CRAY
THE SUPERCOMPUTER COMPANY

Scalable by Design

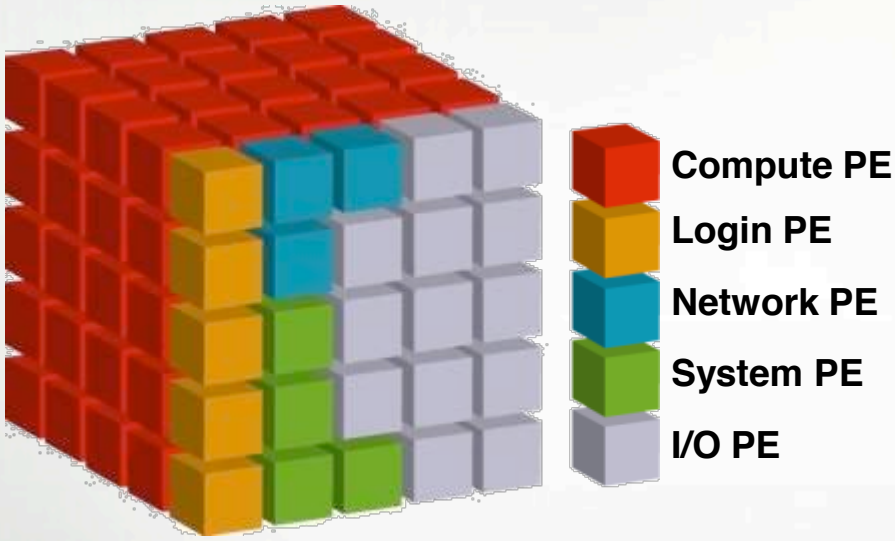
The Cray XT Series of Supercomputers

Cray XT5

(Jaguarpf/Kraken/Hopper)

Scalable Software Architecture: Cray Linux Environment (CLE)

"Primum non nocere"

