Cray SHMEM and OpenSHMEM

David Knaak
Cray Inc.
OpenSHMEM Workshop 2016
Seymour Cray founded Cray Research in 1972
- 1972-1996, Cray Research grew to leadership in Supercomputing
- 1996-2000, Cray was subsidiary of SGI
- 2000- present, Cray Inc. growing to $724.7M in revenue in 2015
- Cray Inc. formed in April 2000

Cray Inc.
- NASDAQ: CRAY
- Over 1,200 employees across 30 countries
- Headquartered in Seattle, WA

Three Focus Areas
- Computation
- Storage
- Analytics

Seven Major Development Sites:
- Austin, TX
- Chippewa Falls, WI
- Pleasanton, CA
- St. Paul, MN
- San Jose, CA
- Seattle, WA
- Bristol, UK
Cray’s Vision: The Fusion of Supercomputing and Big & Fast Data

Modeling The World

Math Models
Modeling and simulation augmented with data to provide the highest fidelity virtual reality results

Data-Intensive Processing
Modeling and simulation augmented with data to provide the highest fidelity virtual reality results

Data Models
Integration of datasets and math models for search, analysis, predictive modeling and knowledge discovery

Compute
Store
Analyze
Computational Tools for Your Most Challenging Problems

A Workflow Approach for a Data-Intensive World

- Compute
- Store
- Analyze

- Earth Sciences
- Manufacturing
- Energy
- Life Sciences
- Higher Education
- Financial Services
- Government and Defense
- Cybersecurity

Cray Inc.
Cray® XC40™ Supercomputer

Adaptive

• Flexibility of x86 processors, coprocessors and accelerators
• Investment protection, upgradable by design

Integrated

• Integrated HPC software environment and storage

High Performing

• Sustained, scalable application performance
• Upgradable to 100 petaflops
• Extreme performance interconnects, packaging, cooling and more

Scalable Performance
Cray® CS400™ Cluster Supercomputers

Configurable
- Designed for broad range of workloads
- Industry standards-based
- Blades or rackmount server; multiple interconnect and storage options

Manageable
- Customizable HPC cluster software stack
- Advanced Cluster Engine system management software

Reliable & Efficient
- Built-in and optional energy efficiencies
- Designed for reliability
- Multiple levels of redundancy

Flexible Performance
Cray® Sonexion® Scale-Out Lustre® Storage

<table>
<thead>
<tr>
<th>Simplified Management</th>
<th>• Fully integrated and preconfigured design; fewer components to manage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision Performance</td>
<td>• Scale I/O from 7.5 GB/s more than 1.7 TB/s in a single file system</td>
</tr>
<tr>
<td>Balanced Scalability</td>
<td>• Scale in modular increments; reduce capital costs as capacity grows</td>
</tr>
<tr>
<td>Quality Design</td>
<td>• Reduce hardware footprint by 50% over component-based solutions</td>
</tr>
<tr>
<td></td>
<td>• Cray-ensured reliability and stability at scale</td>
</tr>
</tbody>
</table>

Get Results — Up to 24x Faster
Unprecedented versatility and speed

* Validated now, additional support to follow

**Serious Agility that’s enterprise accessible**
- Run analytics workloads concurrently: Hadoop®, Spark™, graph, and HPC*
- Dynamic resource repurposing
- Simple, standards-based tools for straightforward management

**Pervasive Speed based on Cray’s Supercomputing experience**
- Pre-integrated and validated software + hardware
- Cray Aries fabric with high I/O throughput and low latency

