High Performance Visualization

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High Performance Technical Computing
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Disclosure Reminder

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The Problem

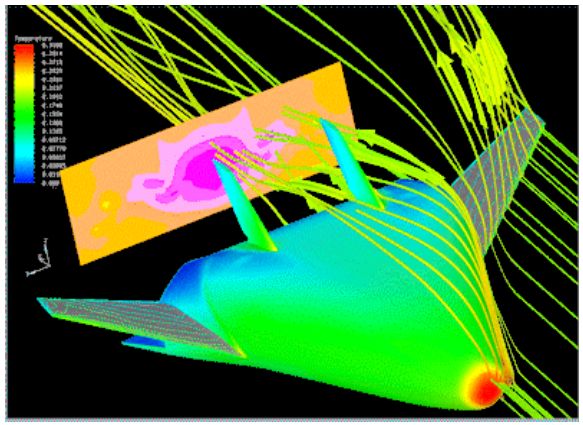
- Our HPTC customers use our computers to do computational science and engineering
- Scalable computing solutions allow larger problems to be solved to finer resolutions, producing vast amounts of data
- Visualization is the best method to gain understanding from data, but the amount of data is overwhelming conventional visualization systems, which haven't scaled
- What is needed is a visualization system that can scale to meet demands, while avoiding an expensive, proprietary solution

What are HPC users saying?

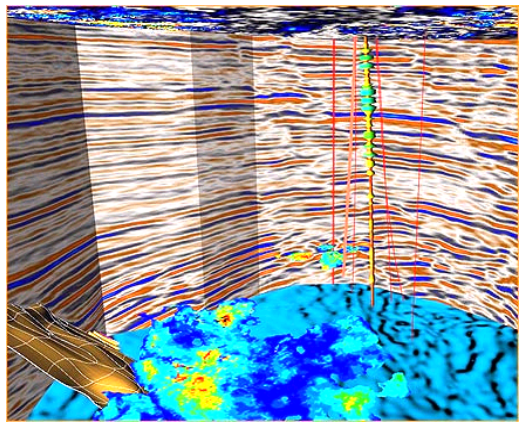
- The development of Computational Science has been accelerated by the advent of Scalable Supercomputing. Scientists & engineers now routinely use computers to simulate physical systems. Computer simulations produce numeric data that must be presented in a visual form in order to be understood. Graphics visualization systems are essential components of any computational science or engineering facility.
  - ***"The purpose of computing is insight - not numbers"***
    - R. W. Hamming

- The revolution of scalable supercomputing allows scientists to solve larger problems with finer detail, resulting in an avalanche of data. Conventional graphics visualizations systems are not up to the task & the gap is widening.
  - ***"Our ability to generate these large data sets … has completely outstripped our ability to visualize them, both for deriving science & for verifying correctness…"***
    - Hugh Couchman, McMaster University

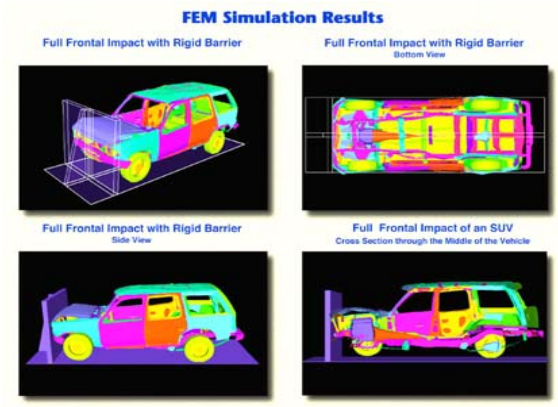
HPC & Visualization



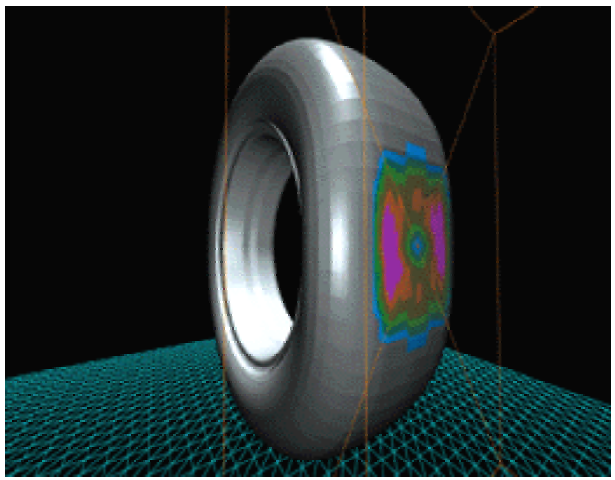
Aerospace



Oil & Gas



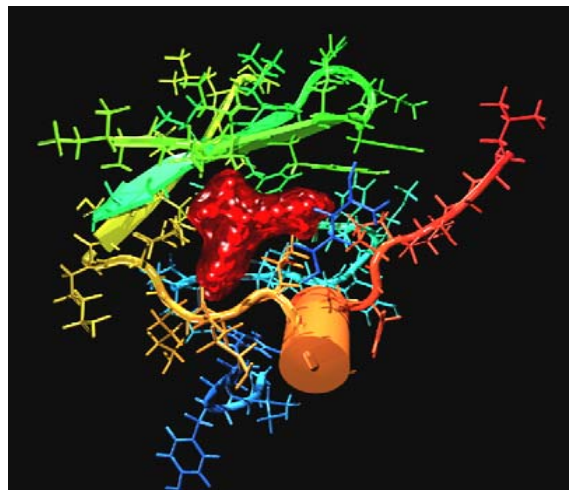
Automotive



Manufacturing

Los Alamos
Sandia
ASCI
Accelerated Strategic Computing Initiative
Lawrence Livermore

Research & Defense



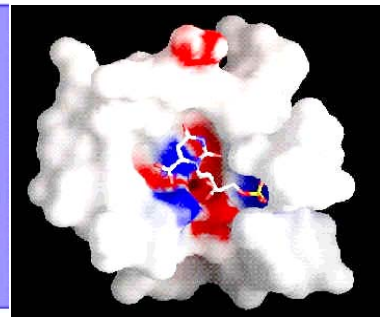
Science

Target Markets

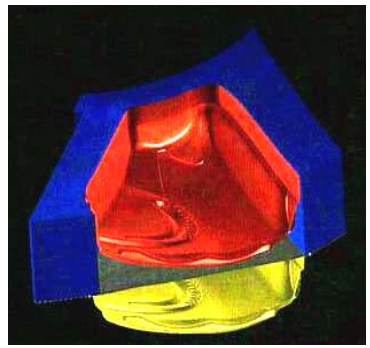
Government, Defense & Scientific Research

Life & Material Sciences

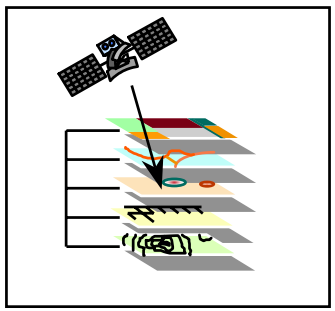
Biological Sciences

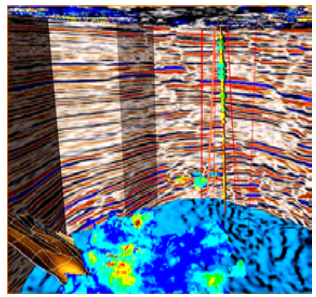


Chemical Sciences



CAE





Geosciences

"Ideal World" Visualization

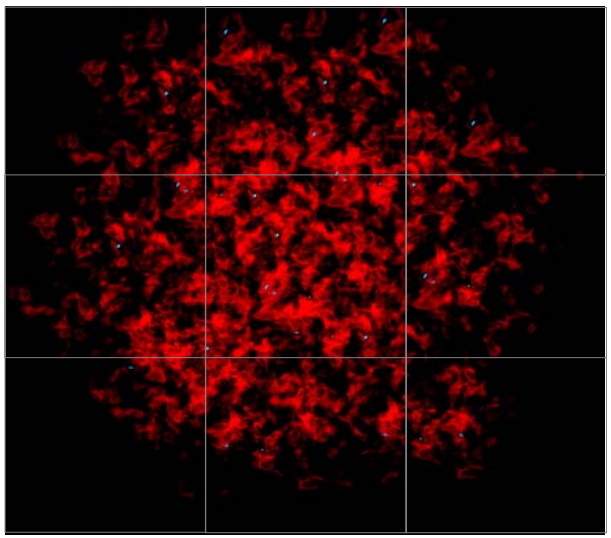
- What would an ideal visualization system have for characteristics?
  - High performance – mega-polygons per second
  - Visualize large datasets – terabyte datasets
  - Scalable – if more is better, then too much is just right
  - Economical – near commodity pricing
  - Renewable – CPU and graphics (latest and greatest)
  - Non-proprietary – industry standards based
  - Configurable resource – distribute resources as needed
  - Support collaboration – across the campus, or around the world

