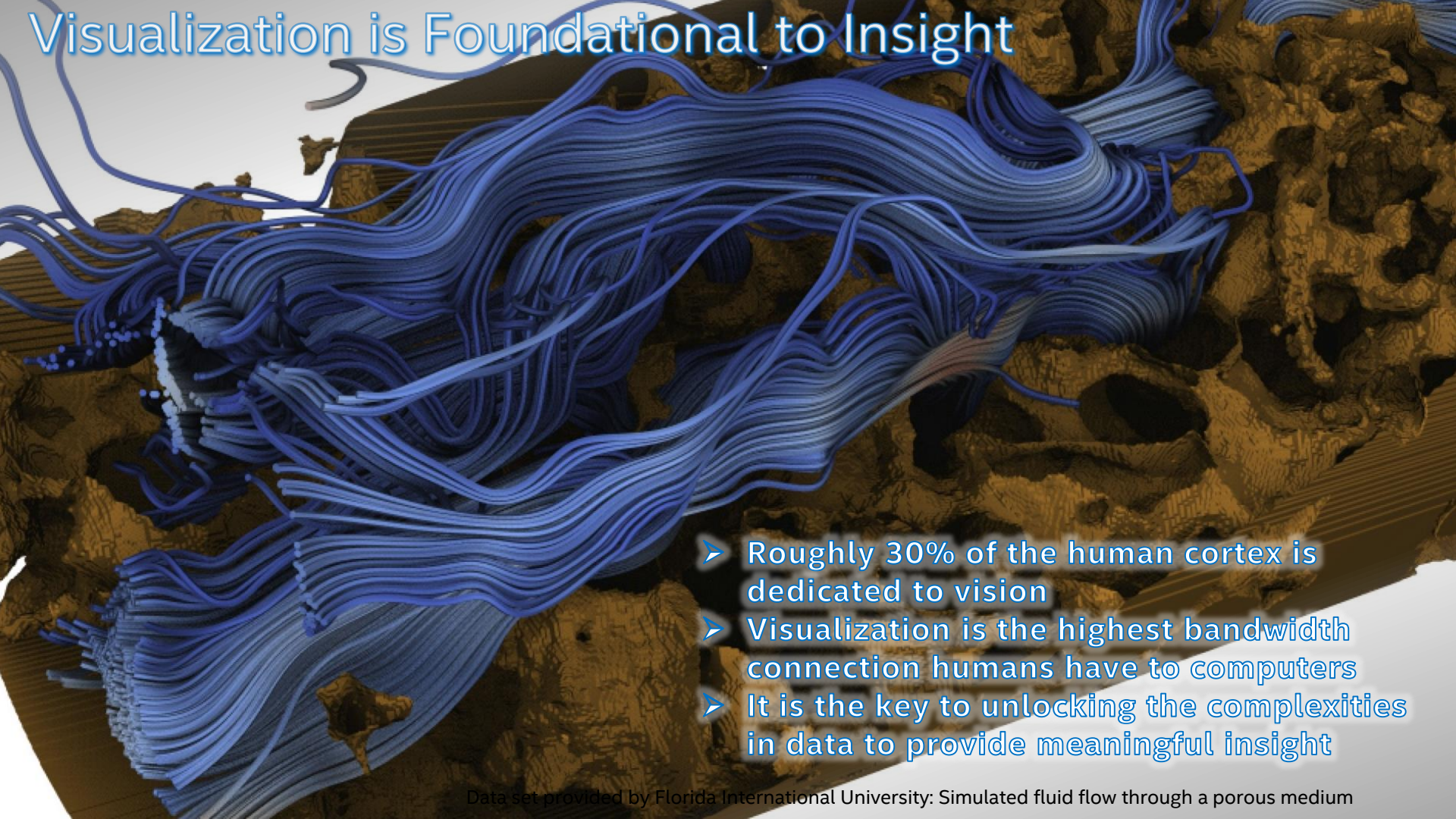
SOFTWARE DEFINED VISUALIZATION:
FAST, FLEXIBLE SOLUTIONS FOR RENDERING BIG DATA

Johannes Günther, Senior Graphics Software Engineer

Intel Data Center Group, HPC Visualization

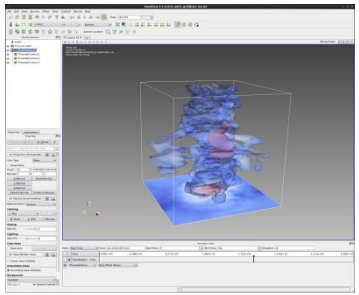
Visualization is Foundational to Insight



- Roughly 30% of the human cortex is dedicated to vision
- Visualization is the highest bandwidth connection humans have to computers
- It is the key to unlocking the complexities in data to provide meaningful insight

Data set provided by Florida International University: Simulated fluid flow through a porous medium

Large Scale Visualization is Widespread

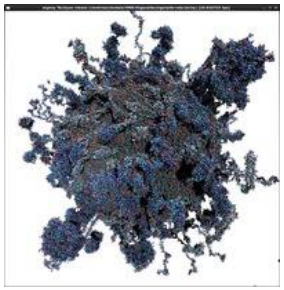


Academics and Researchers

Model used with permission from Wendell Horton (University of Texas / TACC). For more information on this simulation, please read this paper.

Designers and Architects

Thanks to EasternGraphics



Biologists / Life Scientists

Model courtesy Carsten Kutzner, MPI BPC, Goettingen.