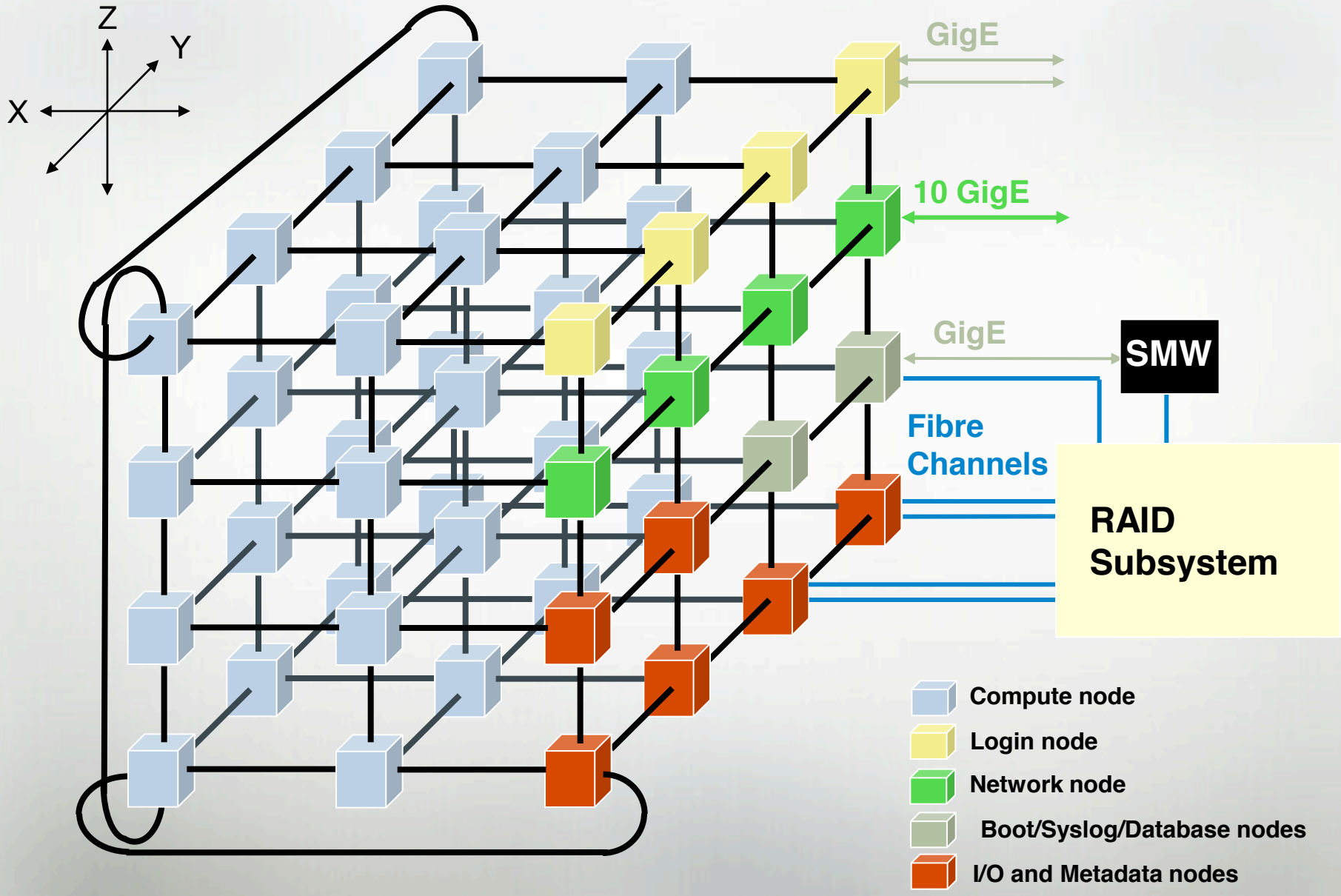


Service Partition

Specialized Linux nodes

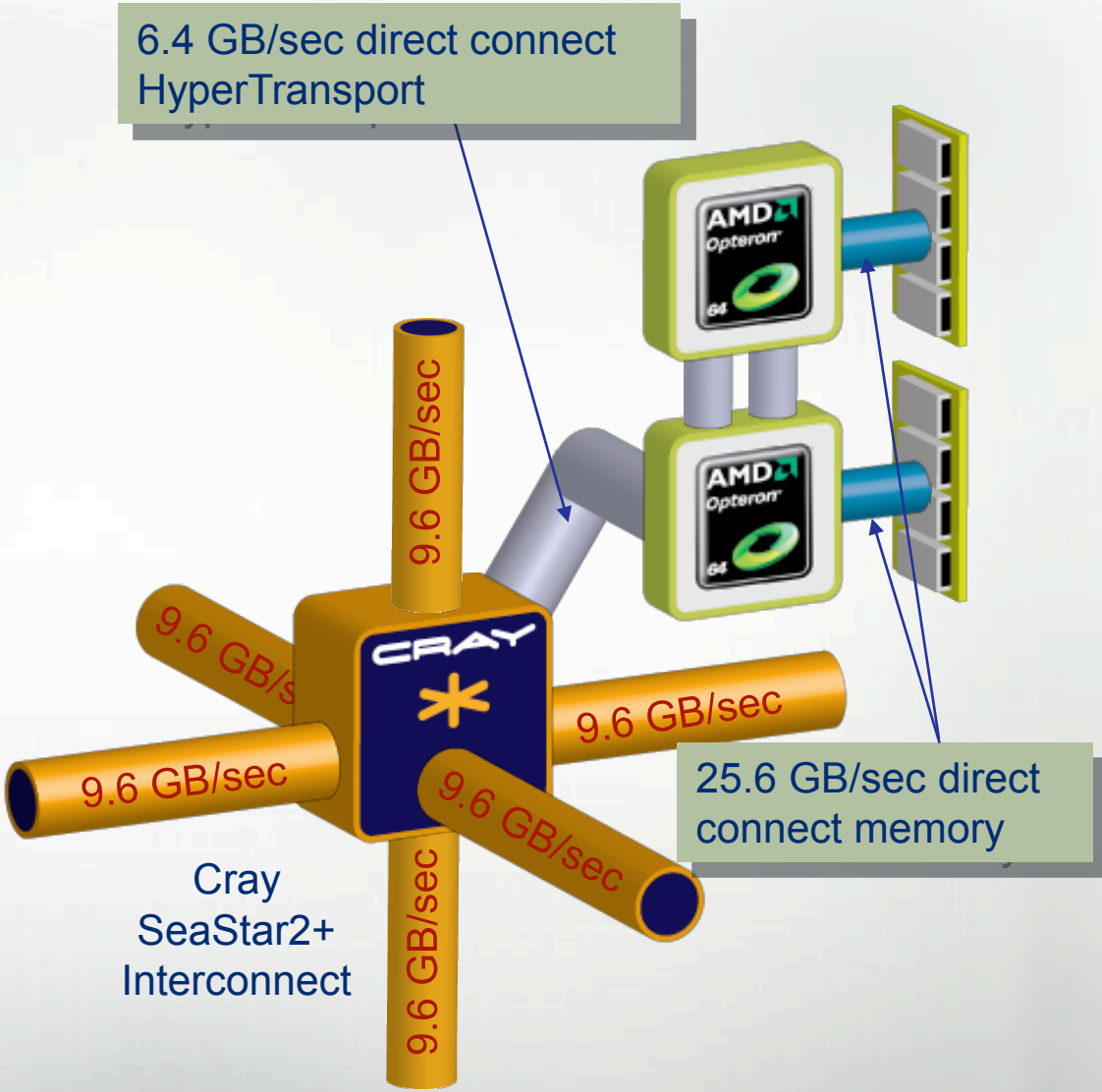
- Microkernel on Compute PEs, full featured Linux on Service PEs.
- Service PEs specialize by function
- Software Architecture eliminates OS "Jitter"
- Software Architecture enables reproducible run times
- Large machines boot in under 30 minutes, including filesystem

XT System Configuration Example

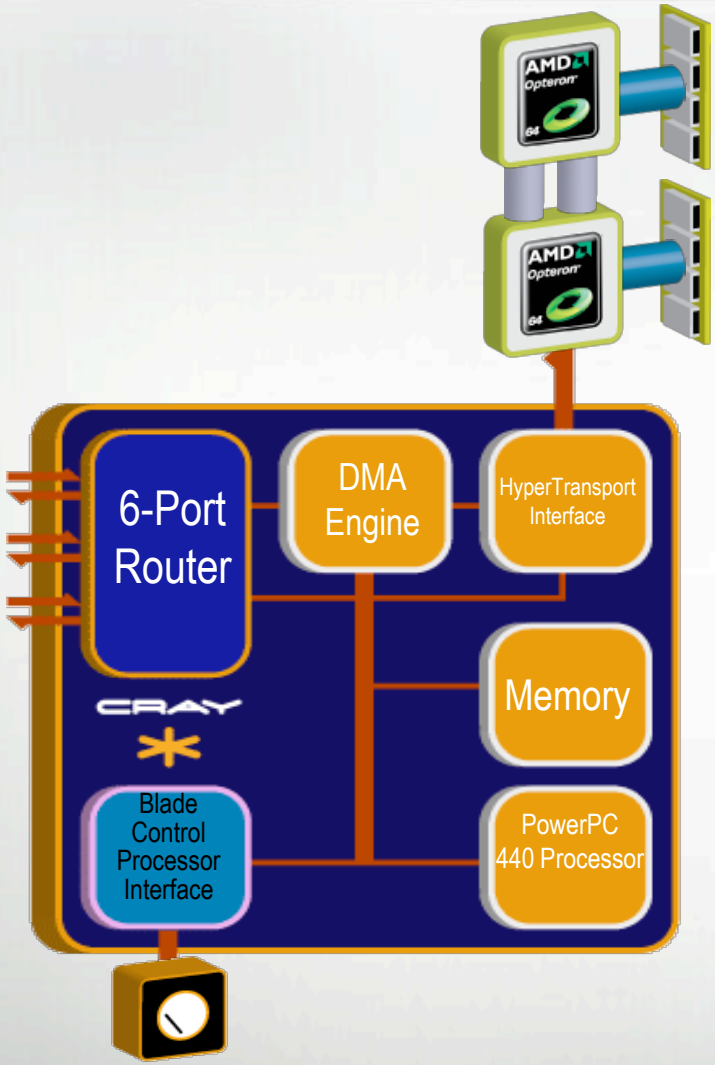


Cray XT5 Node

Characteristics	
Number of Cores	8 or 12
Peak Performance Shanghai (2.4)	76 Gflops/sec
Peak Performance Istanbul (2.6)	124 Gflops/sec
Memory Size	16 or 32 GB per node
Memory Bandwidth	25.6 GB/sec