Needs Analysis

- Targeted Segments
  - Users and Organizations looking to reduce their cost of visualization by an order of magnitude or more.
    - Wanting extremely high resolution, high quality displays
    - With very large data sets >1 TB (including time-step data)
    - Looking to increase productivity by making collaboration easier
    - Looking to use immersive technology
      - Walls & caves
      - Stereographic presentations
        - Active
        - Passive
    - Needing data rendered with near-real time interactivity
    - Needing to display complex simulation data:
      - 3D
      - Volumetric
      - Iso-Surface…

HP's Vision of High-end Visualization

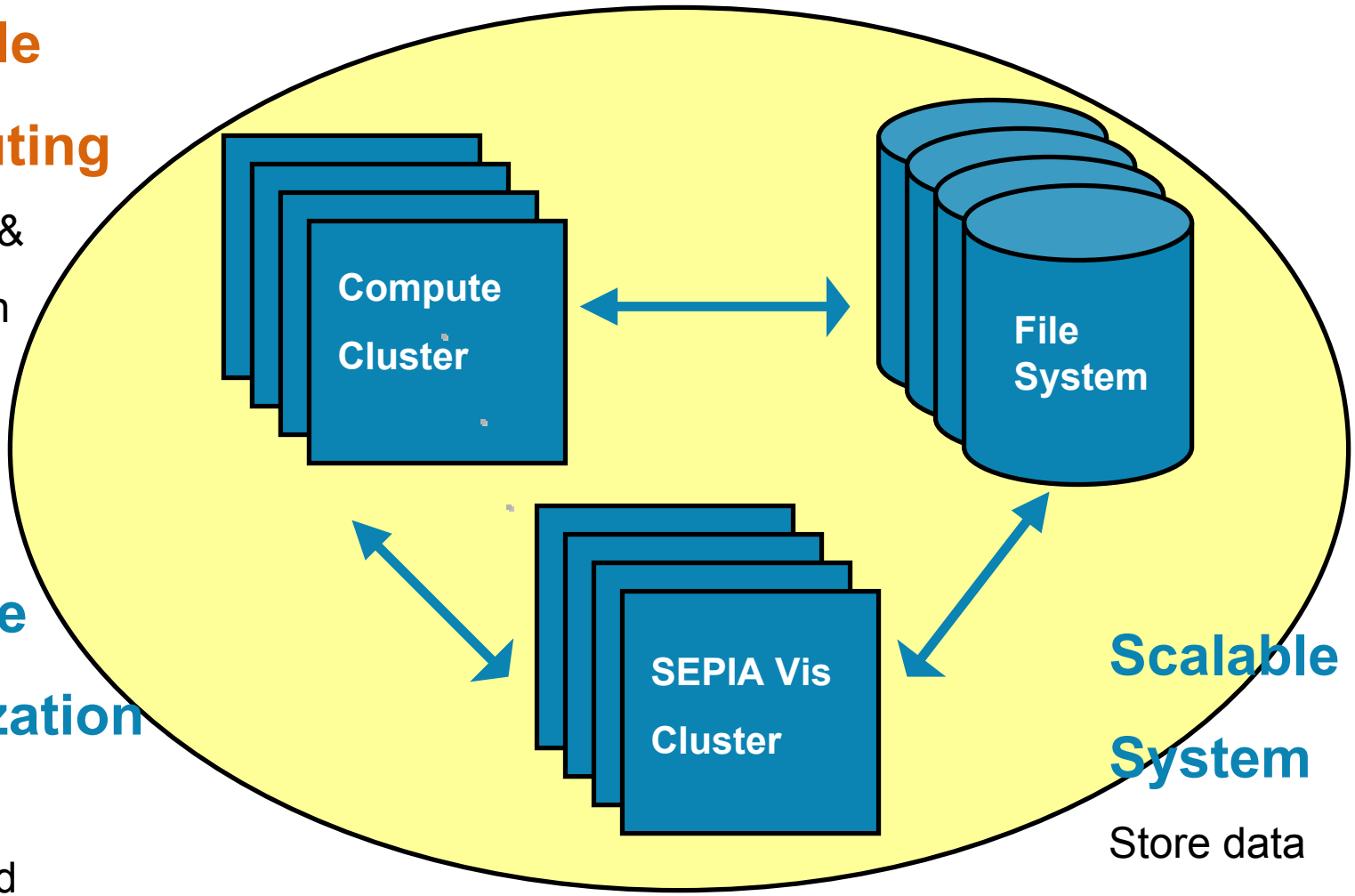
- Scalable visualization performance demanded by High Performance Computing users
  - At affordable price
  - Based on COTS (standard) parts
  - Value added technology (SEPIA)



Scalable High-end Visualization (SHV)

SEPIA POWERED

The HPC Solution Vision



Our Approach to Building an SHV System

- Exploit clustering technology & distributed parallelism
  - widely used for scalable computing
  - now applied to graphics processing & visualization
- Leverage tremendous industry investments in:
  - standard processors (IA-32, IA-64)
  - graphics accelerators
  - high speed interconnects
  - Linux clustering software
- Employ HP unique image compositor technology (SEPIA)

ASC PathForward

- Hewlett-Packard has been awarded a contract by ASC PathForward to develop highly scalable visualization systems based on COTS
  - This award demonstrates the value derived from the fusion of *hp*, Compaq, Tandem, and DEC
  - *hp* technology (SEPIA) is used to add visualization capability to clusters of industry standard systems
  - Both *hp* and ASC are interested in the commercialization of the technology
  - The *hp* technology was first demonstrated at SC2001, and has been the subject of a number of papers

System View

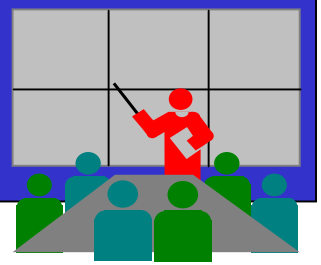
HPTC Supercomputing Systems
Simulation, modeling, Data-mining

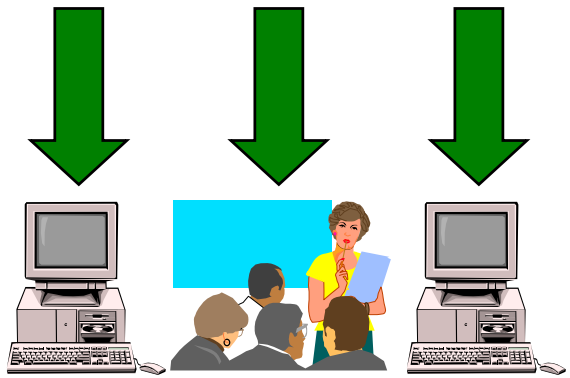
Data over high speed interconnect

Visualization System
(Supporting multiple active sessions)

Images over high speed interconnect

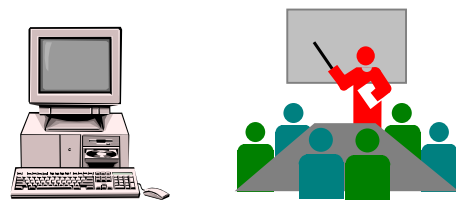
Tiled display





Independent concurrent sessions
for
End-users, Scientists, Researchers

Synchronous viewing at multiple locations



Remote Visualization

Scaleable High-End Visualization System

- SHV offers the customer an economical, high performance, scalable solution to the problem of visualizing extremely large datasets. The solution is based on commercial off-the-shelf components (COTS).
  - SHV will integrate with existing clustering technology and provide a simple path to increase both resolution and performance of the visualization task.
  - For customers needing to replace aging SGI equipment, SHV will offer a clear path out of the proprietary O/S-Hardware maze, thanks to it's COTS-Linux base.
  - For ISVs, SHV offers a clear, open API, with the stability and resources of one of the industry's major players.