Engineers

Model obtained from and used with permission of the Boeing Company (special thanks to Dave Kasik)

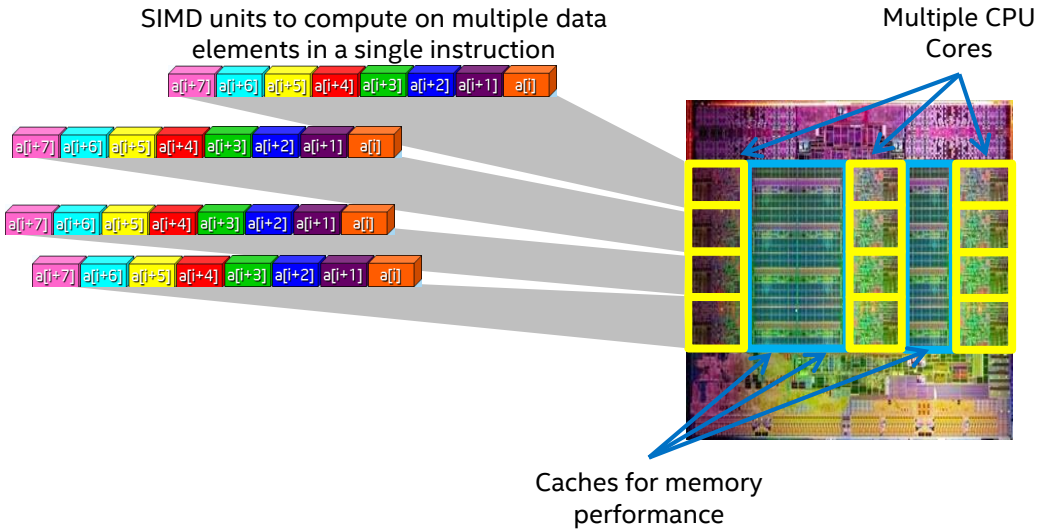
Film and Animation

Model originally created using DAZ3D's DAZ Studio.

Used by everyone who desires realistic, insightful and interactive visual representations of their computer generated models and data

Intel® Processors Provide the Parallelism Needed

General Purpose Hardware



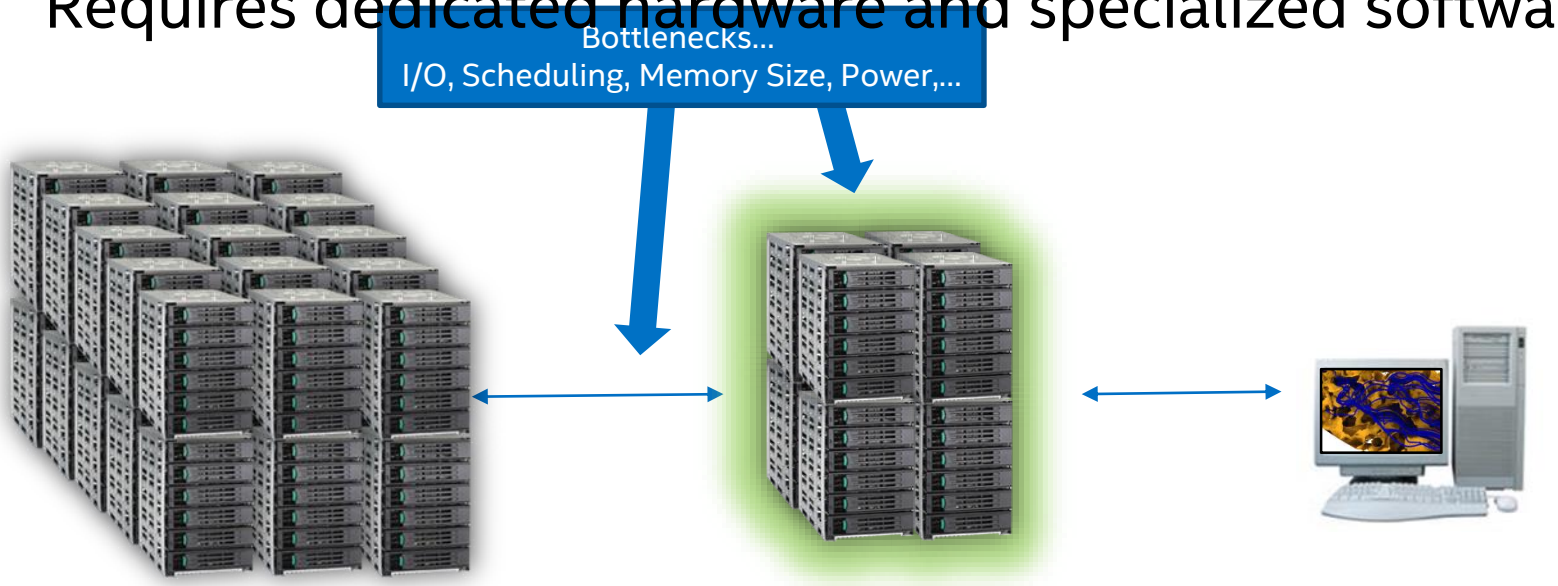
Rendering is a parallel COMPUTE problem!

