OpenHPC: A Cohesive and Comprehensive System Software Stack
The Time is Right

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Agenda

• Trends and Challenges

• OpenHPC Vision

• OpenHPC Architecture and Implementation of Stack

• Intel® HPC Orchestrator

• Questions
Trends and Challenges

• Talk is software focused, but
  – Hardware: scale, power, reliability, network bandwidth and latency, memory bandwidth and latency

• Complexity of software stack
  – Increase in classical HPC computing
    – Richer environments, python
    – New models: UQ, workflows
  – Introduction of big data and analytics
    – BDEC
    – Multi tenancy
  – Need for new frameworks
    – AI: ML/DL
    – Cloud
Trends and Challenges → Needs

• Talk is software focused, but
  – Hardware: Value of co-designing and integrating cores, network, and memory

• Complexity drives the need to integrate and provide a coherent and comprehensive system software stack rather than a bag of parts
  – More components
  – More components lead to a greater potential for incompatibilities
  – Co-design applies within system software also
  – Need to test and continuously integrate
  – Over time fewer organizations could assemble the whole stack
  – Increasing time going to just standing up
    – Versus focusing on mission needs
Overview

Goals

- Provide a common SW platform to the HPC community that works across multiple segments and on which end-users can collaborate and innovate
- Simplify the complexity of installation, configuration, and ongoing maintenance of a custom software stack
- Receive contributions and feedback from community to drive innovation
- Enable developers to focus on their differentiation and unique value, rather than having to spend on developing, testing, and maintaining a core stack
- Deliver integrated hardware and software innovations to ease the path to exascale

Status

Governance:

- Technical steering committee active since June 2016
- Technical submission process published
- Currently there are 30 official members in Platinum, Silver, Academic and Technical Committees
- Held first face to face meeting, post-formation, in June 2016 at ISC, one at SC 2016, and one planned for ISC 2017

Courtesy of OpenHPC*

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Background Motivation for Community Effort

• Many sites spend considerable effort aggregating a large suite of open-source projects to provide a capable HPC environment for their users:
  – necessary to build/deploy HPC focused packages that are either absent or do not keep pace from distro providers
  – local packaging or customization frequently tries to give software versioning access to users (e.g. via modules or similar equivalent)
  – hierarchal packaging necessary for multiple compiler/mpi families

• On the developer front, many successful projects must engage in continual triage and debugging regarding configuration and installation issues on HPC systems

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What is OpenHPC?

• OpenHPC is a community effort endeavoring to:
  – provide collection(s) of pre-packaged components that can be used to help install and manage flexible HPC systems throughout their lifecycle
  – leverage standard Linux delivery model to retain admin familiarity (ie. package repos)
  – allow and promote multiple system configuration recipes that leverage community reference designs and best practices
  – implement integration testing to gain validation confidence
  – provide additional distribution mechanism for groups releasing open-source software
  – provide a stable platform for new R&D initiatives
OpenHPC: Mission and Vision

• **Mission**: to provide a reference collection of open-source HPC software components and best practices, lowering barriers to deployment, advancement, and use of modern HPC methods and tools.

• **Vision**: OpenHPC components and best practices will enable and accelerate innovation and discoveries by broadening access to state-of-the-art, open-source HPC methods and tools in a consistent environment, supported by a collaborative, worldwide community of HPC users, **developers**, **researchers**, **administrators**, and **vendors**.
OpenHPC is a Linux Foundation Project initiated by Intel and gained wide participation right away.

The goal is to collaboratively advance the state of the software ecosystem.

30 Members

Governing board is composed of Platinum members (Intel, Dell, HPE, SUSE) plus reps from Silver & Academic, Technical committees.

OpenHPC: Project Members

- Argonne National Laboratory
- Center for Research in Extreme Scale Technologies – Indiana University
- University of Cambridge

OpenHPC is a Mixture of Academics, Labs, OEMs, and ISVs/OSVs. Courtesy of OpenHPC*

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Contact Kevlin Husser or Jeff ErnstFriedman
jernstfriedman@linuxfoundation.org
Repository server metrics: monthly visitors

Build Server Access: **Unique Visitors**

<table>
<thead>
<tr>
<th>Releases</th>
<th># of Unique Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>v1.0</td>
<td>Jul-15 0</td>
</tr>
<tr>
<td>v1.0.1</td>
<td>Oct-15 500</td>
</tr>
<tr>
<td>v1.1</td>
<td>Jan-16 1000</td>
</tr>
<tr>
<td>v1.1.1</td>
<td>May-16 1500</td>
</tr>
<tr>
<td>v1.2</td>
<td>Aug-16 2000</td>
</tr>
<tr>
<td>v1.2.1</td>
<td>Nov-16</td>
</tr>
<tr>
<td>v1.3</td>
<td>Mar-17</td>
</tr>
</tbody>
</table>