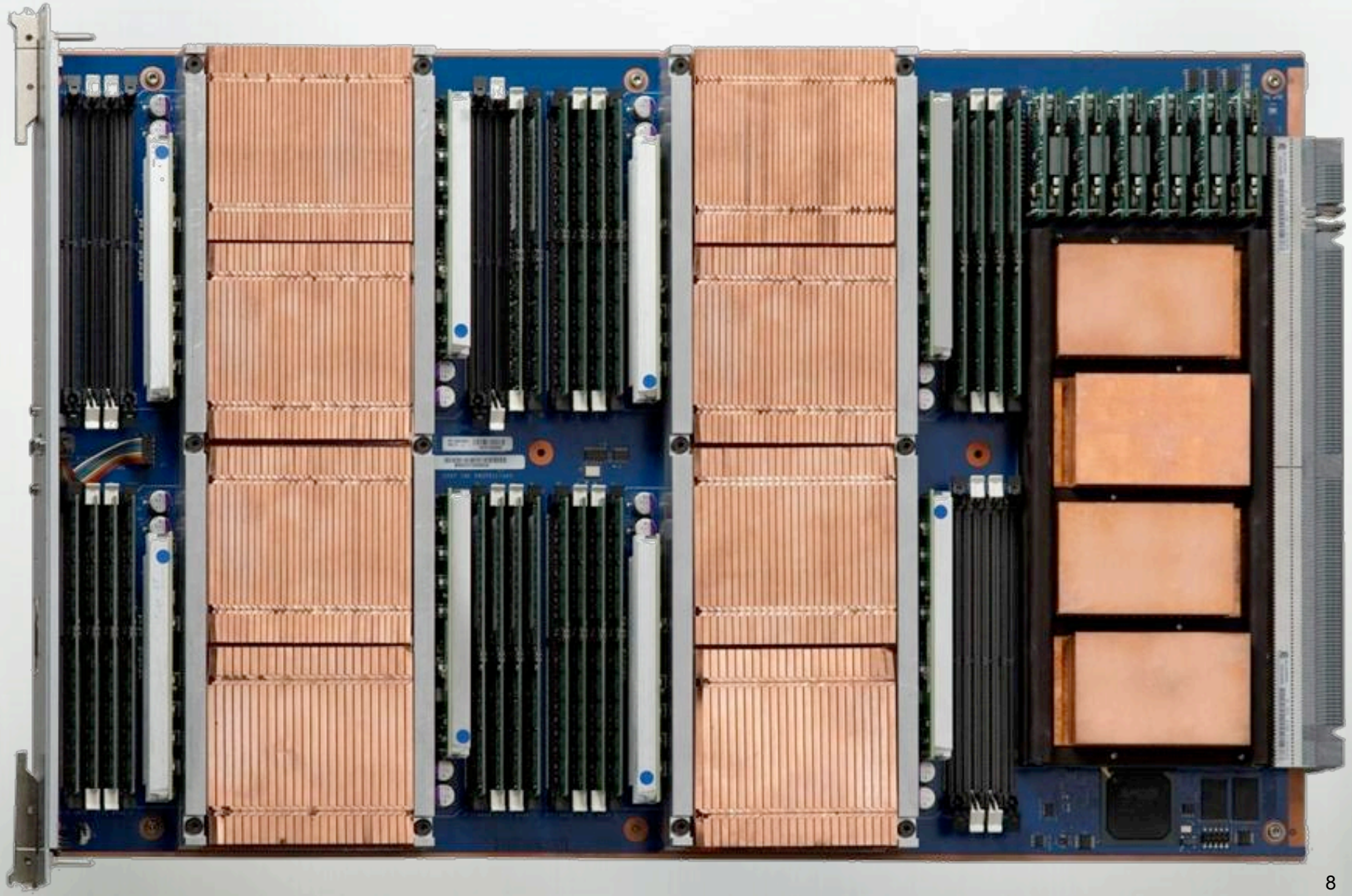
Cray SeaStar2+ Interconnect



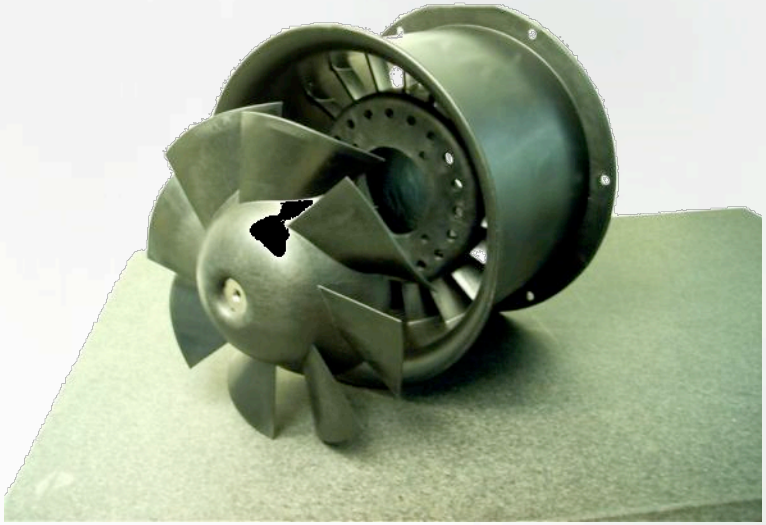
Now Scaled to 225,000 cores

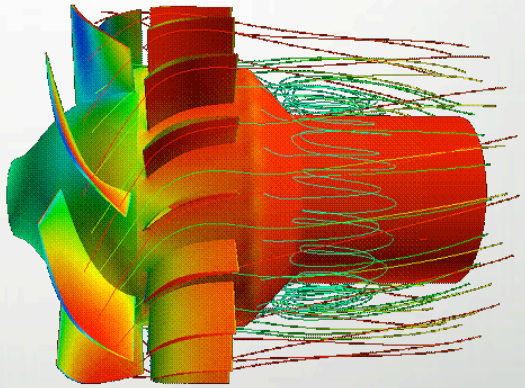
- Cray XT5 systems ship with the SeaStar2+ interconnect
- Custom ASIC
- Integrated NIC / Router
- MPI offload engine
- Connectionless Protocol
- Link Level Reliability
- Proven scalability to 225,000 cores