Visualization is inherently parallel
- Broad task and data parallelism
- Pixels rendered independently
- Linearity lends to vectorization

Intel CPUs are massively parallel processors with
- Multiple processor cores
- Multiple threads per core
- Wide SIMD execution units
- Highly out-of-order cores

The Challenge with Traditional Visualization

Requires dedicated hardware and specialized software



HPC cluster performs modeling and simulations

Dedicated Visualization HW (GPUs) and SW

Client devices view the final images

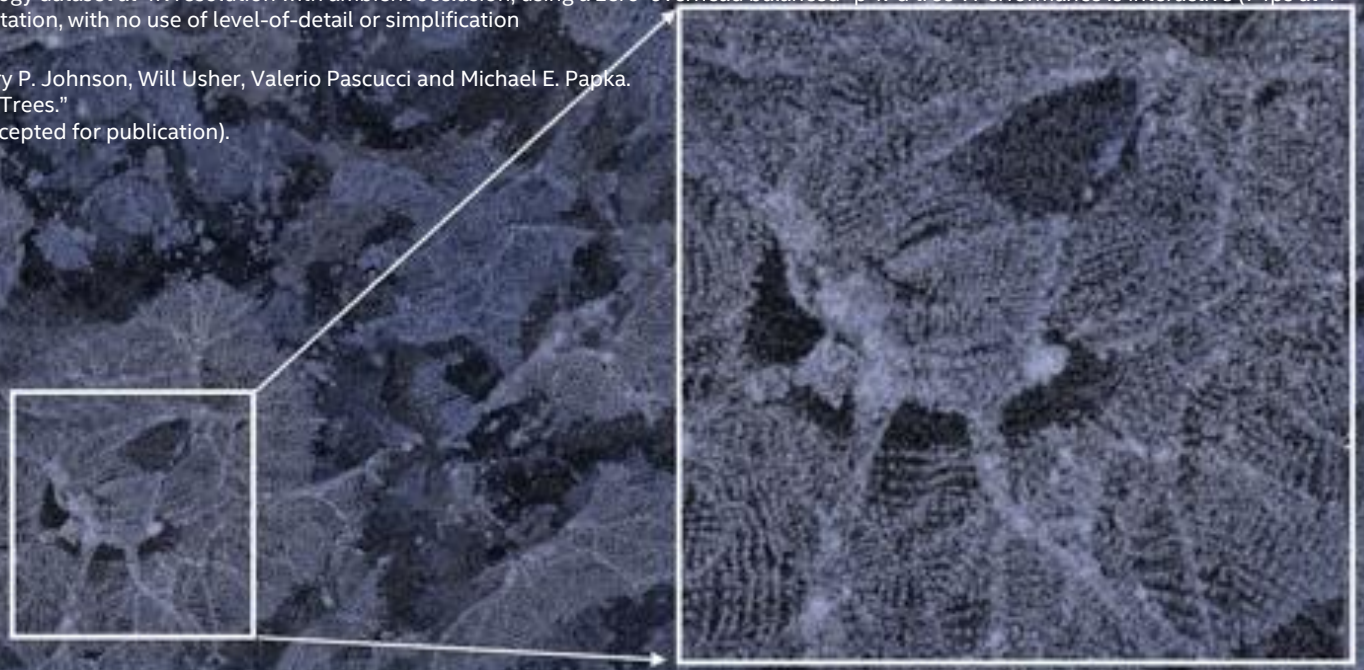
For both ray tracing and rasterization

DATASET Size Matters

SDVis can handle massive data sets, and use the most advanced imaging techniques for greater insight from compute and modeling

Ray tracing a 12-billion (450 GB) particle cosmology dataset at 4K resolution with ambient occlusion, using a zero-overhead balanced “p-k-d tree”. Performance is interactive (7 fps at 4 megapixels) on a quad-socket Haswell-EX workstation, with no use of level-of-detail or simplification

(complements of Ingo Wald, Aaron Knoll, Gregory P. Johnson, Will Usher, Valerio Pascucci and Michael E. Papka.
“CPU Ray Tracing Large Particle Data with P-k-d Trees.”
IEEE Visualization (SciVis) 2015 (conditionally accepted for publication).



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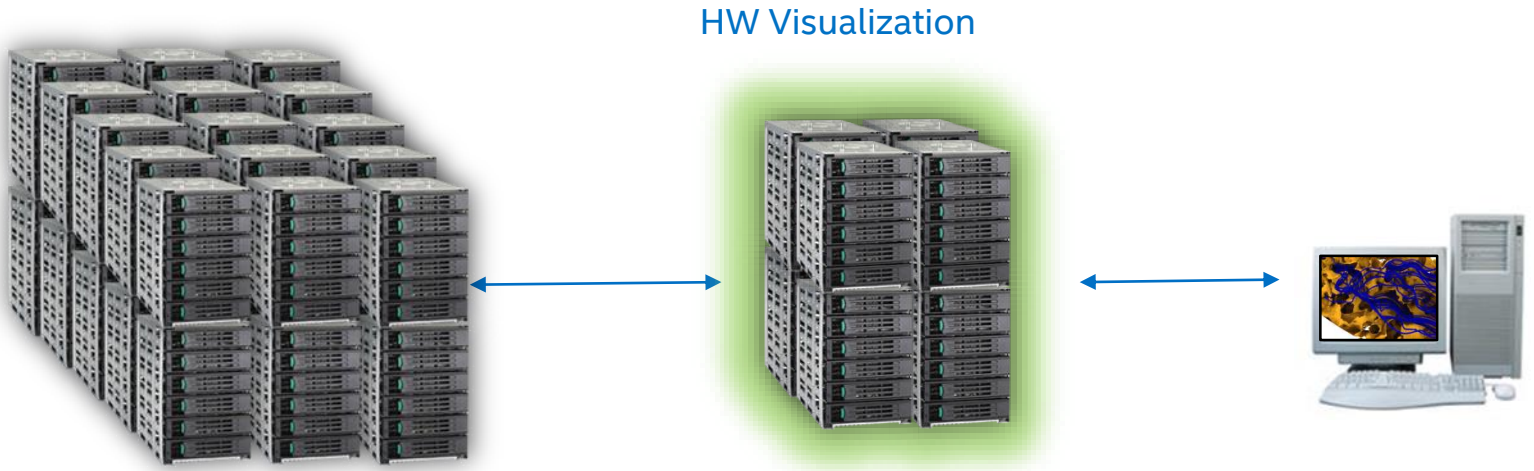
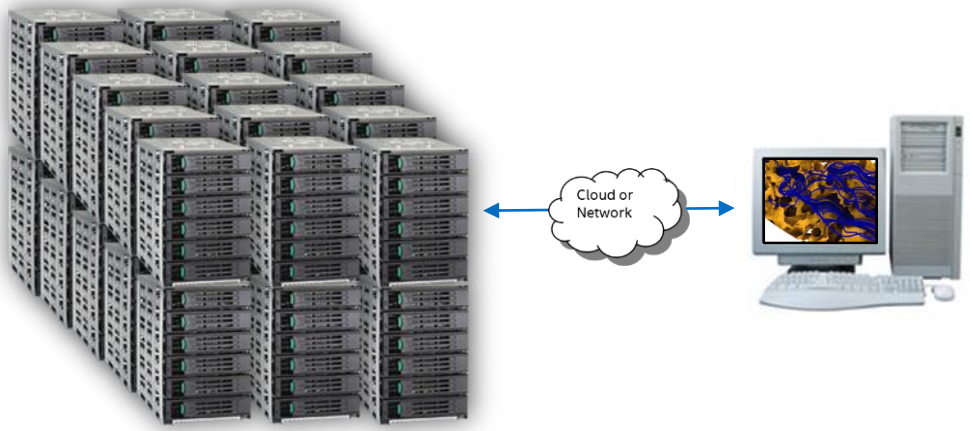