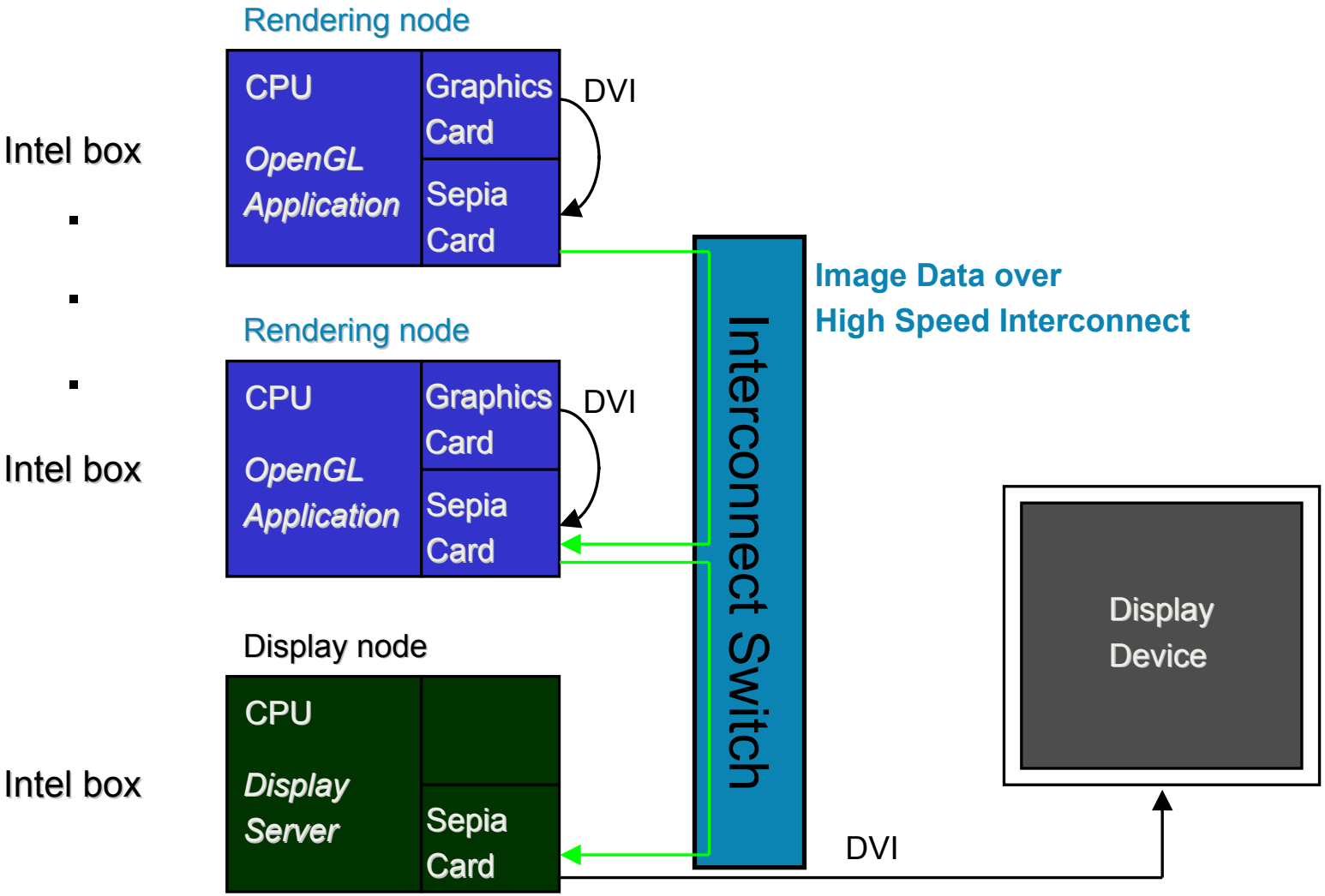
Scalable High-end Visualization (SHV) Platform

- SHV platform supports parallel rendering for performance and resolution scalability
  - Render Cluster
    - render nodes divide input data and render in parallel
    - scales from 8 to 1000+ rendering nodes – Intel/Linux
  - High-speed image compositing hardware
    - dedicated compositing interconnect transmits image data at interactive frame rates
    - SEPIA cards in each node composite image data
  - Displays nodes connected to compositing interconnect
    - display nodes drive multi-tiled displays, immersive displays
    - 10s to 100s of Megapixels

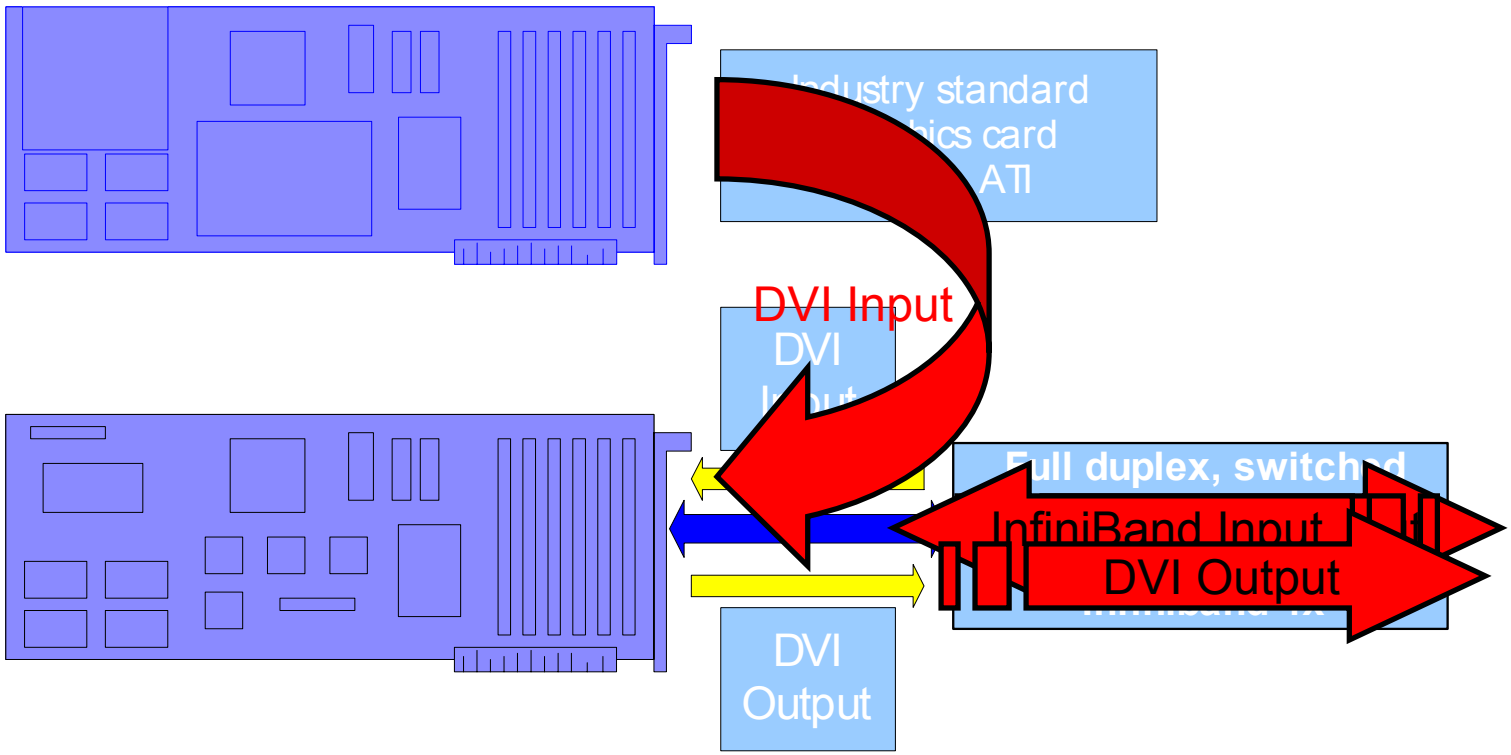
What would an SHV solution be?

- Rack-mounted cluster of Intel/Linux boxes, each with an industry standard AGP graphics card
- Sepia compositing card (PCI)
  - DVI acquisition HW, SW, FW
- Sepia-based hi-speed image compositing network
- Software:
  - Compositing APIs
  - Display & Management Software
  - Diagnostics
  - MPI
  - Tools….
- Plus Vis applications & libraries from ISVs & 3rd parties