Cray XT5 Compute Blade

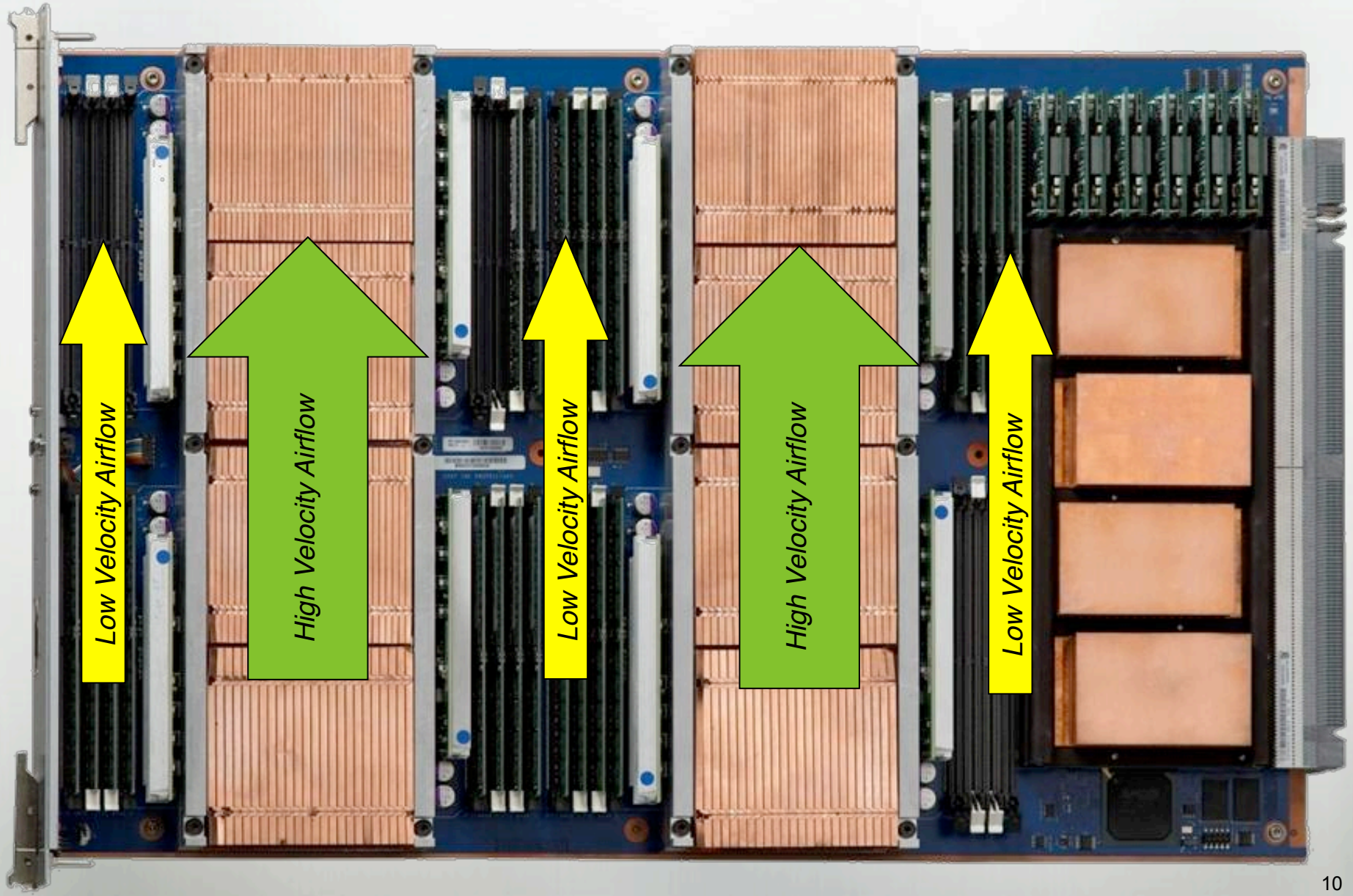


XT5 Axial Turbofan – 78% Efficient



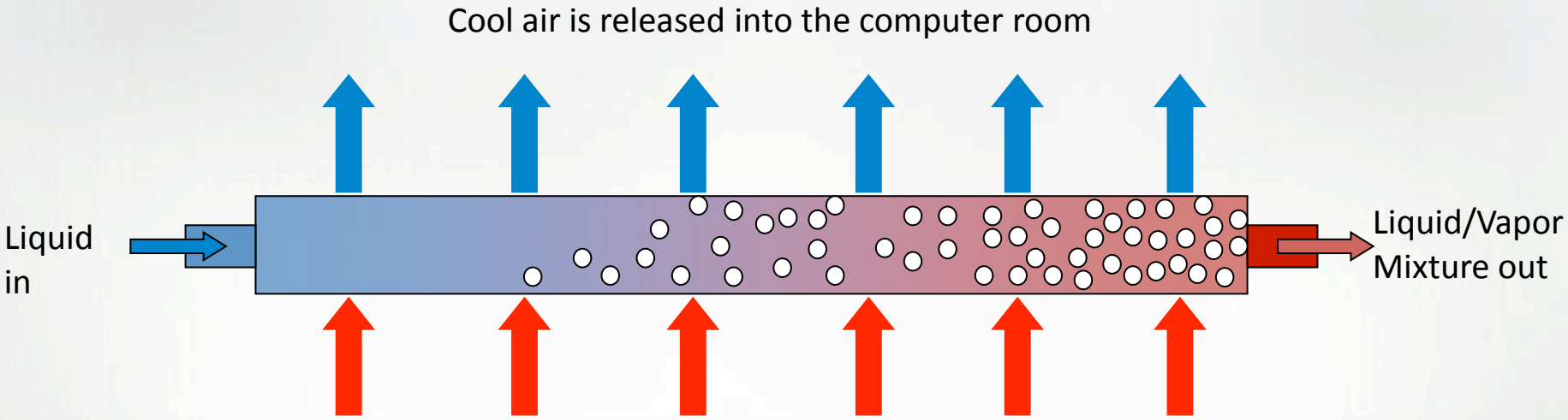


Cray XT5 Compute Blade



Cray ECOphlex Liquid Cooling

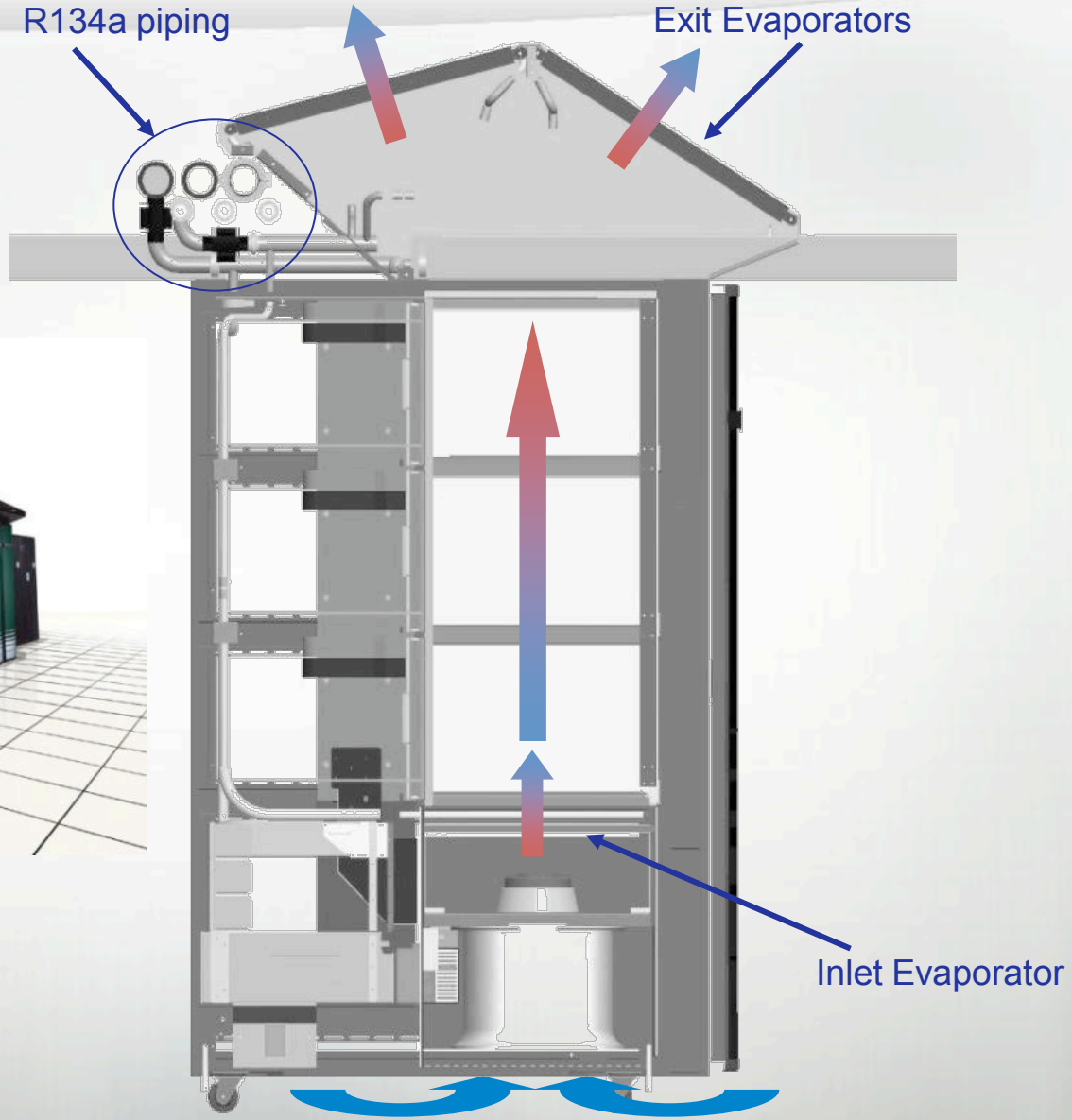
ECOphlex Cooling



R134a absorbs energy only in the presence of heated air.

Phase change is 10x more efficient than pure water cooling.