For both ray tracing and rasterization

The Software Defined Visualization Advantage

General Purpose Hardware and Open Software

Cluster enabled with
Software Defined Visualization



Visualization performed “in memory” on HPC Cluster in Software

Client devices view the final images

High Fidelity
- Work with larger data sets – not constrained by GPU memory
- Continuously improving state-of-the-art algorithms

Excellent Performance
- Less data movement, I/O
- Invest power, space, budget in greater compute capability
- Dynamically allocate resources
- Enables efficient ‘in situ’ use cases

Resource Efficient
- No dedicated visualization cluster
- Save power, operations costs
- Simplified cluster Management

SDVis Runs at All Scales

Software Visualization

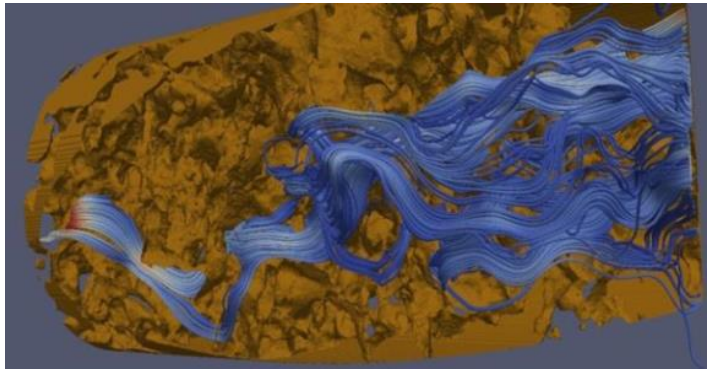
Supercomputers

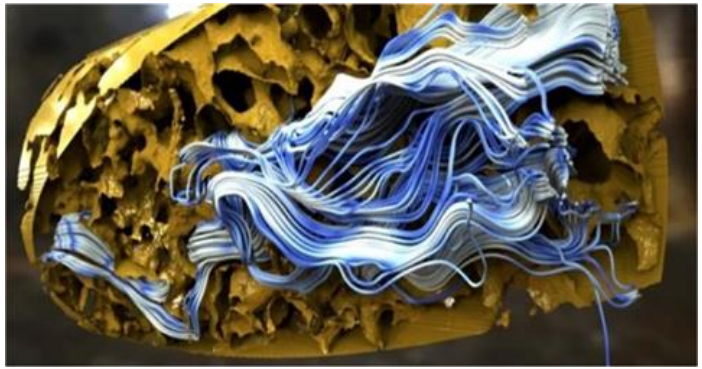
Clusters

Clients & Workstations

SDVis offers Flexibility

- Larger model size
- Larger display size
- Scalability in image quality
- Scalability in render cost





Data set provided by Florida International University

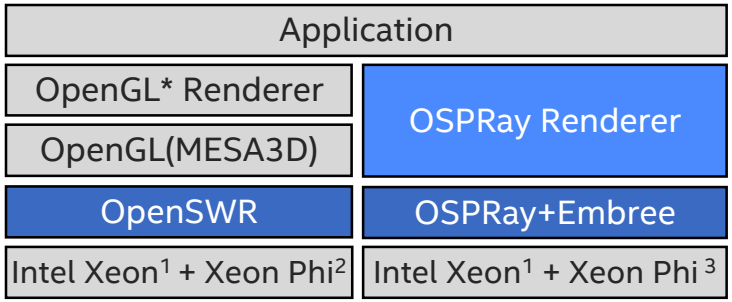
Software Defined Visualization: Our Approach

Option 1: Support existing APIs (OpenGL*)

- Good option for new applications
- Works with existing applications
- No code changes or recompilation required
- ➔ **OpenSWR** software rasterizer

Option 2: Enable new functionality and improved performance through a new API

- Good option for new applications
- Integration underway for existing Key applications (ParaView*, VisIt, VMD, ….)
- ➔ **OSPRay** ray tracing based rendering engine
- [*built on Embree kernel library*]



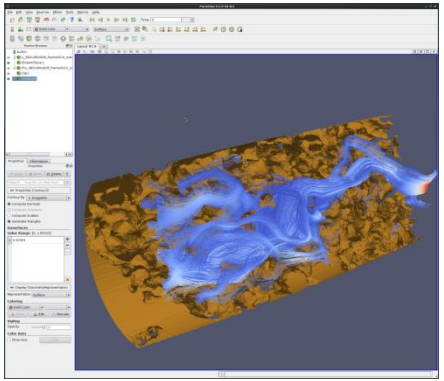
[1] Intel® Xeon® processor, [2] Intel® Xeon Phi™ processor,
[3] Intel Xeon Phi processor and Intel Xeon Phi coprocessor

Our SDVis solutions support BOTH options!