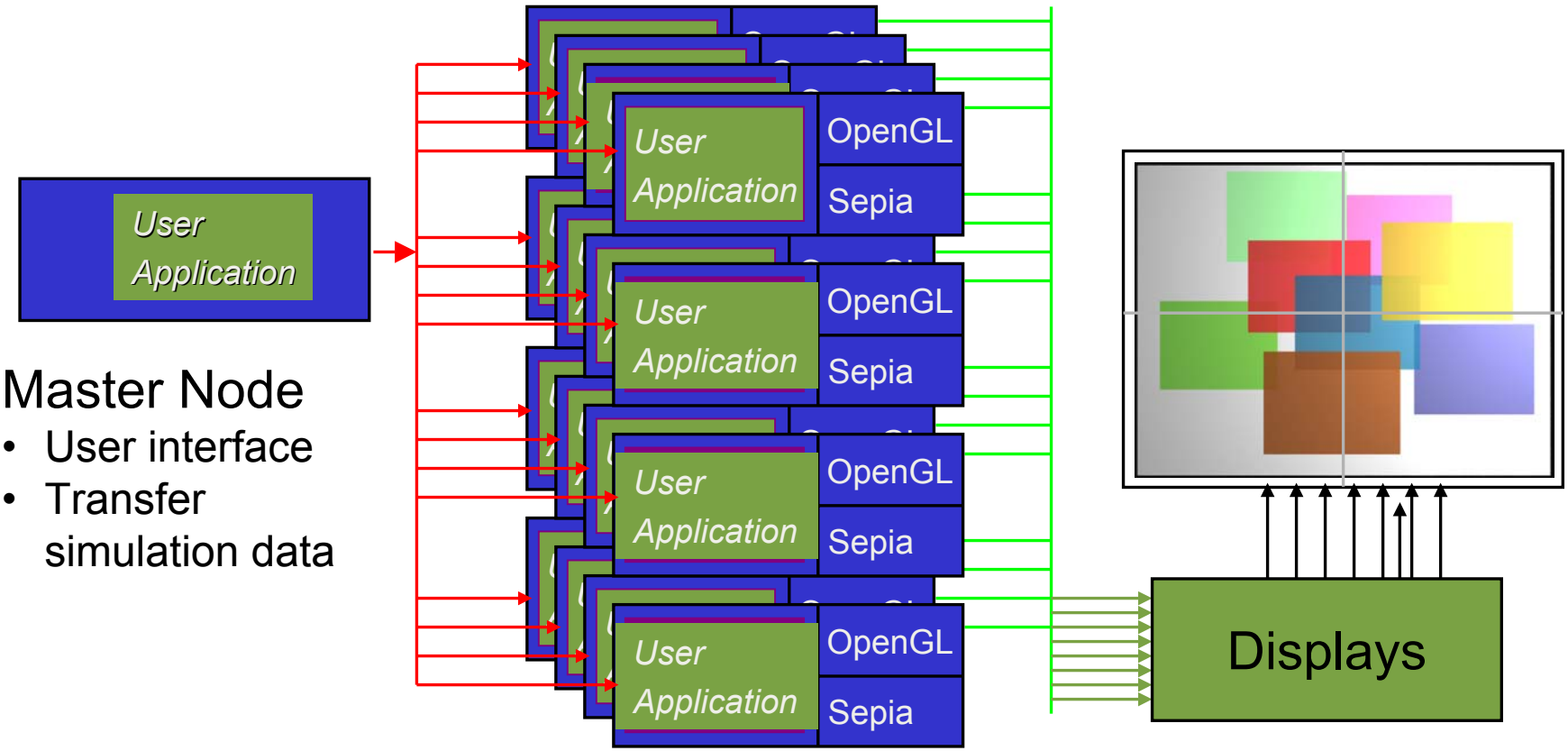
SHV Platform - Building Blocks



SHV Components in a Rendering Node

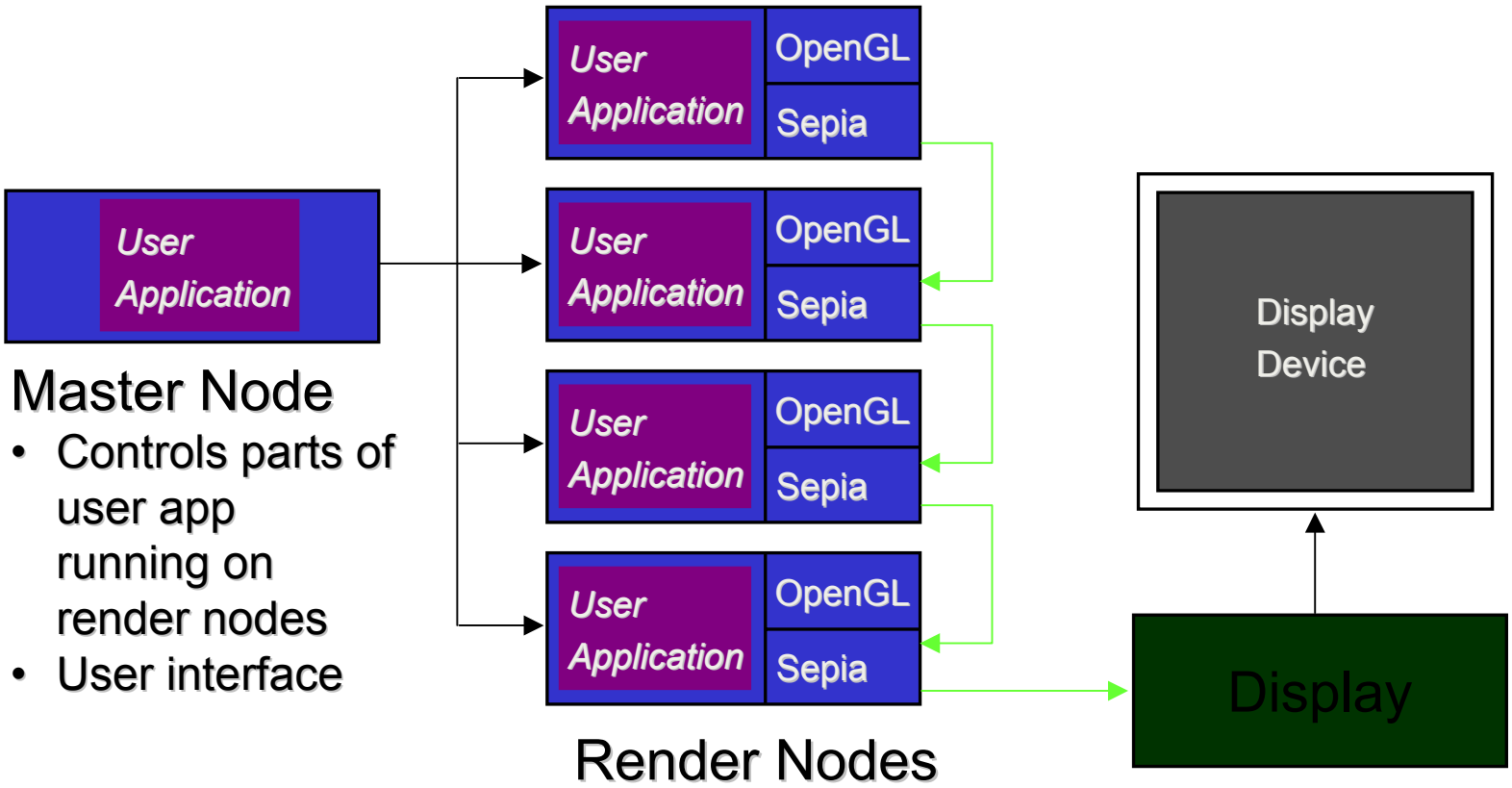


Multi-pipe Example – 4 pipes (4 nodes/pipe)