ECOphlex Technology in the Cray High Efficiency Cabinet



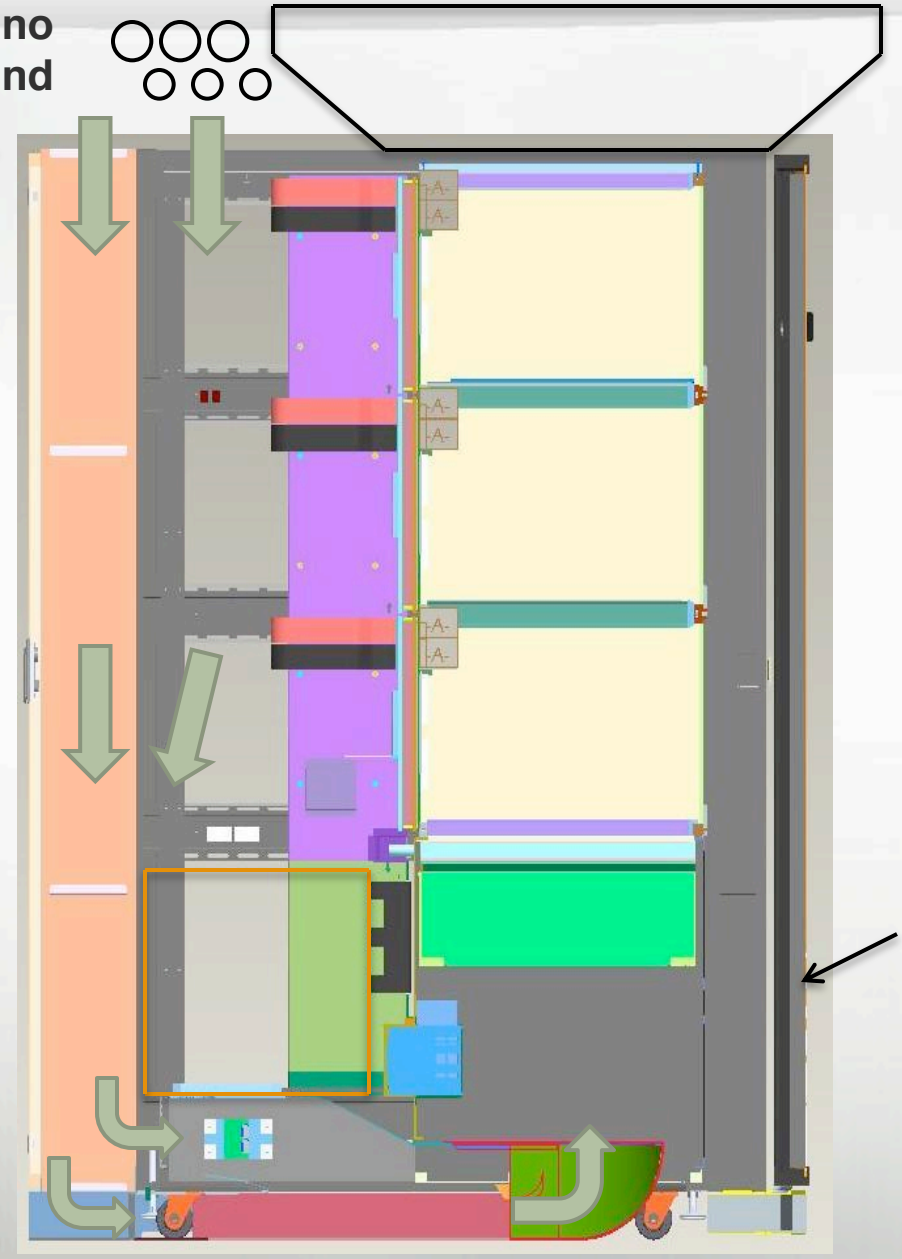
Newer “Flat Top” ECOphlex Design

Other Changes

- New enhanced blower to handle the 130 Watt Magny-Cours Processor
- Enhanced sound kit to reduce noise
- More efficient design
- New VFD (Variable Frequency Diode) for blower
- An upgrade kit product code will be available for existing XT5 customers which will contain the required components

Enhanced Series 6 ECOphlex Cabinet

Air taken from top, no line of sight for sound



Foam lined duct for sound absorption

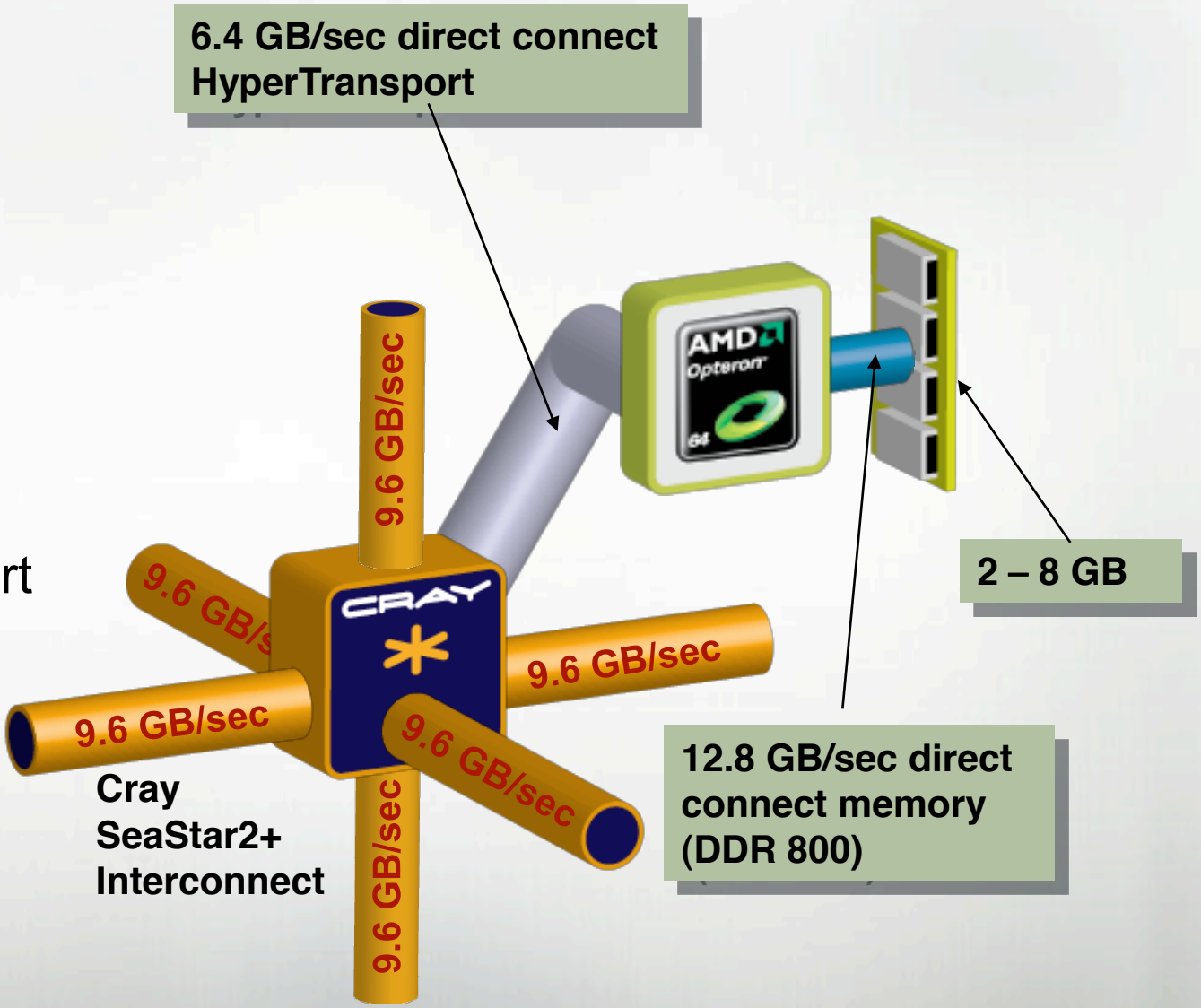
Extra foam added to front. Door now seals to front IO extension