OPENSWR
SOFTWARE RASTERIZER

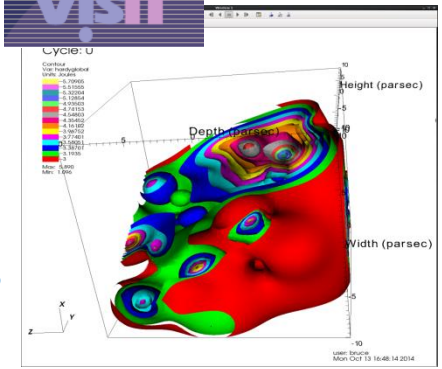
OpenSWR Software Rasterizer (www.openswr.org)

ParaView

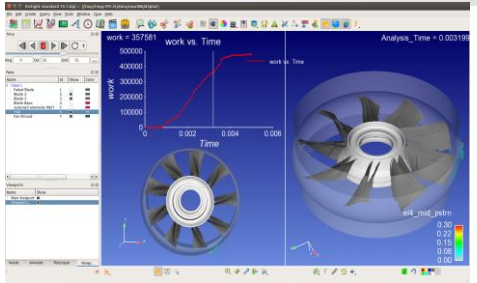


- High performance open source software implementation of OpenGL*
  - Fully multi-threaded and vectorized for Intel® processors
  - Leverages community development effort (MESA)
- Drop in replacement for OpenGL library
- Implementing an increasing subset of OpenGL as required by vis applications

VisIt



CEI EnSight
Extreme Visualization Software



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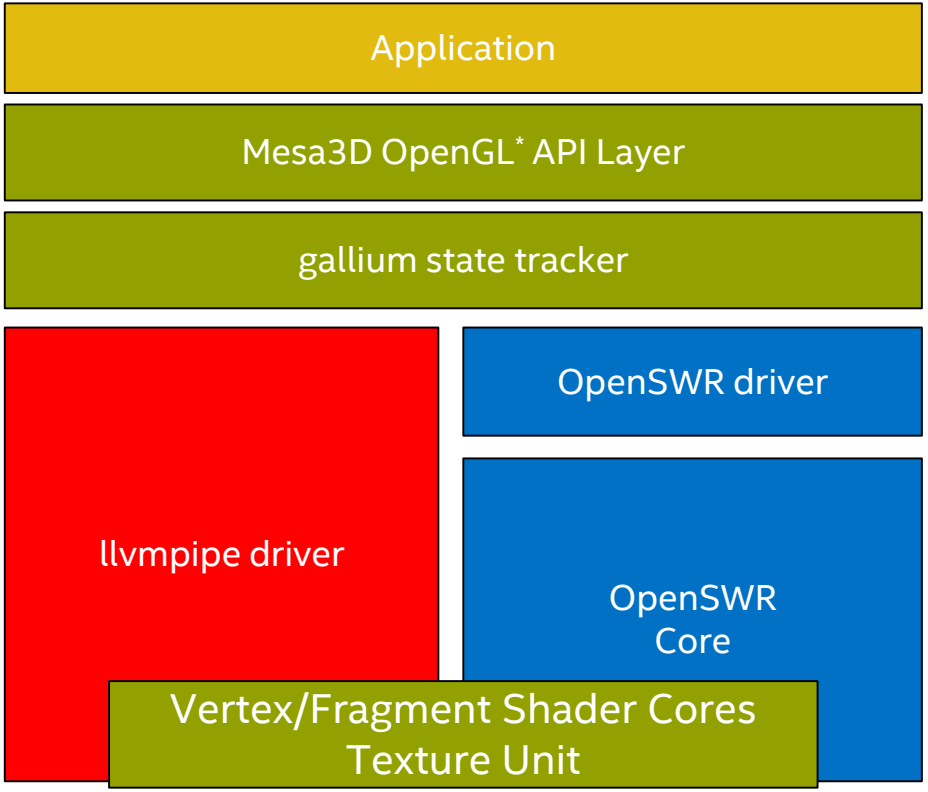
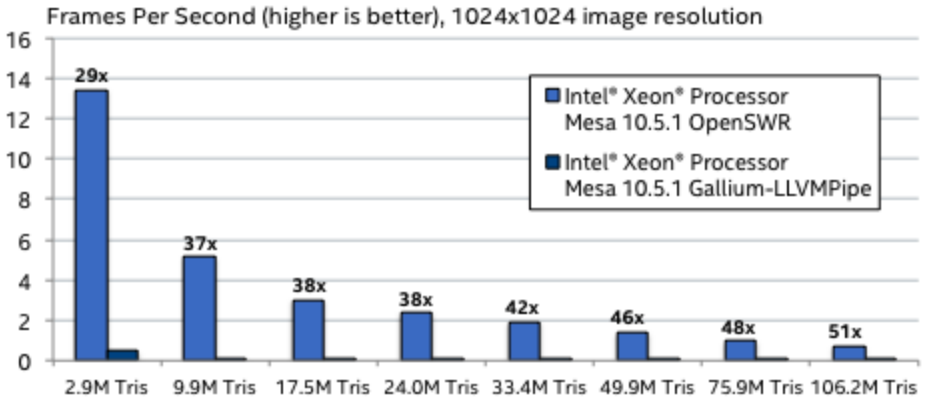
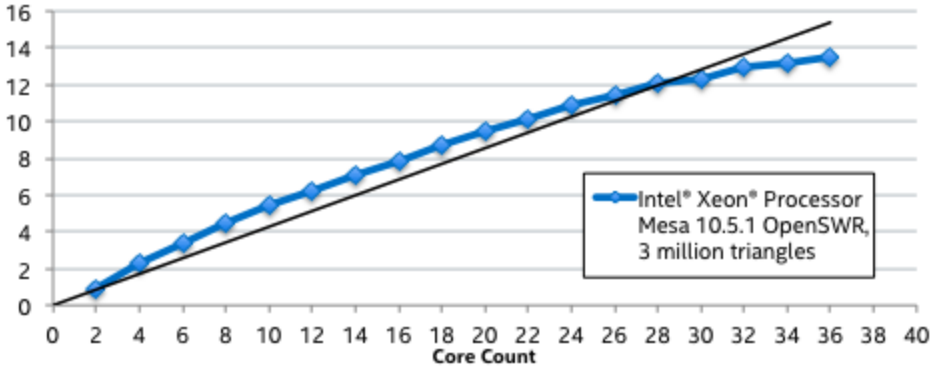
OpenSWR: Architecture within Mesa3D