Scalable to 1000s of nodes and 100s of Megapixels

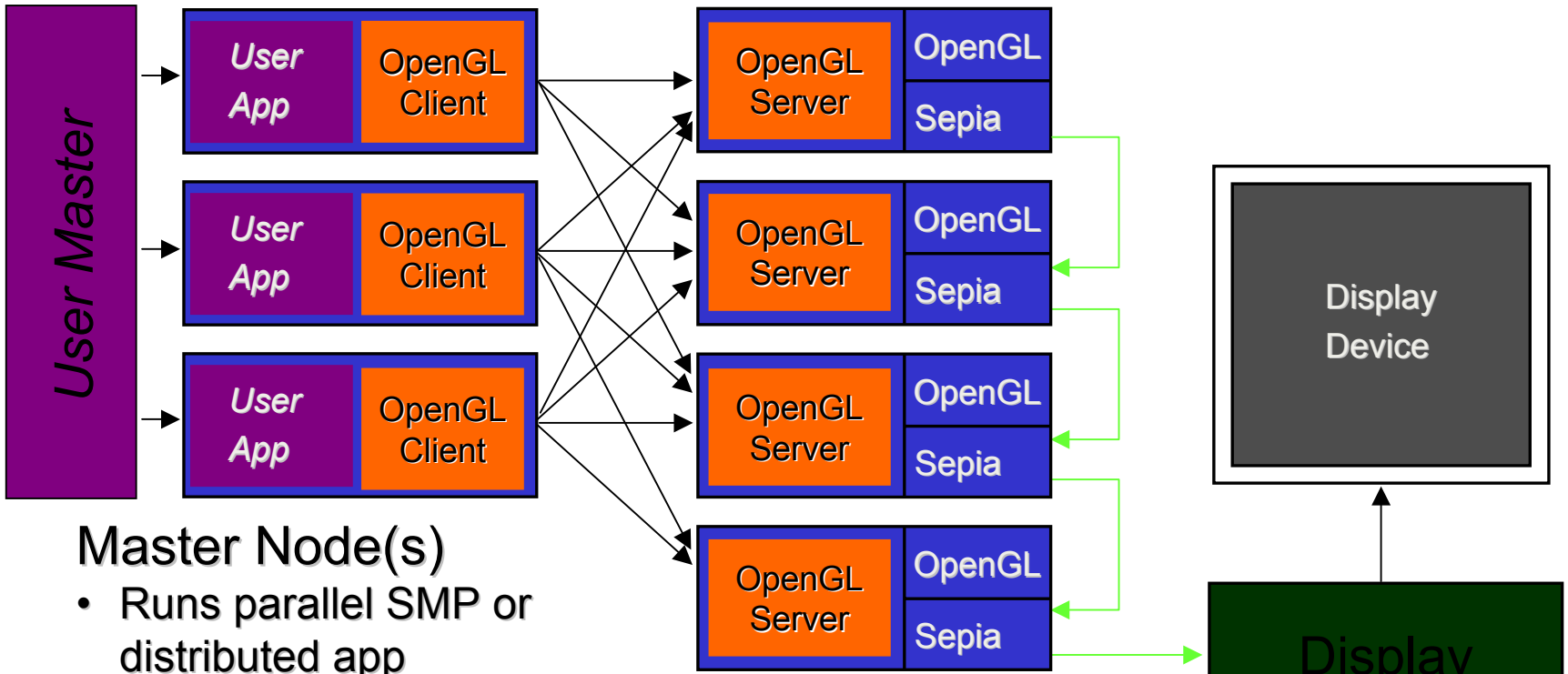
Data-Parallel Distributed Application



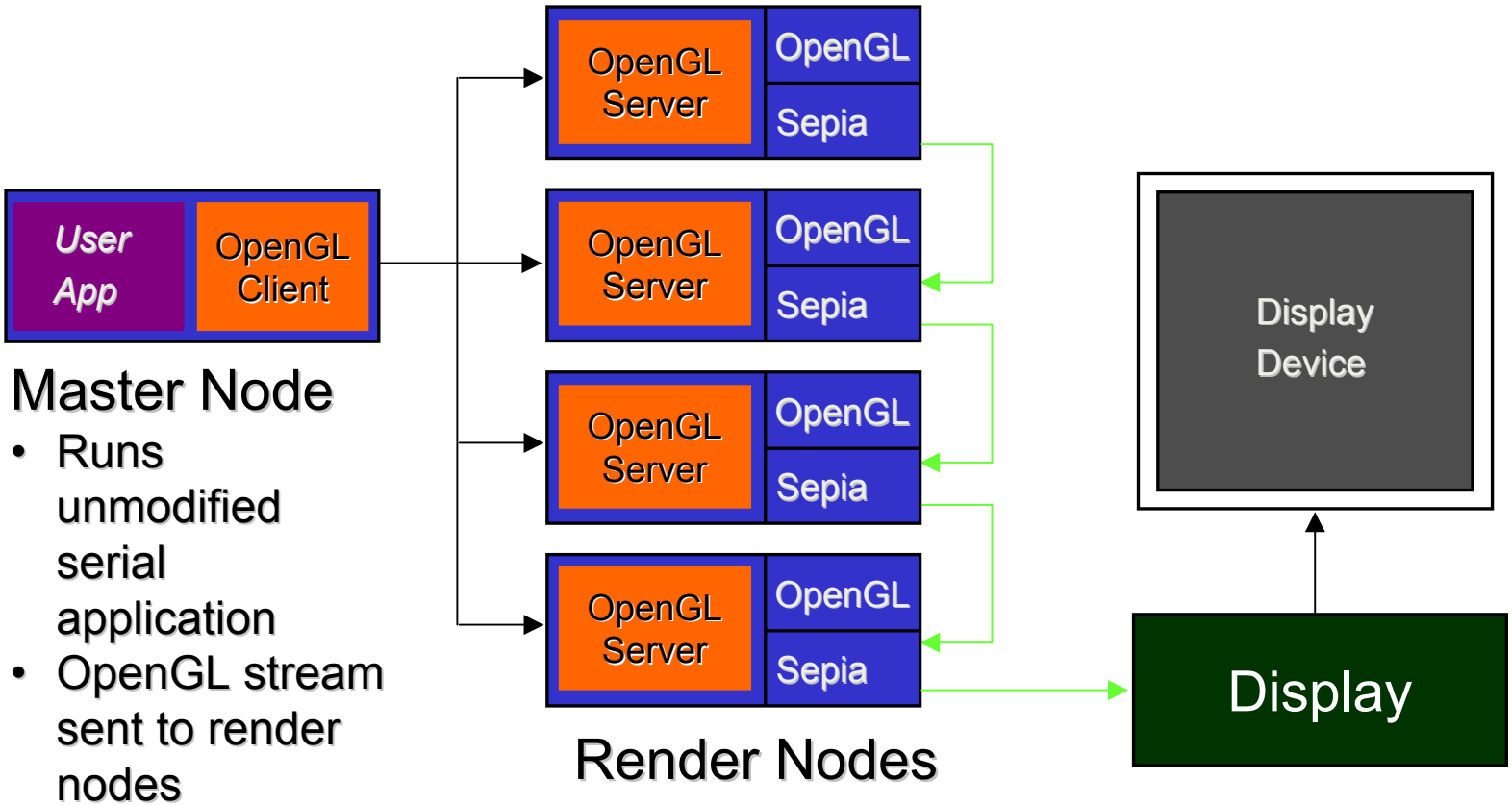
Data and application distributed across render nodes

Scalable to 1000s of nodes and 100s of Megapixels

Parallel SMP/DMP Application



Automatically Distributed Application



Data and application on master node
Graphics automatically distributed
Scalable to 10s of nodes and 10s of Megapixels

Parallel Visualization Technology

- Rendering Power
  - Scales up performance by allowing multiple graphics systems to divide the work for a single image
    - Handles larger data
    - Improves frame rate
- Display Power
  - Scales up resolution by allowing images for multiple tiles to be rendered and displayed in parallel
    - Handles fine-grained data
    - Handles large display surfaces, immersive displays

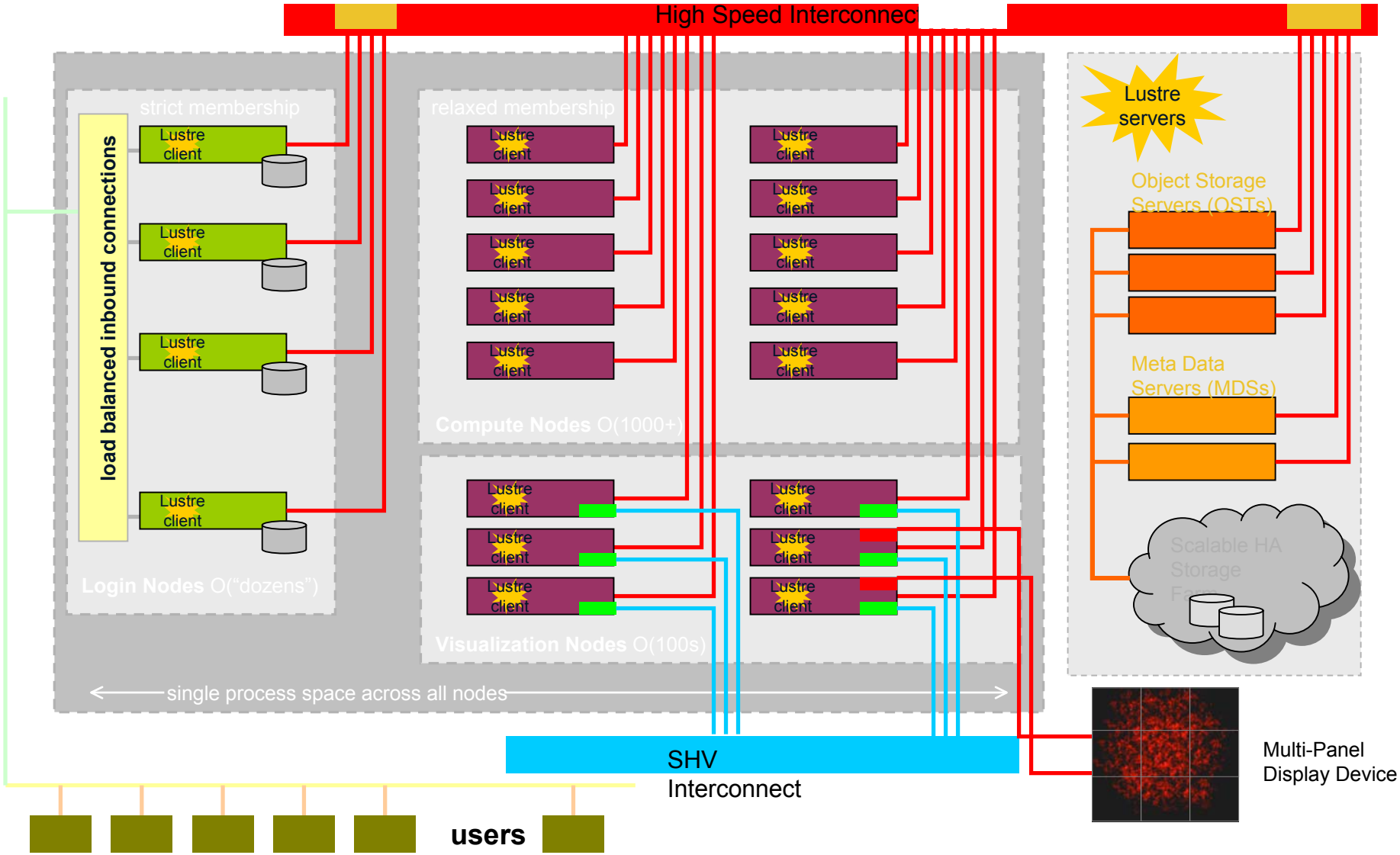
What makes SEPIA technology unique?