Cray XT4

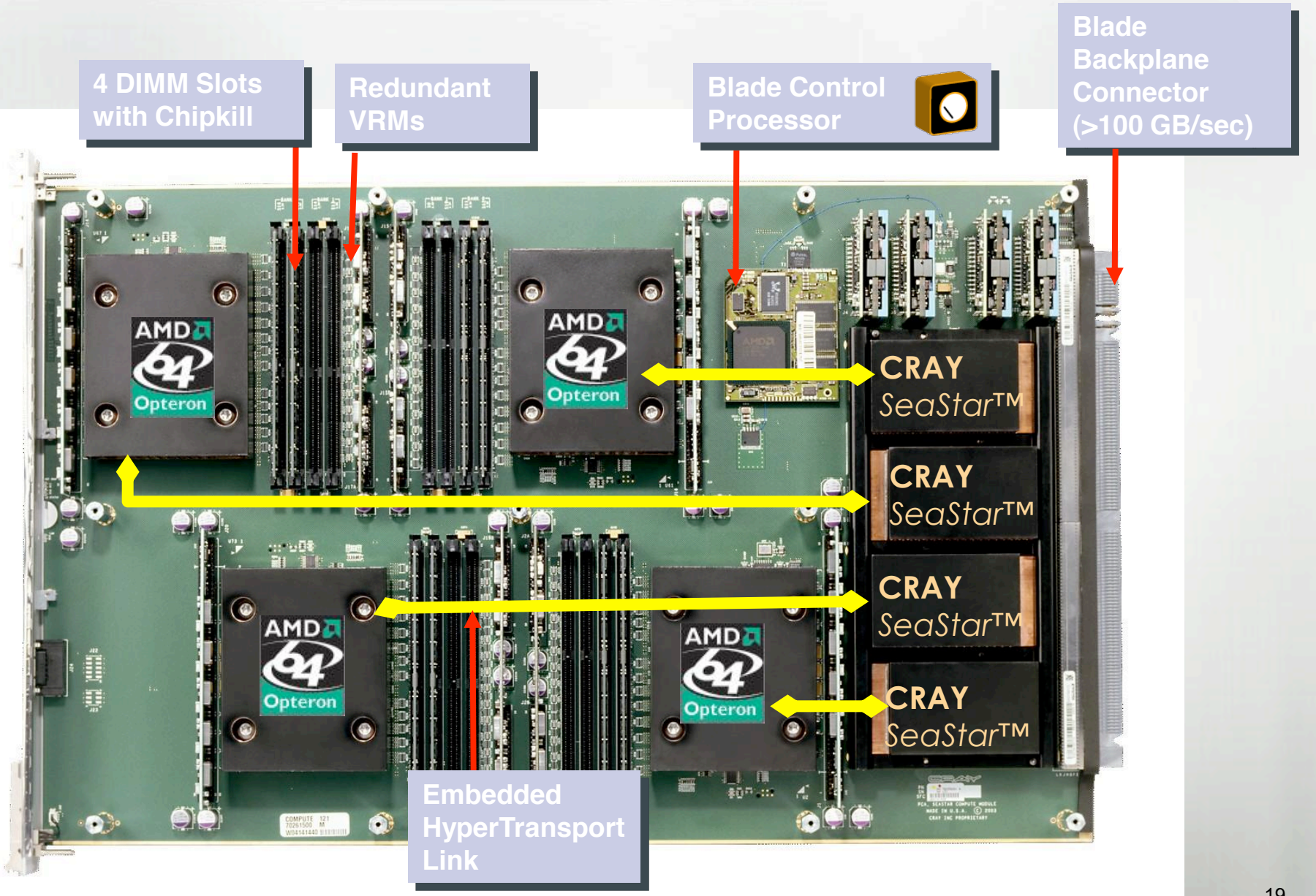
(Jaguar/Athena/Franklin)

Quad-Core Cray XT4 Node

- 4-way SMP
- >35 Gflops per node
- Up to 8 GB per node
- OpenMP Support within socket