**High-Frequency Insights**
- Make decisions with near immediacy using the Cray Graph Engine

* Validated now, additional support to follow

**Unpreceoned versatility and speed**
<table>
<thead>
<tr>
<th>Segment</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Sciences</td>
<td>Met Office, NERC, Los Alamos, Argonne, Oak Ridge, Oak RidgeEpics, CSYS,</td>
</tr>
<tr>
<td></td>
<td>Swiss Meteorological Society, NCEP, KMA, Met Office, NERC, Los Alamos,</td>
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<tr>
<td></td>
<td>Argonne, Oak Ridge, Oak Ridge Epics, CSYS, Swiss Meteorological Society,</td>
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<tr>
<td></td>
<td>NCEP</td>
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<tr>
<td>Govt. &amp; Defense</td>
<td>Sania National Laboratory, Argonne, Oak Ridge, Oak Ridge Epics, CSYS,</td>
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<td></td>
<td>Swiss Meteorological Society, NCEP, KMA, Met Office, NERC, Los Alamos,</td>
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<tr>
<td></td>
<td>Argonne, Oak Ridge, Oak Ridge Epics, CSYS, Swiss Meteorological Society,</td>
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<tr>
<td></td>
<td>NCEP</td>
</tr>
<tr>
<td>Higher Education</td>
<td>EPSRC, Pawsey, Supercomputing Centre, KAUST, NCSA, CSYS, Swiss</td>
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<tr>
<td></td>
<td>Meteorological Society, NCEP, KMA, Met Office, NERC, Los Alamos, Argonne,</td>
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<tr>
<td></td>
<td>Oak Ridge Epics, CSYS, Swiss Meteorological Society, NCEP, KMA, Met Office</td>
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<tr>
<td></td>
<td>NERC</td>
</tr>
<tr>
<td>Life Sciences</td>
<td>Mount Sinai, Mayo Clinic, Duke, Total, Petrobras, State University of</td>
</tr>
<tr>
<td></td>
<td>Florida, Hong Kong Sanatorium &amp; Hospital</td>
</tr>
<tr>
<td></td>
<td>University of Florida, Lawrence Livermore National Laboratory,</td>
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<tr>
<td></td>
<td>Finnish Meteorological Institute</td>
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<tr>
<td>Energy</td>
<td>ExxonMobil, Chevron, Total, Petrobras, State University of Florida,</td>
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<tr>
<td></td>
<td>Lawrence Livermore National Laboratory, Finnish Meteorological Institute</td>
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<td></td>
<td>University of Florida</td>
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<td>Manufacturing</td>
<td>FORTUNE 100, Stalprodukt S.A., Undisclosed, FORTUNE 100, Undisclosed</td>
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<td>Financial Services</td>
<td>FORTUNE 100, Undisclosed, Undisclosed, Undisclosed</td>
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OpenSHMEM 2016

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Cray Technology Innovations

Combining advanced technologies into productive, scalable systems

**System Interconnect**
Interconnect and optimization software to address the data transfer bottleneck at large scale

**Systems Management & Performance Software**
Software to productively manage and extract performance out of thousands of processors used as a single system

**Packaging**
Greenest x86 supercomputers with innovative cooling and upgradability to improve TCO
Cray SHMEM and OpenSHMEM

Cray is a leader in HPC systems, in SHMEM design and implementation, and in OpenSHMEM standardization.

Cray is committed to supporting its HPC customers with a high performance and high quality implementation of the OpenSHMEM API. Our customers' needs often require that we pioneer extensions to the API. We usually design and implement the extensions as soon as possible to meet those needs but we also work with the OpenSHMEM Committee to define these APIs so that they also meet the needs of the broader set of OpenSHMEM users.
OpenSHMEM Extensions

Why do we need more than current API?
Primarily due to trends in system architectures as we move towards exascale:

- Increased complexity
- Increasing number of cores in multi-core processors
- Memory hierarchies, including high bandwidth memory
- Processor accelerators
- Increased network capabilities to offload communication work from compute processors
- Other new concepts that help programmability and performance
OpenSHMEM Extensions

What makes a desirable OpenSHMEM extension?

- Improves ease of OpenSHMEM programming
- Improves performance of OpenSHMEM programs
- Aids portability by hiding system differences within the specific implementations
- Has a user friendly API
- Is consistent with existing OpenSHMEM API
## Cray SHMEM extensions to OpenSHMEM

<table>
<thead>
<tr>
<th>Proposed Features</th>
<th>Cray SHMEM</th>
<th>OpenSHMEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Blocking Put</td>
<td>2007</td>
<td>V1.3</td>
</tr>
<tr>
<td>Non-Blocking Get</td>
<td>2011</td>
<td>V1.3</td>
</tr>
<tr>
<td>Alltoall Collectives</td>
<td>2013</td>
<td>V1.3</td>
</tr>
<tr>
<td>Alltoallv Collectives</td>
<td>2013</td>
<td>#183</td>
</tr>
<tr>
<td>Global Exit</td>
<td>2014</td>
<td>V1.2</td>
</tr>
<tr>
<td>Flexible PE Subsets, aka Teams</td>
<td>2014</td>
<td>#193</td>
</tr>
<tr>
<td>Thread-Safety</td>
<td>2014</td>
<td>#186</td>
</tr>
<tr>
<td>Put With Signal</td>
<td>2014</td>
<td>#77</td>
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<tr>
<td>Memory Hierarchy, HWB memory</td>
<td>2016</td>
<td>N/A</td>
</tr>
<tr>
<td>Contexts-Domains</td>
<td>prototype</td>
<td>#177</td>
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</tbody>
</table>
Summary – Cray SHMEM and OpenSHMEM

- We are committed to giving our customers a high performance and high quality implementation of the OpenSHMEM API
- We are committed to working with our customers to advance OpenSHMEM with new features
- We evaluate requests in light of resources available and other priorities
- We are committed to working with OpenSHMEM Committee
- We have a proven track record of doing these
Discussion

- Cray extensions you have used?
- Other vendors’ extensions you have used?
- Proposed extensions you hope to use?
- Additional extensions you would like to see?