- True network based pixel compositing
- Sort last compositing architecture
- FPGA based programmable pixel operators
- Multi-user environment
- COTS components
  - *SEPIA powered*

SHV Differentiates *hp* Clusters

- SHV is an *hp* exclusive technology consisting of software, a PCI card per node, and a high speed interconnection between nodes.
  - SHV integrates visualization into the computational infrastructure.
  - SHV interactively visualizes what is being computed on a Linux cluster consisting of hundreds or thousands of processors.
  - SHV supports stereoscopic vision, depth blending, spatial compositing, and volumetric rendering in
    - Scientific Visualization
    - Geophysical Exploration
    - Modeling & Simulation
    - Engineering & Testing.

HPTC Cluster Vision (including Visualization)



Summarizing key benefits of SHV technology

Clustered visualization (DMP) offers:

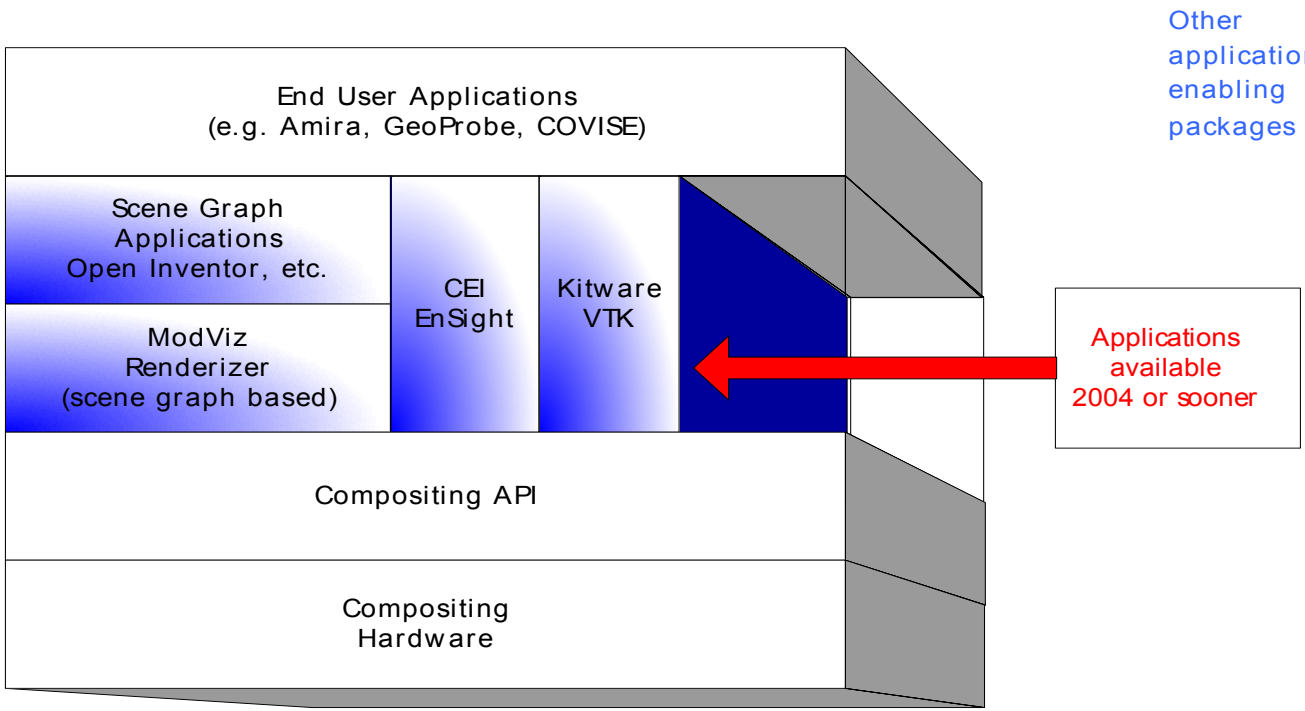
- Scalable performance & capability required by HPTC customers at competitive price
- Viable alternative to SGI
- Completes HPTC Cluster solution – scalable computing, vis & file system

- COTS & Linux Cluster Technology – lower cost, good performance
- Multi-user environment
- Broad market applicability:
  - all HPTC market segments
  - enhanced by Patent-pending SEPIA technology

How close is SHV to the ideal?

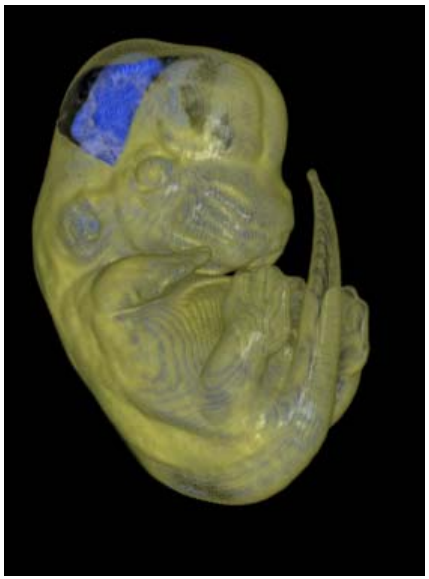
- ✓ High performance
- ✓ Visualize large datasets
- ✓ Economical
- ✓ Scalable
- ✓ Renewable
- ✓ Configurable resource
- ✓ Support collaboration
- ✓ Non-proprietary (mostly, but a small part is proprietary)

Application Support



Flexible Compositing

Sepia can be applied to a variety of applications



Volumetric blending non-commutative Porter-Duff operators

Santiago Lombeyda, Russ Jacob & Scott Fraser

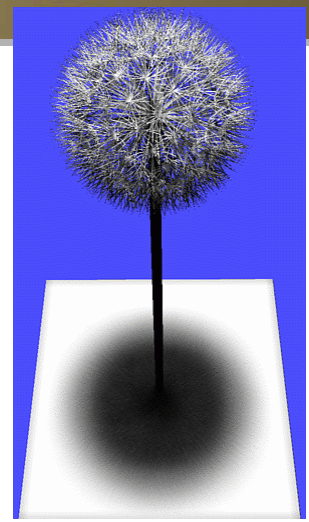
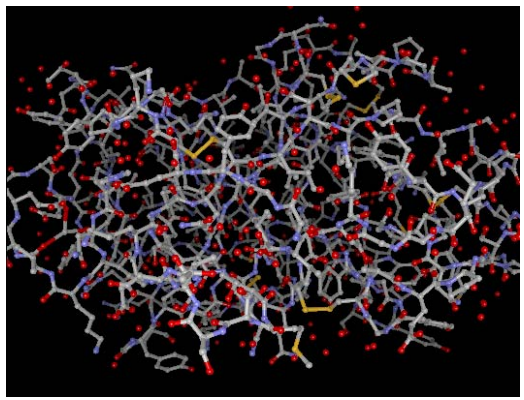


Photo-realistic image projection

SIGGRAPH 2000
Agrawala, Ramamoorthi, Heirich & Moll

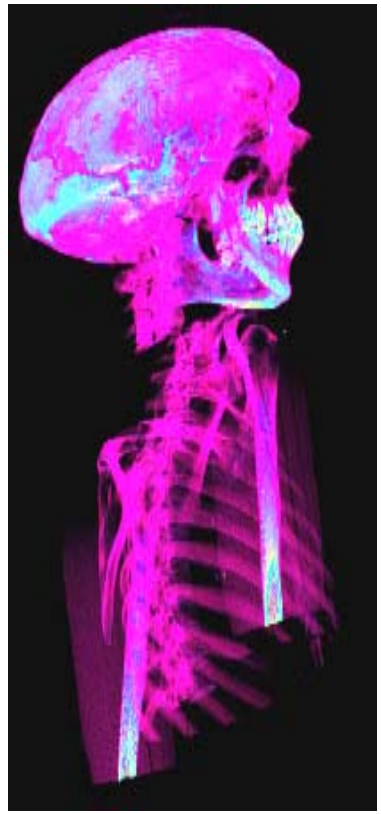
Depth compositing visual simulators isosurface rendering



