Introduction to Intel® Solutions for Lustre® Software
Legal Disclaimer

- THIS DOCUMENT AND RELATED MATERIALS AND INFORMATION ARE PROVIDED "AS IS" WITH NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS, OR ANY WARRANTY OTHERWISE ARISING OUT OF ANY PROPOSAL, SPECIFICATION, OR SAMPLE. INTEL ASSUMES NO RESPONSIBILITY FOR ANY ERRORS CONTAINED IN THIS DOCUMENT AND HAS NO LIABILITIES OR OBLIGATIONS FOR ANY DAMAGES ARISING FROM OR IN CONNECTION WITH THE USE OF THIS DOCUMENT.
- All products, product descriptions, plans, dates, and figures are preliminary based on current expectations and subject to change without notice. Availability in different channels may vary.
- Intel and the Intel logo are trademarks or registered trademarks of Intel Corporation in the United States and other countries.
- *Other names and brands may be claimed as the property of others.
- Copyright 2016 © Intel Corporation. All rights reserved.
Module Objectives

At the end of this course you will be able to:

- Define what the Lustre* file system is
- List the major characteristics of the Lustre* file system
- Identify the basic components of the Lustre* file system architecture
- Identify the differences between traditional network file systems and a Lustre* file system
- List the three Lustre*-based software solutions developed and offered by Intel
- Identify the features and technology that Intel adds to the Lustre* file system
Module Overview

High-level Lustre* overview
- What is Lustre*?
- Characteristics of Lustre*
- Key markets for Lustre*
- Advantages of Lustre*
- Lustre* architecture
- Typical Lustre* I/O
- Traditional network file systems versus Lustre*

Intel® Solutions for Lustre* Software
- Open source products
- Lustre* enhancements from Intel
High-level Lustre* Overview
What is Lustre*?

- Object based, distributed, parallel, clustered file system
- Accessed by clients over network (Ethernet, InfiniBand)
  - Up to 512 PB file system size, 32 PB per file
  - Production file systems have I/O rates in excess of 1.2TB/sec
- Open source and Linux-based - largest install bases are on RHEL* / CentOS* and SLES*
- Also provides storage for other Operating Systems - Windows and OS X using a gateway server such as NFS or CIFS
- Foundation in traditional High Performance Computing (HPC) - still core business
  - Excels in sequential, large block parallel I/O from multiple clients
- Now getting established in data centers of non-traditional HPC
  - Data centers with large data sets and high availability needs
# Lustre* Characteristics

<table>
<thead>
<tr>
<th>Open Source (GPL v2)</th>
<th>High Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Anyone can obtain the source code</td>
<td>- Measured in aggregate throughput</td>
</tr>
<tr>
<td>- Compliance to Open Source License terms and conditions</td>
<td>- Workload is distributed equally servers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scalable</th>
<th>POSIX* Compliant</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Start small - add more components</td>
<td>- No need to rewrite applications</td>
</tr>
<tr>
<td>- Performance scales - almost linearly</td>
<td>- Drop in and run</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distributed</th>
<th>Resource Efficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>- File system distributed across many arrays</td>
<td>- Nodes can withstand intense workloads</td>
</tr>
<tr>
<td>- Allows for large scale solutions</td>
<td>- Customers are not forced to <em>buy more</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parallel</th>
<th>Cost Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>- I/O with multiple storage targets simultaneously</td>
<td>- Commodity hardware and open source software</td>
</tr>
<tr>
<td>- Client bandwidth increases</td>
<td>- Considering support, Lustre* compares well</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clustered</th>
<th>Global, shared namespace</th>
</tr>
</thead>
<tbody>
<tr>
<td>- High availability for most components</td>
<td>- Everything looks like one big file system</td>
</tr>
<tr>
<td>- If one component fails, another picks up the load</td>
<td>- All clients can access all data in parallel</td>
</tr>
</tbody>
</table>

*Note: Intel logo present in the bottom left corner.*
Key Markets Using Lustre* Today

**Bioscience**
Genomic data analysis, modeling and simulations

**Government**
Research and defense

**Large-scale manufacturing**
Mechanical computer-aided design & computer-aided engineering systems

**Weather and Climate**
Highly complex CGI rendering

**Energy**
Seismic processing, reservoir modeling / characterization, sensor data analysis

**Finance**
Fraud detection, Monte Carlo simulations, risk management analysis
Lustre* Advantages

- **Speed**: Excellent performance, especially large block sequential I/O
- **Open platform**: Intel® Xeon® servers and leading Linux distributions
- **Efficiency**: Can achieve 90+% utilization of storage and network hardware
- **Storage choice**: Storage hardware neutral, broad array of block storage partners
- **Affordability**: Low CAPEX and OPEX
- **Scalability**: Independently scale storage capacity and bandwidth ("build up" and/or "build out")
- **Stability and reliability**: Backed by Intel, the worldwide leader in Lustre® support
Lustre* Architecture - What Does a Lustre* Solution Look Like?