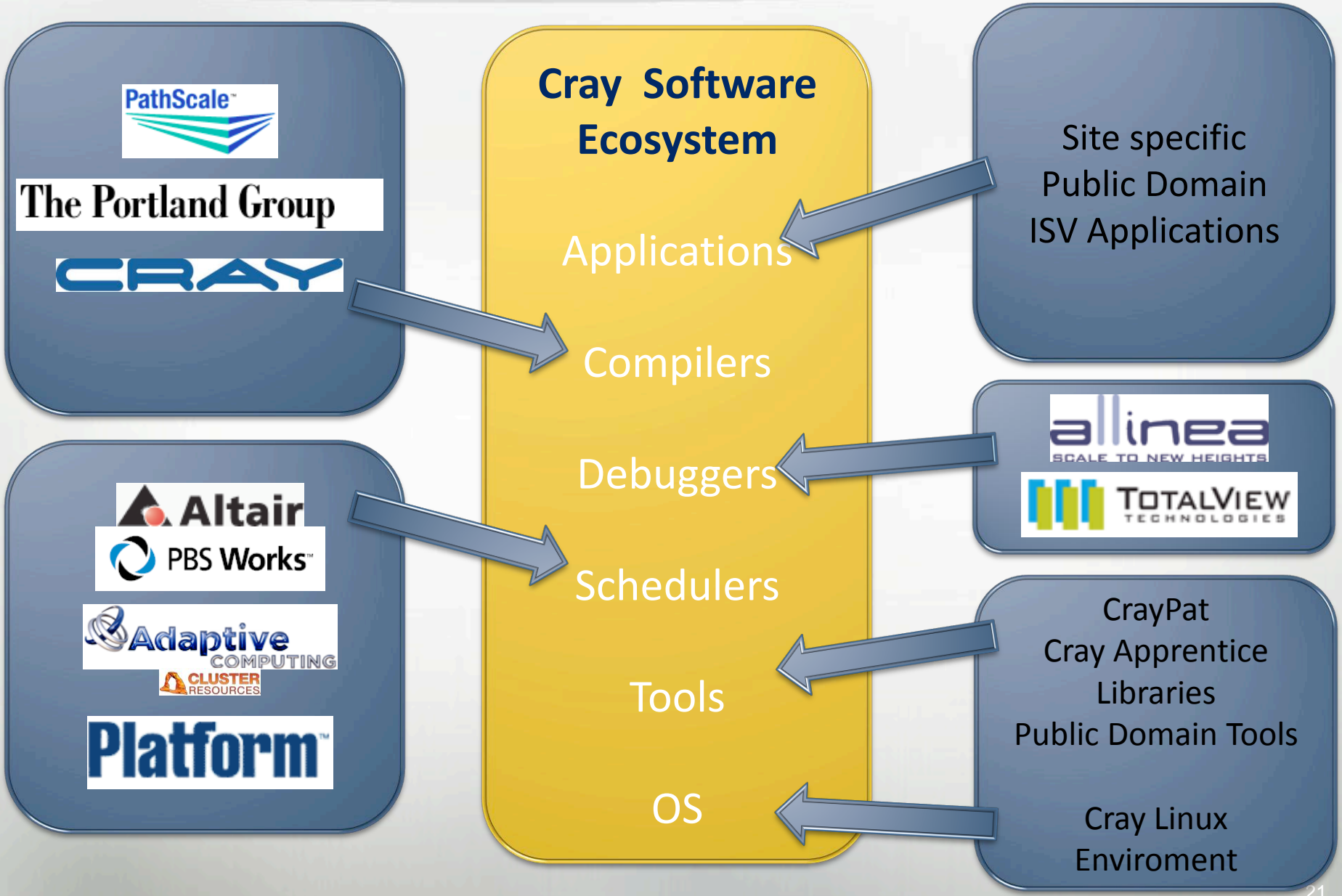


Cray XT4 Compute Blade



Software

Cray Software Ecosystem



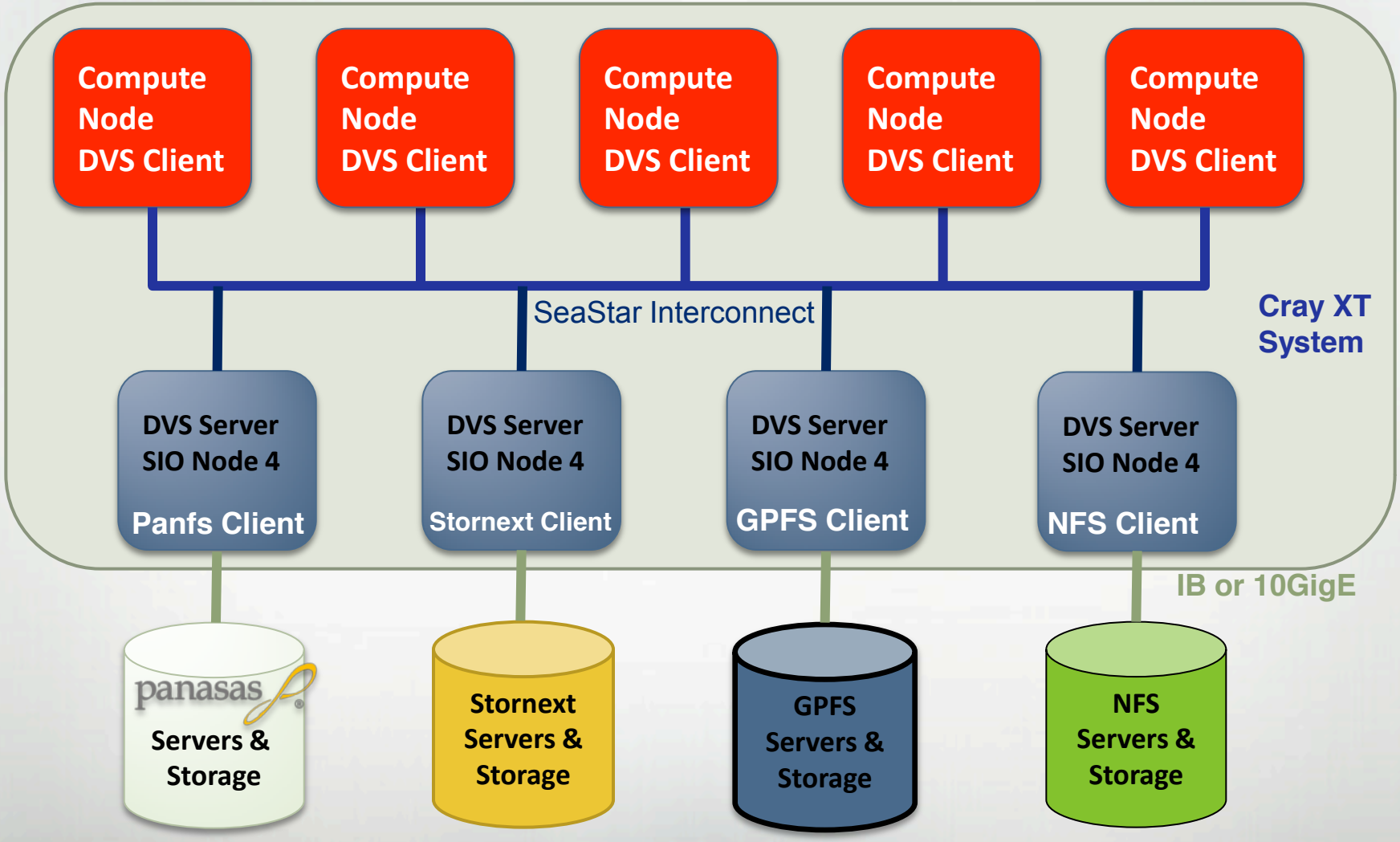
Cray Linux Environment (CLE)

- **Service nodes run a full-featured SLES10 Linux installation**
  - We add our tools, libraries, and services
- **Compute nodes run a slim-line Linux kernel with only necessary services**
  - Only run what's needed so the application can rule the roost
- **Libraries**
  - MPT – Message Passing Toolkit
  - LibSci – Cray Scientific Libraries (BLAS, LAPACK, SCALAPACK, FFTW, etc)
  - I/O Libraries – HDF5 & NetCDF
- **Tools**
  - Compilers – PGI, Cray, GNU, Pathscale, Intel
  - CrayPAT – Performance Analysis Tools
- **ALPS**
  - Application placement, job launching, application clean-up
  - Users interface with ALPS primarily via aprun
- **PBS/TORQUE & MOAB**
  - All jobs on the local XTs are batch jobs
  - MOAB is an advanced job scheduler that is used on Jaguar and Kraken

New CLE Features for 2009 / 2010

- Parallel Data Virtualization Service support
- Scalable Dynamic Libraries
- Virtual Cluster Environment
- Core Specialization for codes with high synchronization requirements
- NodeKARE (Node Knowledge and Reconfiguration) resiliency features
- Checkpoint / Restart