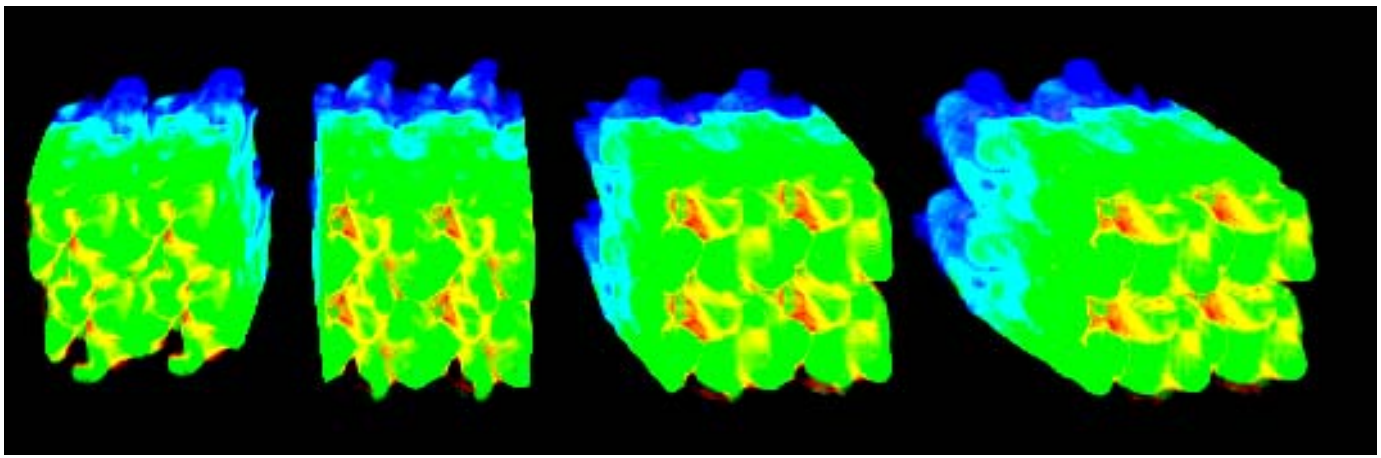
Others ...

Real-time scalable direct volume rendering

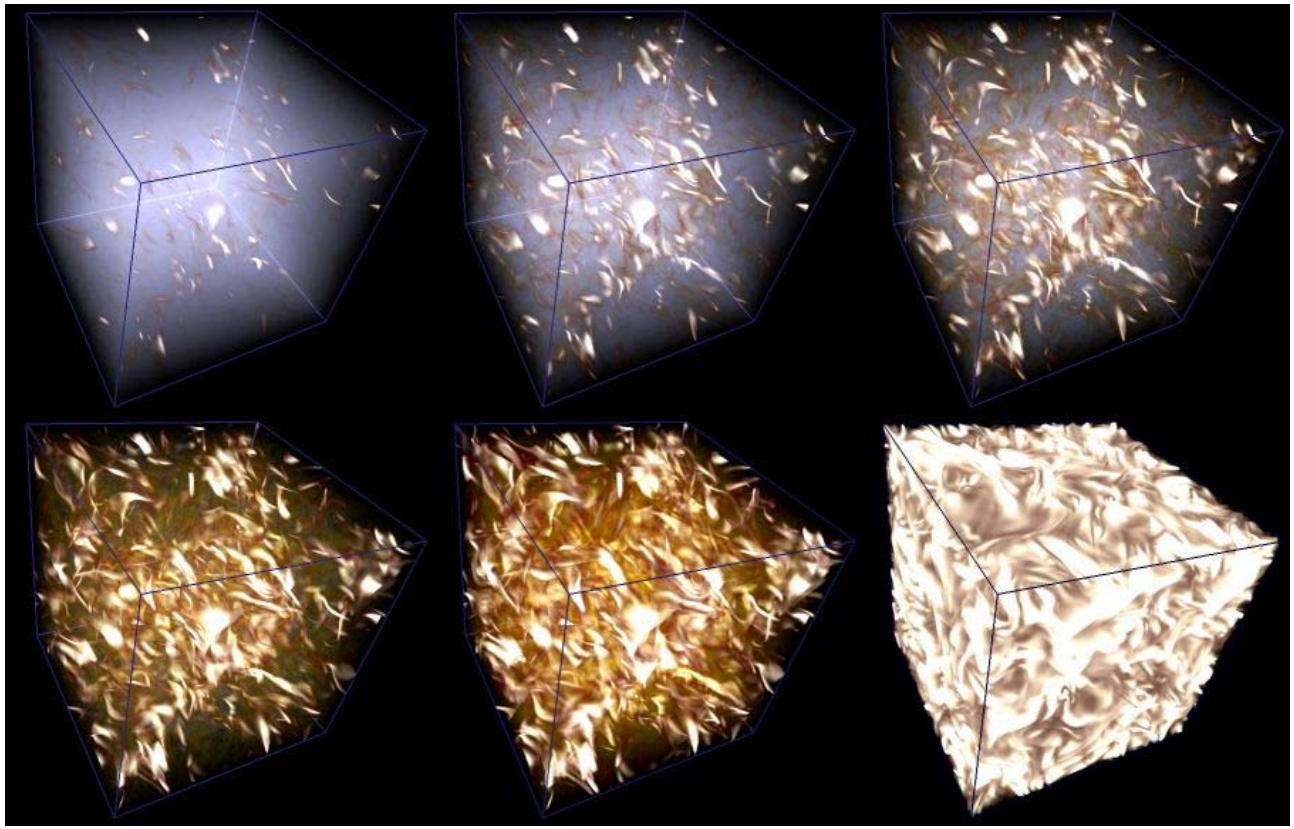
Demonstration:
512^3 voxels
1024^2 pixels
24-28 fps
8 computers



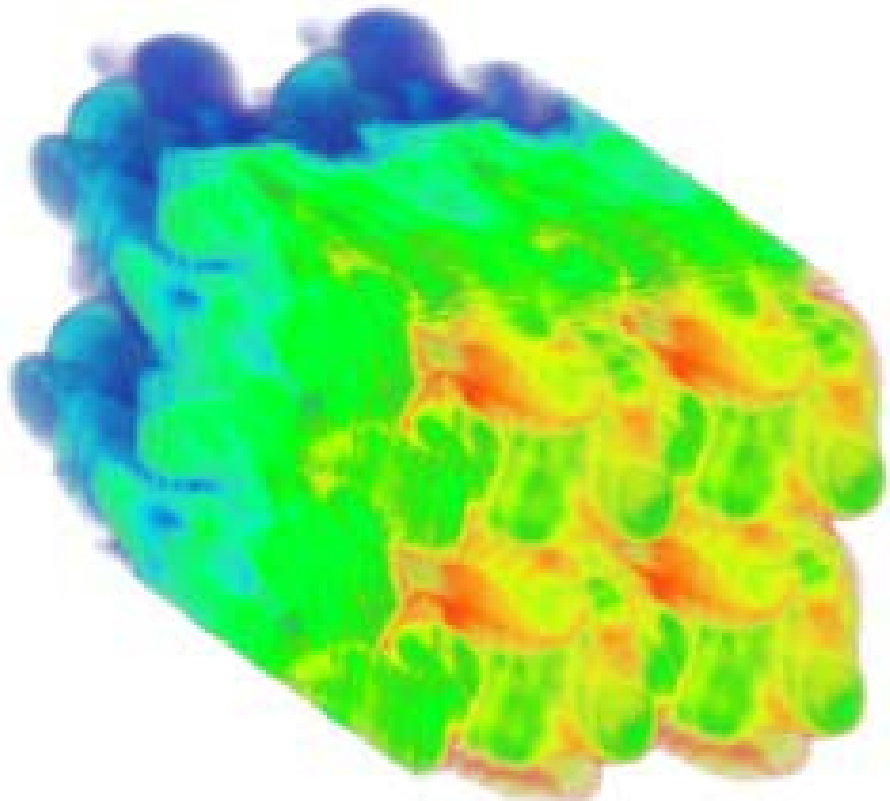
Scalable to more . . .