- Management Target (MGT)
- Metadata Target (MDT)
- Object Storage Targets (OSTs)
- Management Network
- Metadata Servers
- Object Storage Servers
- High Performance Data Network (InfiniBand®, 10GbE)
- Intel® Manager for Lustre®

Storage servers grouped into failover pairs
Lustre® Clients
Typical I/O

- Different targets for metadata and block data
- Backend file system on targets to store data
- Client applications see namespace as single POSIX file system
- Targets exported to clients via the Lustre network
- Lustre uses a Client / Servers design
Traditional Network File Systems vs Lustre*

Distributed client, central server, e.g. NFS, CIFS/SMB
- Network performance and scalability limited by single server bandwidth
- Scalability limited by physical constraints of server and array
- New storage server creates a separate file system
- Storage becomes fragmented into silos

Distributed client, distributed servers (Lustre*)
- Scale performance and capacity linearly as clients grow
- Client network scalability is not limited by the file system
- All clients can access all storage servers simultaneously and in parallel
- Single coherent namespace across all servers
- Hundreds of network storage servers in a single file system
Intel® Solutions for Lustre*
What Intel Adds to Lustre*

- Manpower dedicated to software development
- Releases and features beyond the Community Lustre* release
- Infrastructure/technology for better software testing and development
- Industry leading Lustre* experience and support
What Intel Adds to Lustre* – Manpower

- Intel - 4th largest software development company in the world
- More than 10,000 developers at over 35 sites
- Largest team of Lustre* software developers and engineers in the world
- Most contributions to Lustre* code
- Commitment to development of Linux kernel and compilers
Intel® Solutions for Lustre*

Intel® Enterprise Edition for Lustre* Software
High performance, petascale storage platform, ready for business

Intel® Foundation Edition for Lustre* Software
The newest features, the latest technology

Intel® Cloud Edition for Lustre* Software
Scalable, parallel storage performance on demand, available today on Amazon Web Services

* All three editions are supported by Intel.
Intel® Enterprise Edition for Lustre® Software

Key Features
- Production quality Lustre® file system, enhanced by Intel
- Intel® Manager for Lustre® (IML) software
- Intel Lustre® adapter for Apache Hadoop and Cloudera Hadoop
- HSM support, including POSIX® copy tool and a powerful policy engine
- Maximum data protection using ZFS
- Improved small file performance using DSS
- 24x7 Enterprise support
- Xeon Phi client optimization
Intel® Foundation Edition for Lustre® Software: Fusing Innovation with Support

Key Features
- Community Lustre® software base, with additional open source code from Intel
- Maximum configuration size and scale
- Flexible deployment architectures
- Global technical support expertise

- **Customers:** Technically strong end-users and OEMs looking for the latest features and maximum flexibility
- **Key Markets:** HPC markets – large scale research, top500 supercomputing
- **Key Benefits:** Targeted at customers with Lustre® experience seeking the latest releases, unusual deployment architectures, extreme scale, or in-house development on top of Lustre
Intel® Cloud Edition for Lustre® Software: Parallel Storage for Unparalleled Results

Key Features
- Storage performance and scalability boost app performance
- Compliant with key industry standards
- Broad AWS® compute instance support
- AWS® Elastic Block Storage or ephemeral storage
- Global technical support expertise from Intel

Current Status
- Available today on Amazon Web Services Marketplace and Azure

Customers: End-users or cloud infrastructure providers wanting superior storage performance
Key Markets: HPC moving onto cloud, emerging applications deployed to cloud infrastructure
Key Benefits: I/O and capacity of parallel, distributed storage for cloud-based workloads; cost effective and productive; runs larger, more complex simulations and models with minimal risk or cost impact
Lustre*, by Itself, Does Not Make the Storage Solution

How do you create a high performance, reliable Lustre* storage system?
Whatever you need, from designing a solution to debugging Lustre*, Intel is there.

How can you tell what is happening in your Lustre* file system?
When you get a call saying “the file system is running slow” or asking “is everything ok with Lustre?”, what do you do? Intel has an app for that.

Who can give 24x7, world wide support for Lustre* on your preferred hardware?
When you have problems with the file system, Intel is there.

Where do you start when tuning your Lustre* file system?
When you need in depth knowledge tuning Lustre* for your applications, Intel is there.

How can you have the most reliable version of Lustre* with the best possible support?
Intel's Lustre* software goes through extensive testing and bug fixes, adding reliability and stability, and includes Intel's world class support.
What Intel Adds to Lustre* – Technology

Intel's Infrastructure and Technology for better software

- Proven quality assurance for all Lustre* and Intel® Enterprise Edition for Lustre* Software releases
- Close partnership with community to drive new features
  - Management and hosting of issue ticketing system for both Intel customers and open source community
- Intel manages the delivery of all new code including features and maintenance
What YOU Add to Lustre*

- First line of support for your customer
- Interface between your customer and Intel
- Improve customer satisfaction with Lustre*
- Improve Lustre* quality
- Educate your customer on Lustre*
Summary

- What is Lustre*?
  - Object based, distributed, parallel, clustered file system
  - Open source and Linux-based
- Lustre* Characteristics
  - Scalable, POSIX* compliant, resource efficient, and cost effective
- Key Markets Using Lustre* Today
  - Bioscience, government, large-scale manufacturing, weather and climate, energy, and finance
- Lustre* Advantages
  - Speed, open platform, efficiency, storage, affordability, scalability, stability and reliability
- Architecture
  - Client(s), Metadata services, Object Storage services and Networking
Summary (cont.)

• Typical I/O
  • Use Client / Servers design
  • Applications see single namespace and access storage targets indirectly
• Traditional Network File Systems vs Lustre*
  • No bottleneck with scalability
  • 90+% utilization of storage and network hardware
• Largest team of Lustre* software developers and engineers in the world
• Support from the people who bring you Lustre*
## Summary (cont.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Production quality Lustre® file system</td>
<td>• Community Lustre® software base</td>
<td>• Excellent storage performance and scalability</td>
</tr>
<tr>
<td>• Intel® Manager for Lustre®</td>
<td>• Flexible deployment architectures</td>
<td>• Global technical support expertise from Intel</td>
</tr>
</tbody>
</table>

- What Intel adds to Lustre® – Technology
  - Infrastructure and technology to produce quality software
  - New features, driven by community
- What YOU add to Lustre®
  - First line of support to your customer
  - Interface between your customer and Intel
Congratulations! You have completed:
Introduction to Intel® Solutions for Lustre®
Software