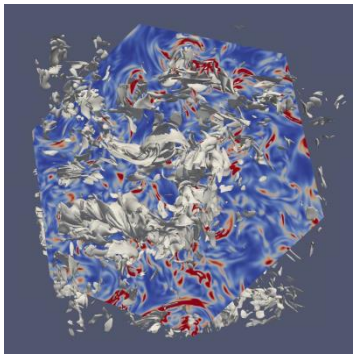


Included in Mesa3D 12.0

Performance: OpenSWR vs MESA* llvmpipe



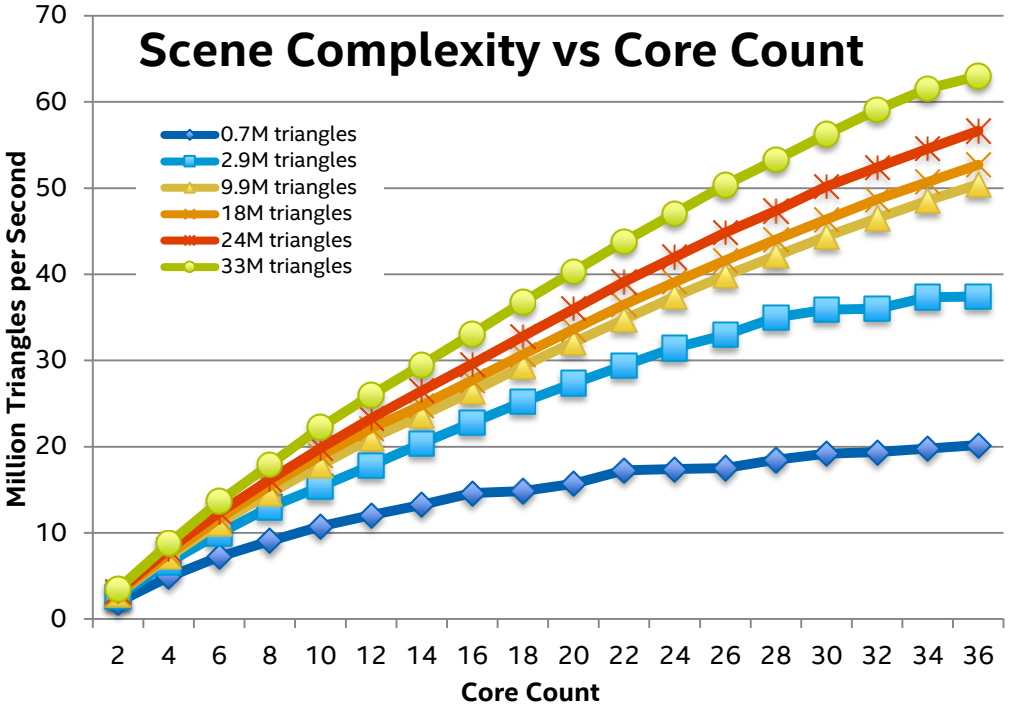


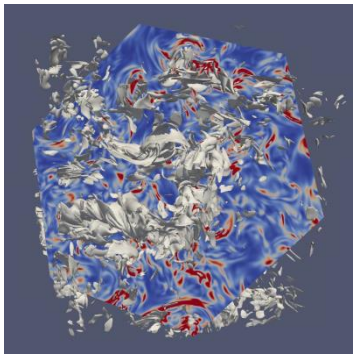


- Intel® Xeon® E5-2699 v3 Processor 2 x 18 cores, 2.3 GHz
- ParaView* 4.3.1
- OpenSWR “alpha 2”
- (full system configuration on slide 17)

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark* and MobileMark*, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to http://www.intel.com/performance.