Volumetric Simulation

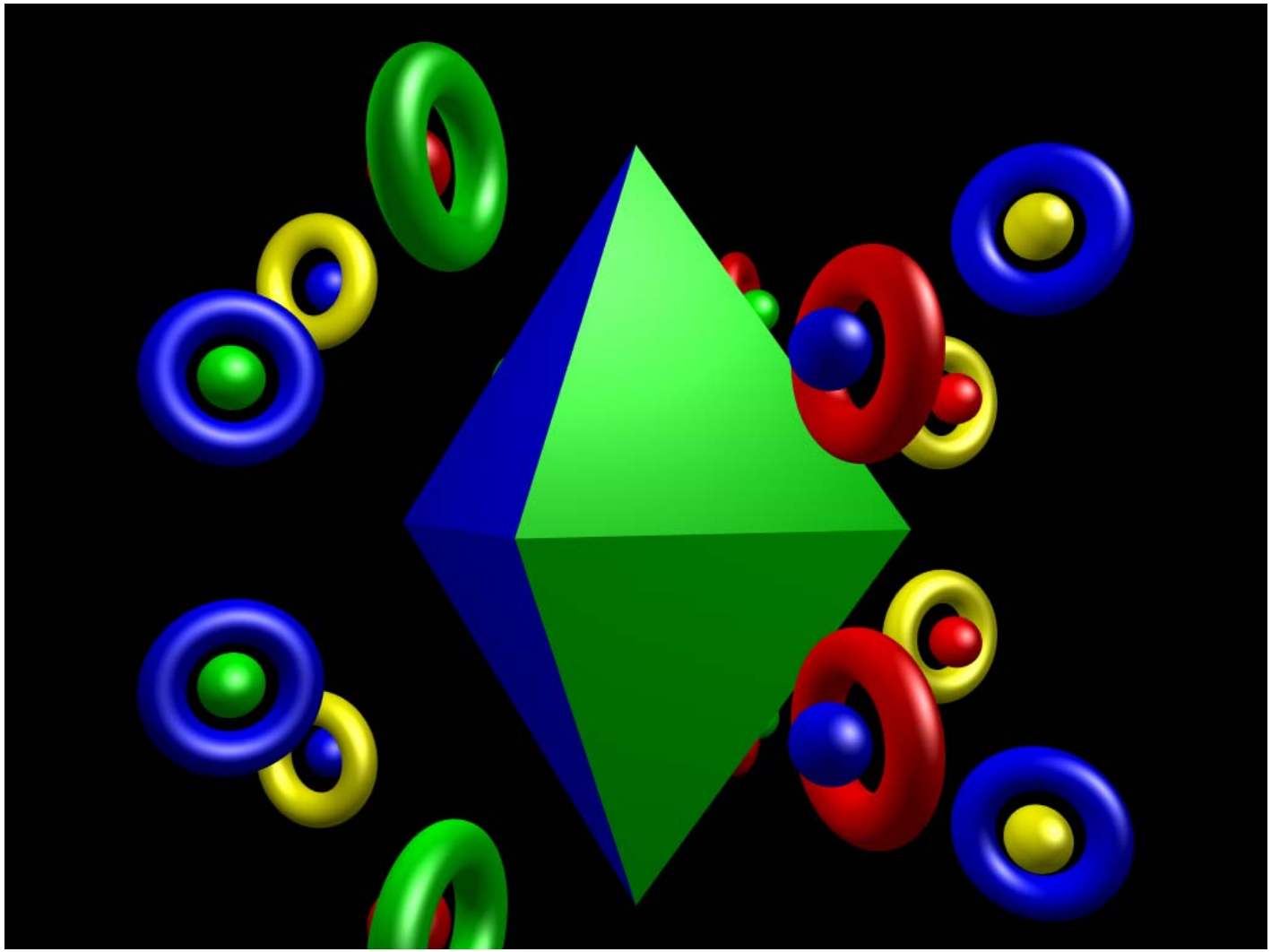


Volumetric Rendering

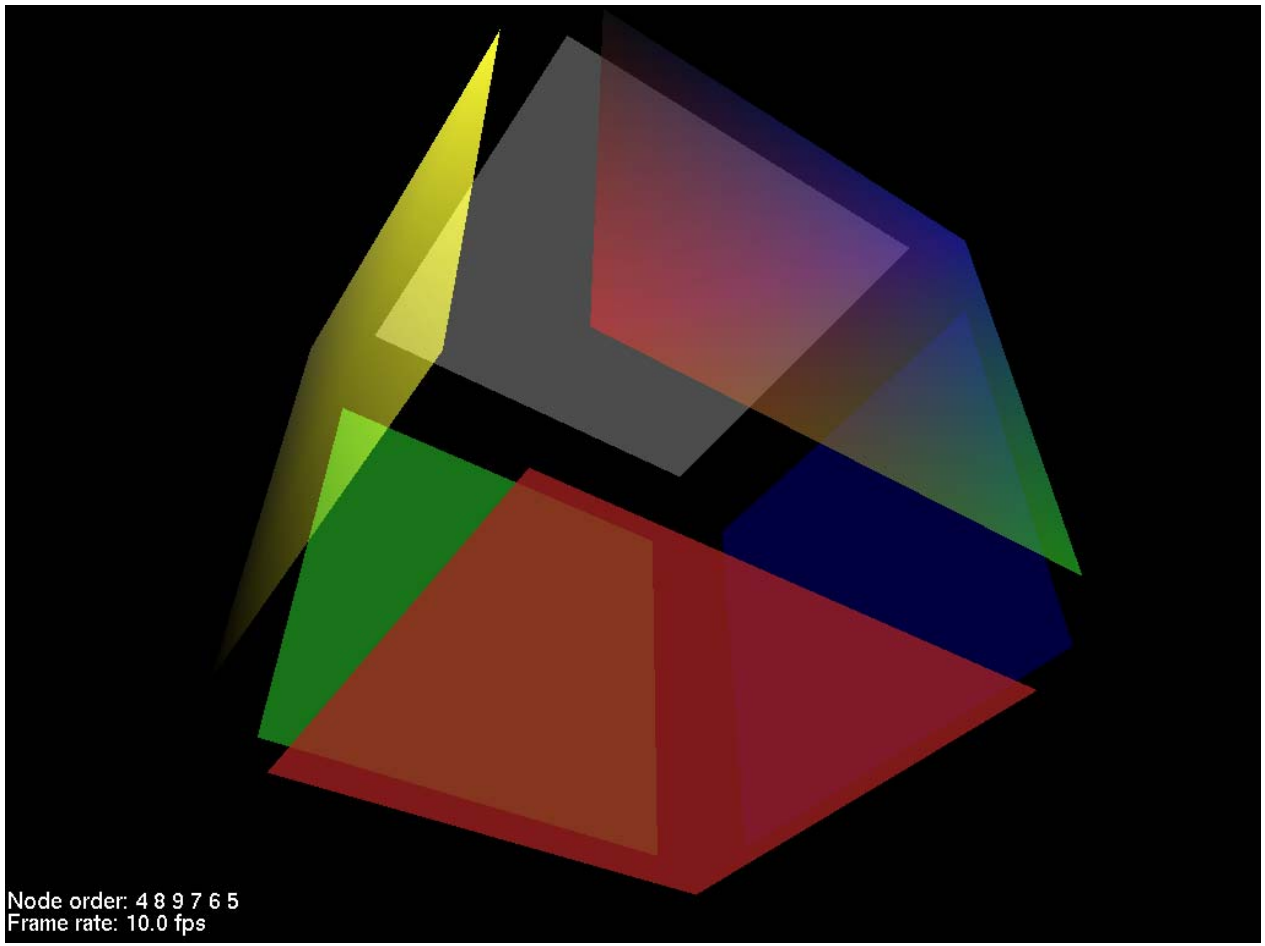


Volumetric rendering of simulated Rayleigh-Taylor instability with fluid density represented by color, simulation by Andrew Cook, Lawrence Livermore National Laboratories, 1024x256x256 voxels

8-Way Anti-Aliasing on SHV Technology



Rotating cube demo



Visualization Clusters* Outperform Conventional High-End Solutions

	Performance	Price	Price/Performance (lower is better)
	GigaPixels/sec	$K	(Cost/(Millions tri/sec))
SGI Onyx 3800	7.700	1000	3533.57
SGI Onyx 3200	0.484	117.8	6657.85
SGI Onyx 300	0.192	118.6	16950.00
SHV Cluster (16 render nodes)	16.000	< 400	<806.45
SHV Cluster (8 render nodes)	8.000	< 200	<806.45
Note that the performance of the SHV Cluster scales linearly thus the price/performance of the system is constant			

SGI Onyx data from SGI

SHV Cluster data projections from Modern Visualization measurements using functional prototype hardware

This comparison doesn't constitute a commitment by Hewlett-Packard for productization of the technology.

*** With Renderizer**

Modern Visualization, Inc.

+ Computer Hardware

Interex, Encompass and HP bring you a powerful new HP World.