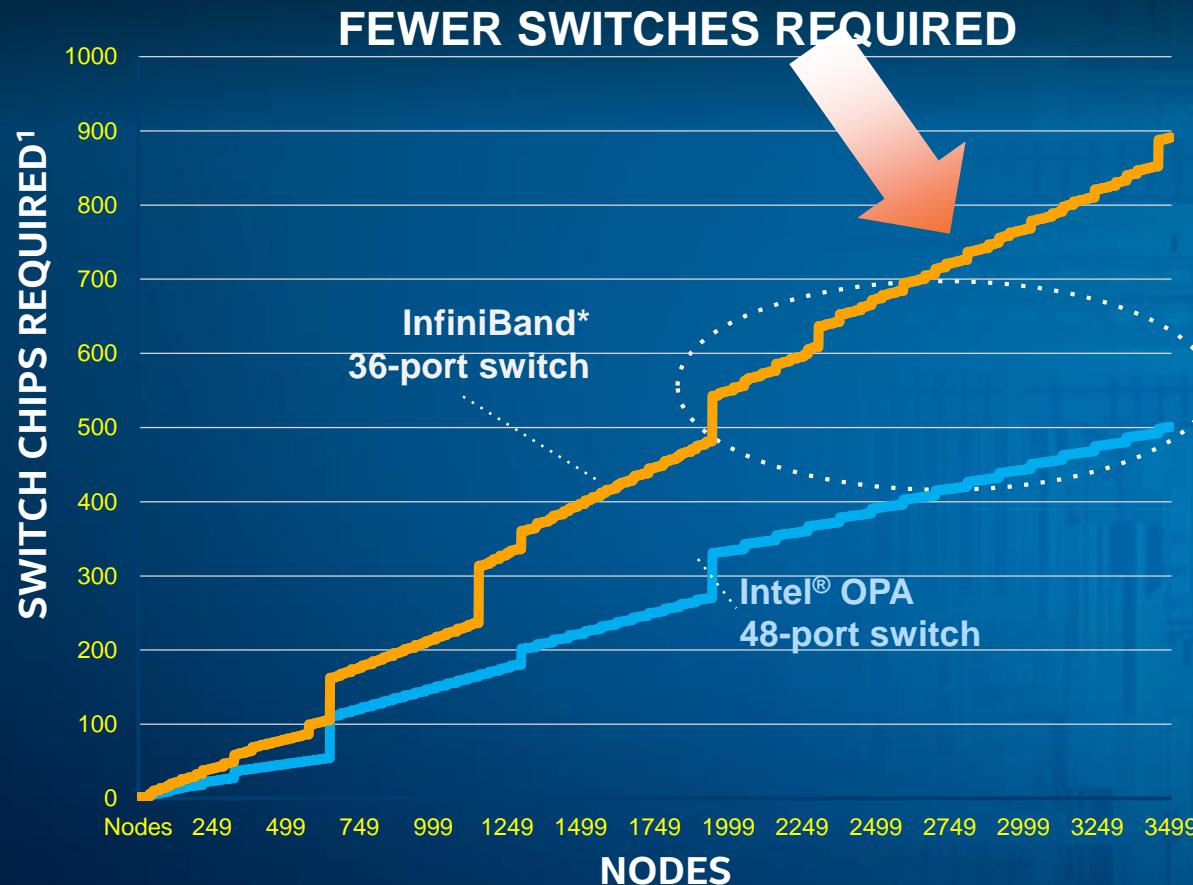
KEY VALUE VECTORS

- ✓ Performance
- ✓ Density
- ✓ Cost
- ✓ Power
- ✓ Reliability

PERFORMANCE

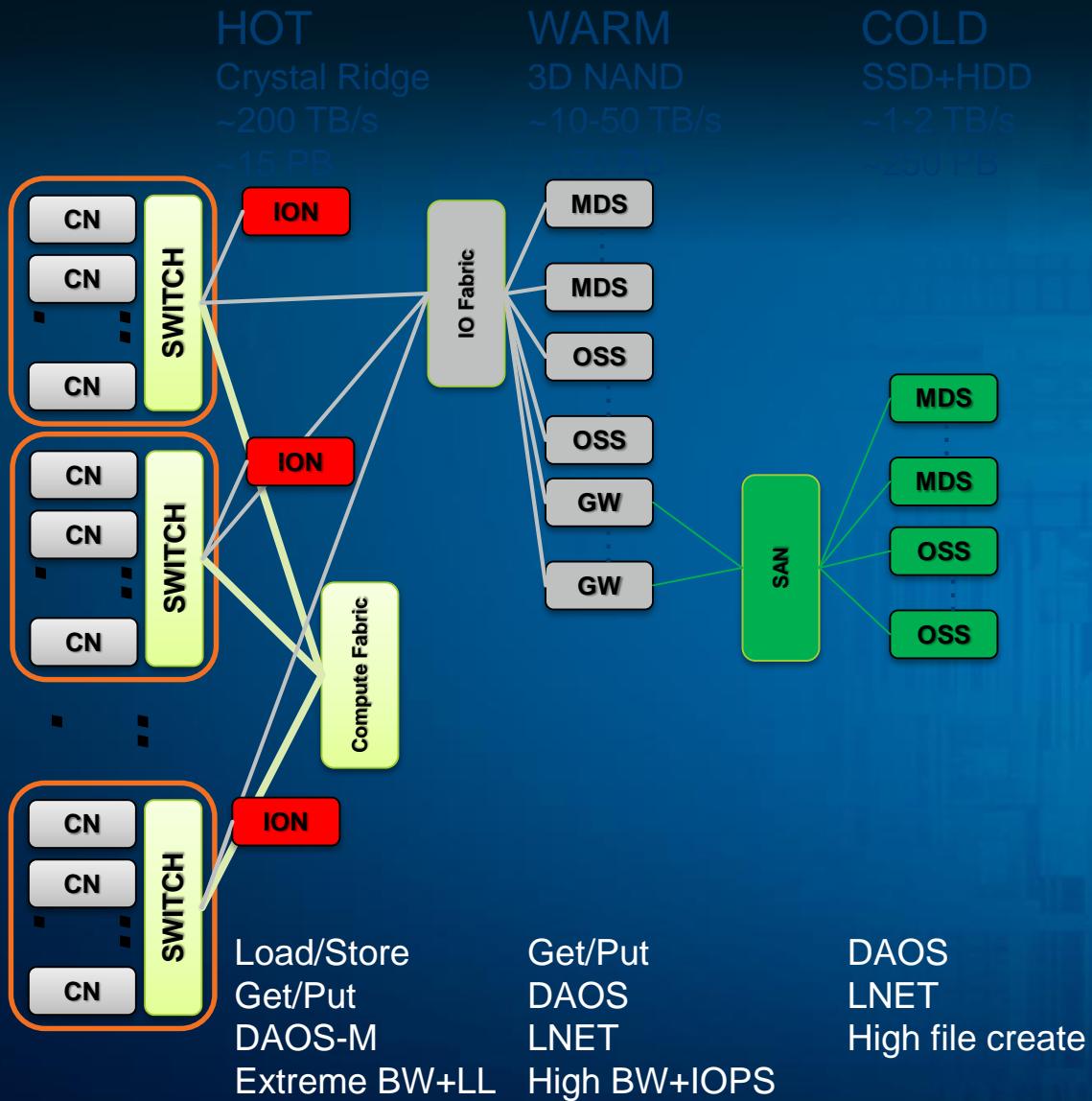


OmniPath is Optimized for scalability



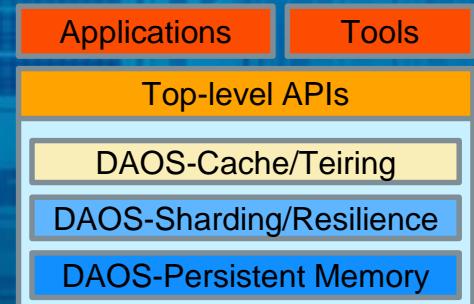
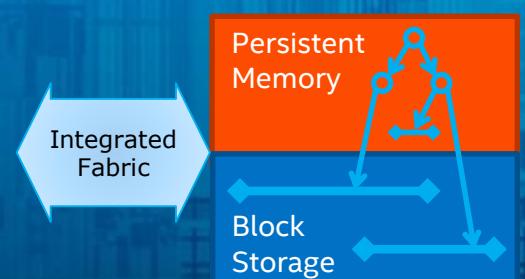
¹ Configuration assumes a 750-node cluster, and number of switch chips required is based on a full bisectional bandwidth (FBB) Fat-Tree configuration. Intel® OPA uses one fully-populated 768-port director switch, and Mellanox EDR solution uses a combination of 648-port director switches and 36-port edge switches. Intel and Mellanox component pricing from www.kernelsoftware.com, with prices as of May 5, 2016. Compute node pricing based on Dell PowerEdge R730 server from www.dell.com, with prices as of November 3, 2015. Intel® OPA pricing based on estimated reseller pricing based on projected Intel MSRP pricing at time of launch. * Other names and brands may be claimed as property of others.