Performance: OpenSWR





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Performance Test Configuration

Node count	1
Platform	Cottonwood Pass Platform (Intel)
CPU	Intel® Xeon® processor E5-2699 v3 LGA2011 2.3GHz 45MB 145W (DP) Dual socket 18 core
RAM	128 GB total 8*16GB 2133MHz Reg ECC DDR4
BIOS	Vendor: Intel Corporation Version: SE5C610.86B.01.01.0005.101720141054 Release Date: 10/17/2014 BIOS Configuration: default
Hard drive	Intel® SSD SA2M160G2GC 1x160 GB SATA* SSD
NVIDIA GPU	NVIDIA* GeForce* GTX* Titan X 3072 CUDA Cores 12GB memory Software Details: CUDA Version 7.0.28 OptiX Version 3.8.0 NVIDIA Driver Version 346.46
OS / Kernel	CentOS release 6.6 / 2.6.32-504.23.4.el6.x86_64

EMBREE
RAY TRACING KERNEL LIBRARY

Ray Tracing Foundation: Embree Kernel Library

- Provides highly optimized and scalable Ray Tracing Kernels (data structure build and ray traversal)
- High performance on current (and future) CPUs (1.5x – 6x speedup reported by users)
- Targets application developers in professional and scientific rendering environments
- API for easy integration into applications
- Free and Open Source under Apache* 2.0 license (http://embree.github.io)

INDUSTRY Adoption*

DREAMWORKS

UBISOFT MOTION PICTURES

AUTODESK.

V-RAY by CHAOSGROUP

SURVICE ENGINEERING COMPANY

FluidRay RT Physically Based Renderer

EasternGraphics visualize your business

corona

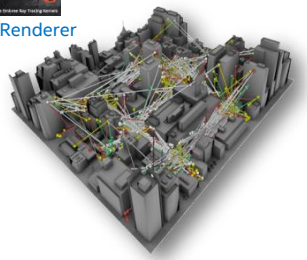
Simlab Soft Bringing Art closer

3DEXCITE

SMITH MICRO SOFTWARE

Courtesy of Jeff Patton, Rendered with Corona Renderer

Image rendered with FluidRay RT

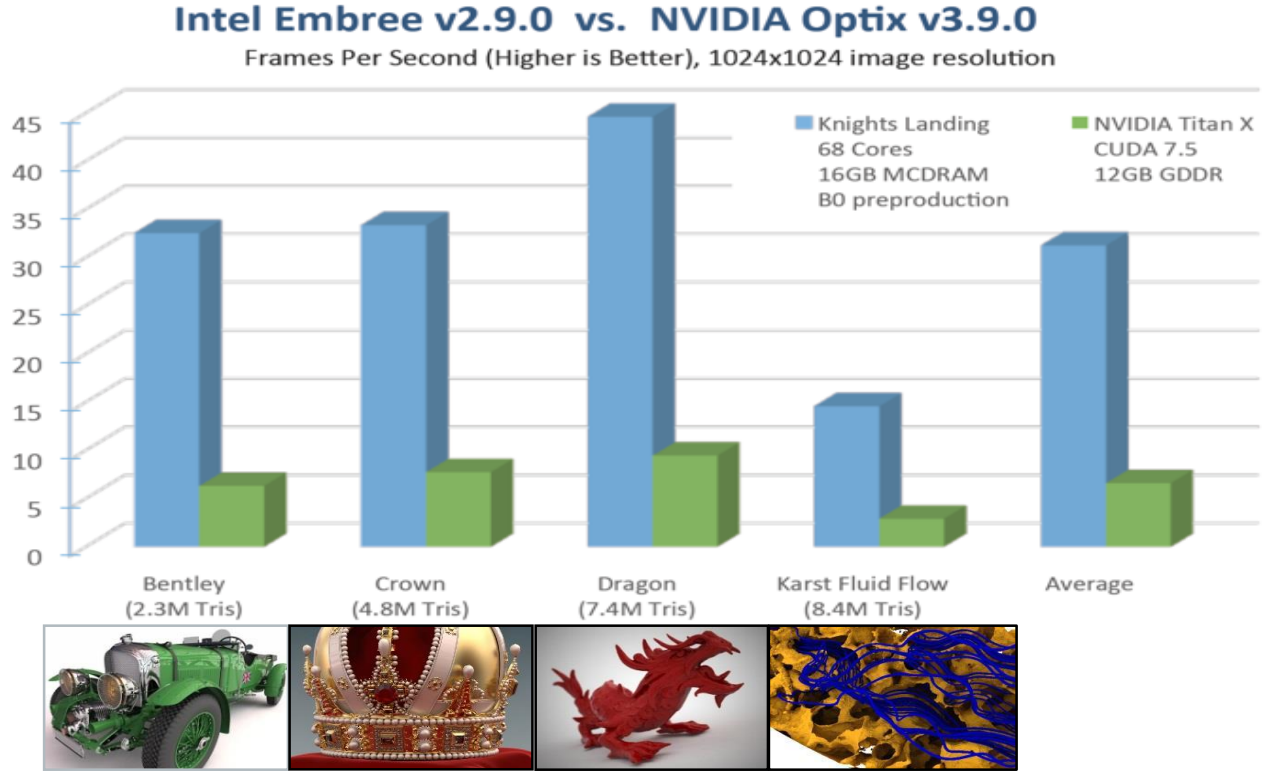


Rendered with StingRay, SURVICE Engineering

pCon.planner rendered courtesy EasternGraphics

intel

Performance Leadership



Embree 2.9.0, Intel® SPMD Program Compiler (Intel® SPC) 1.9.0
Intel C/C++ Compiler 16.0.1