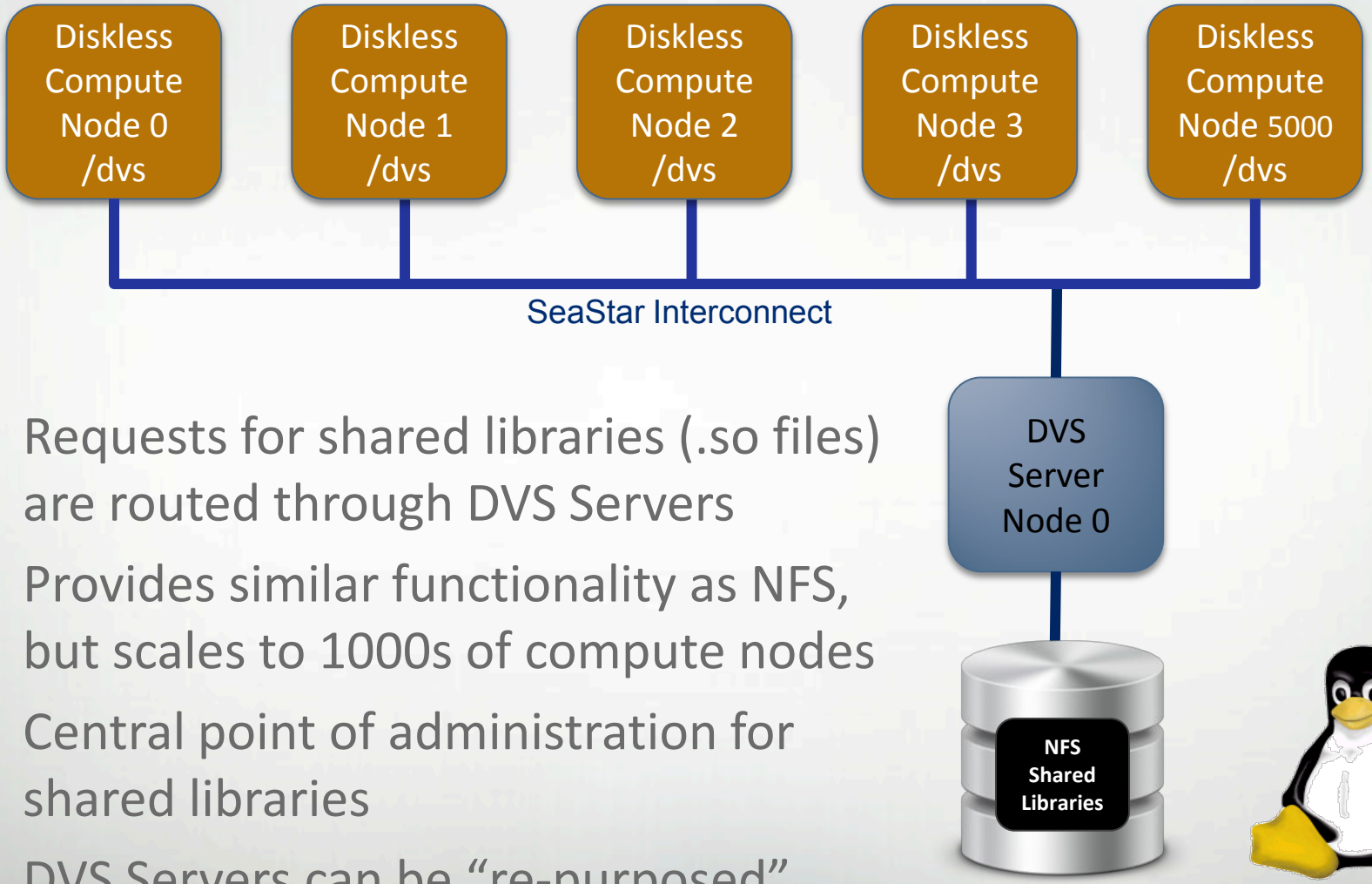
Mounting Other Filesystems with DVS



Dynamic Shared Libraries

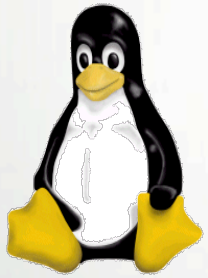
- Benefit: root file system environment available to applications
- Shared root from SIO nodes will be available on compute nodes
- Standard libraries / tools will be in the standard places
- Able to deliver customer-provided root file system to compute nodes
- Programming environment will support static and dynamic linking
- Performance impact negligible, due to scalable implementation

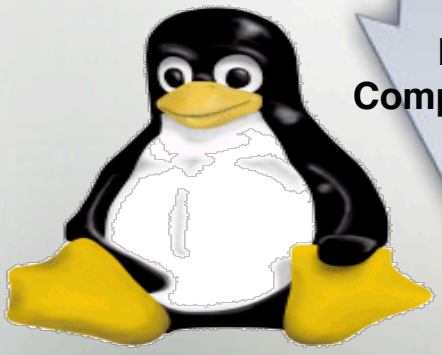
Scaling Shared Libraries with DVS



- Requests for shared libraries (.so files) are routed through DVS Servers
- Provides similar functionality as NFS, but scales to 1000s of compute nodes
- Central point of administration for shared libraries
- DVS Servers can be “re-purposed” compute nodes

Cray Linux Environment – Adaptive Vision





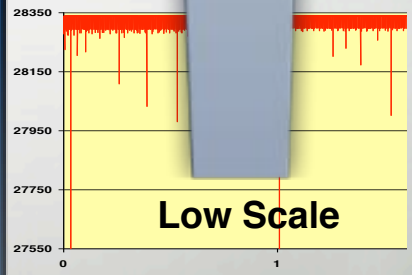
Less Compatibility

Full Compatibility

Capability (Ultra-light Linux Image)

Capacity/Production
(Mid-weight Linux Image)

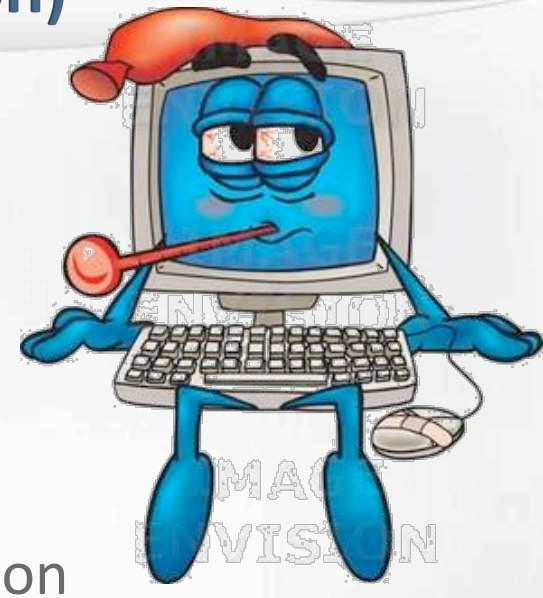
Shrink-wrap
3rd Party Application
(Full Linux Image and all services)



A Very Skinny Penguin – Core Specialization

- **Benefit: Eliminate noise with overhead (interrupts, daemon execution) directed to a single core**
- **Rearranges existing work**
  - Without core specialization: overhead affects every core
  - With core specialization: overhead is confined, giving app exclusive access to remaining cores
- **Helps some applications, hurts others**
  - POP 2.0.1 on 8K cores on XT5: 23% improvement
  - Larger jobs should see larger benefit
  - Future nodes with larger core counts will see even more benefit
- ***This feature is adaptable and available on a job-by-job basis***

Reliability Features in the Operating System NodeKARE (Knowledge and Reconfiguration)



- **Feature Also Known As "Node Health Checker"**
  - Benefit: verify that nodes are healthy so that jobs are not started on unhealthy nodes, that is, improved application completion rates
  - Checks more possible sources of error: file system checks, memory usage, application termination, site-specific check
  - Configurable: when to run, what to do on errors, callout to site-specific script
  - Suspect Mode minimizes burden on administrator
  - Future release will dump and restart downed nodes
- **Checkpoint / restart**
  - Released in CLE 2.2 (Jul 09)
  - Supported by PBS Pro (10.1 or later) and Moab/Torque
  - MPI and SHMEM

New CPE Features for 2009/2010

- **Cray continues the partnership with PGI to provide compilers on XT**
- **Cray Compilation Environment**
  - UPC implementation
  - Co-Array implementation
  - Smooth transition to Cascade
  - Laying support for integrating accelerators
- **Intel compiler also available for XT systems**
- **Cray acquired Pathscale Technology**
- **Support for dynamic libraries and ISV codes**


JAGUAR
APPLIED MECHANICS
Railway Technical Research Institute
HLRS
CRAY XT5m
Thank You!