New storage paradigm for data intensive systems

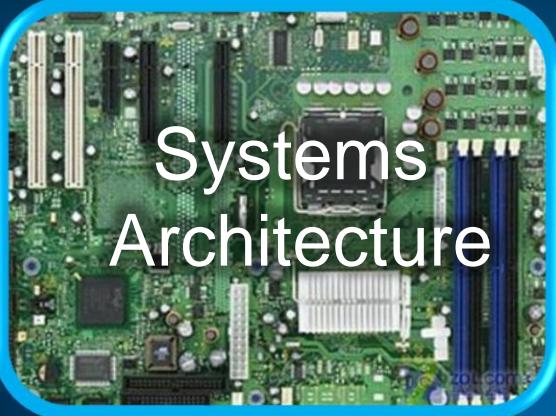


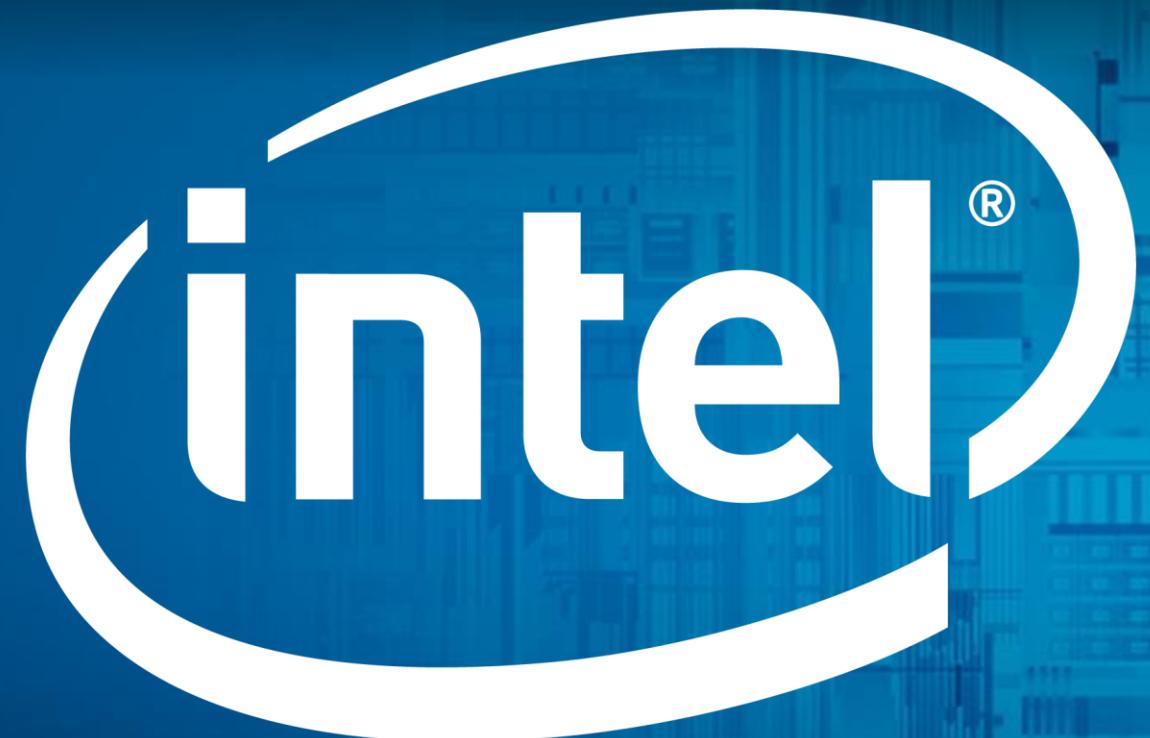
- SSF Enables HPC+HPDA workloads
 - System components can be configured to match workload requirements
 - Enables new access methodologies (DAOS) to create new generation applications
 - Incremental improvements to Lustre to provide enhanced performance for existing applications

Distributed Asynchronous Object Storage



Benefit from Intel's long-standing investments





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