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**Intel® HPC Orchestrator Modular View**

- Intra-stack APIs to allow for customization/differentiation (OEMs enabling)
- Defined external APIs for consistency across versions (ISVs)

<table>
<thead>
<tr>
<th>Operator Interface</th>
<th>Applications (not part of initial stack)</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Management</td>
<td>ISV Applications</td>
</tr>
<tr>
<td>(Conf, inventory)</td>
<td></td>
</tr>
<tr>
<td>Provisioning</td>
<td>Compiler &amp; Programming Model Runtimes</td>
</tr>
<tr>
<td>Fabric Mgmt</td>
<td>SW Development Toolchain</td>
</tr>
<tr>
<td>System Diagnostics</td>
<td>User Space Utilities</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overlay &amp; Pub-sub Networks, Identity</td>
</tr>
<tr>
<td></td>
<td>Linux* Distro Runtime Libraries</td>
</tr>
<tr>
<td></td>
<td>Node-specific OS Kernel(s)</td>
</tr>
</tbody>
</table>

**Hardware**

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### Functional Areas

<table>
<thead>
<tr>
<th>Functional Areas</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base OS</td>
<td>CentOS 7.3, SLES12 SP2</td>
</tr>
<tr>
<td>Architecture</td>
<td>x86_64, aarch64 (Tech Preview)</td>
</tr>
<tr>
<td>Administrative Tools</td>
<td>Conman, Ganglia, Lmod, LosF, Nagios, pdsh, prun, EasyBuild, ClusterShell,</td>
</tr>
<tr>
<td></td>
<td>mrsh, Genders, Shine, Spack, test-suite</td>
</tr>
<tr>
<td>Provisioning</td>
<td>Warewulf</td>
</tr>
<tr>
<td>Resource Mgmt.</td>
<td>SLURM, Munge, PBS Professional</td>
</tr>
<tr>
<td>Runtimes</td>
<td>OpenMP, OCR</td>
</tr>
<tr>
<td>I/O Services</td>
<td>Lustre client (community version)</td>
</tr>
<tr>
<td>Numerical/Scientific</td>
<td>Boost, GSL, FFTW, Metis, PETSc, Trilinos, Hypre, SuperLU, SuperLU_Dist,</td>
</tr>
<tr>
<td>Libraries</td>
<td>Mumps, OpenBLAS, Scalapack</td>
</tr>
<tr>
<td>I/O Libraries</td>
<td>HDF5 (pHDF5), NetCDF (including C++ and Fortran interfaces), Adios</td>
</tr>
<tr>
<td>Compiler Families</td>
<td>GNU (gcc, g++, gfortran)</td>
</tr>
<tr>
<td>MPI Families</td>
<td>MVAPICH2, OpenMPI, MPICH</td>
</tr>
<tr>
<td>Development Tools</td>
<td>Autotools (autoconf, automake, libtool), Valgrind,R, SciPy/NumPy</td>
</tr>
<tr>
<td>Performance Tools</td>
<td>PAPI, IMB, mpiP, pdtoolkit TAU, Scalasca, ScoreP, SIONLib</td>
</tr>
</tbody>
</table>

### Notes:
- Additional dependencies that are not provided by the BaseOS or community repos (e.g. EPEL) are also included.
- 3rd Party libraries are built for each compiler/MPI family.
- Resulting repositories currently comprised of ~300 RPMs.

Future additions approved for inclusion:
- BeeGFS client
- hwloc
- Singularity
- xCAT

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Intel® HPC Orchestrator Framework

Contributors include Intel, OEMs, ISVs, labs, academia

Integrates and tests HPC stacks and makes them available as OS

Continuous Integration Environment
- Build Environment & Source Control
- Bug Tracking
- User & Dev Forums
- Collaboration tools
- Validation Environment

“RRV” = Relevant and Reliable Version

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Base Stack and Derivatives

“CUSTOM”
Additions Targeting High End Market

Common Core (same across all offerings)

“ADVANCED”
- Sufficient performance and scalability
- Ease of Install

Additions Targeting Top 500 & Verticals

“TURNKEY”
Additions Targeting Volume Market

Provides
- Performance & scalability
- Energy efficiency

Ease of administration across multiple tiers in the same data center

Provides
- Ease of use & administration
- Auto-configuration

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Provides
- Ease of use & administration
- Auto-configuration
• Trends and challenges led to the need for a cohesive and comprehensive system software stack for HPC

• OpenHPC provides a vehicle that facilitates collaboration, removes replicative work, and provides a more efficient ecosystem

• Intel® HPC Orchestrator provides a supported version of OpenHPC analogous to CentOS and RHEL with three tiers for different computing needs

• OpenHPC is gaining momentum with increased contributions

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