NVIDIA* OptiX* 3.9.0, CUDA* 7.5
Intel Xeon E5-2699 2x18 cores, 2.3 Ghz

Source: Intel

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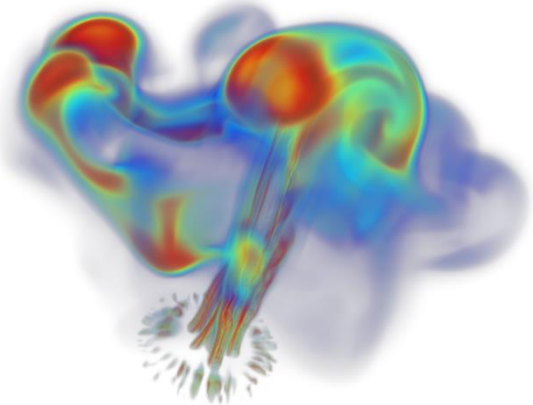
OSPRAY
RAY TRACING BASED RENDERING ENGINE

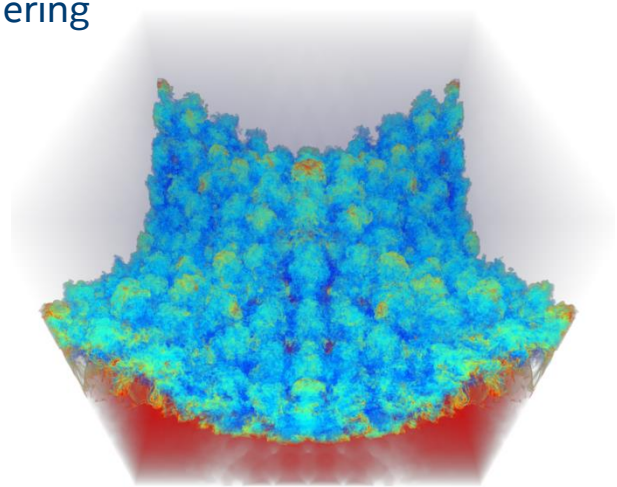
OSPRay Ray Tracing Based Rendering Engine

www.ospray.org

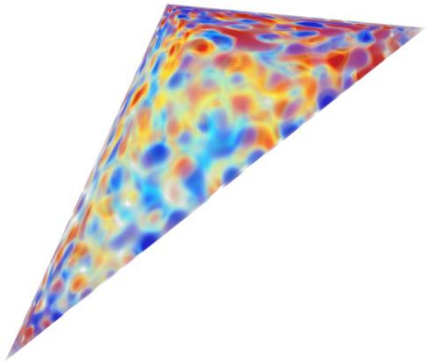
- High performance, scalable open source rendering API
- Enables expanded functionality
  - Volume rendering
  - Large Scale Distributed Rendering



Heptane volume (256^3). Data courtesy SCI Institute, University of Utah.

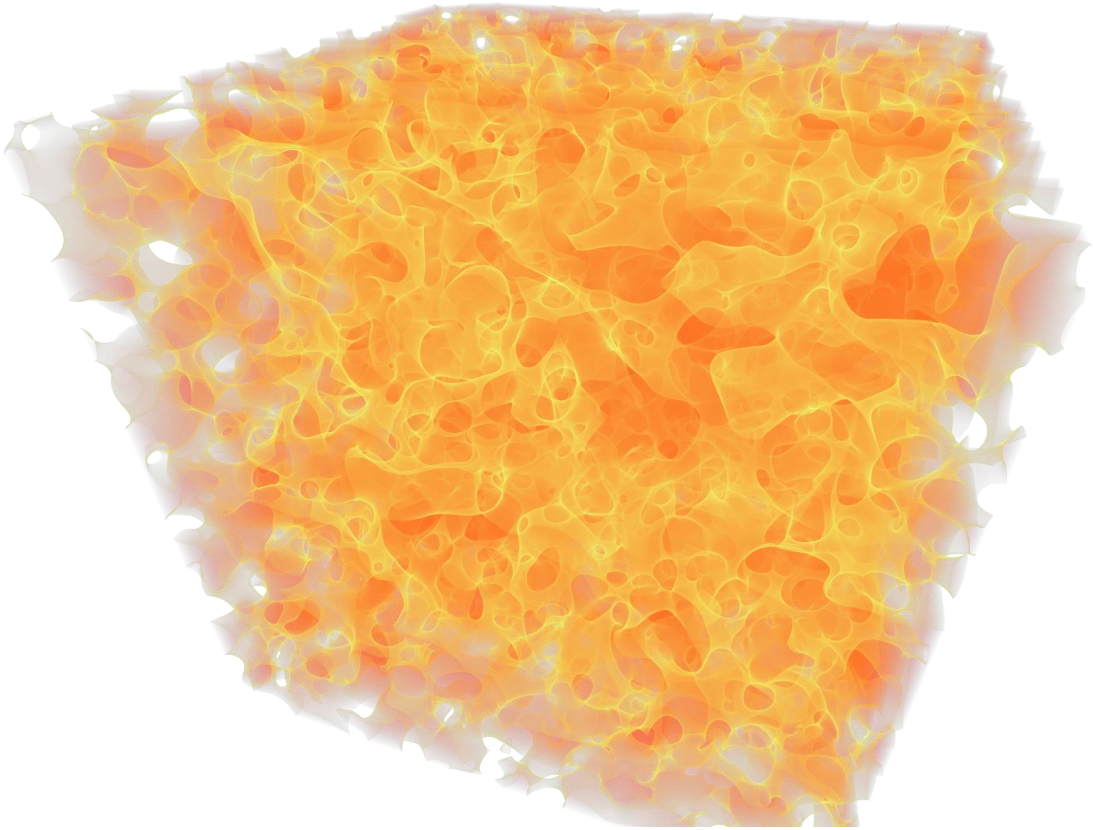


Richtmyer-Meshkov volume (2048^3 uint8, 8 GB). Data courtesy TACC.



Cosmic Microwave Sky Bispectrum volume (2001^3 float, 30 GB). Data courtesy Stephen Hawking CTC.

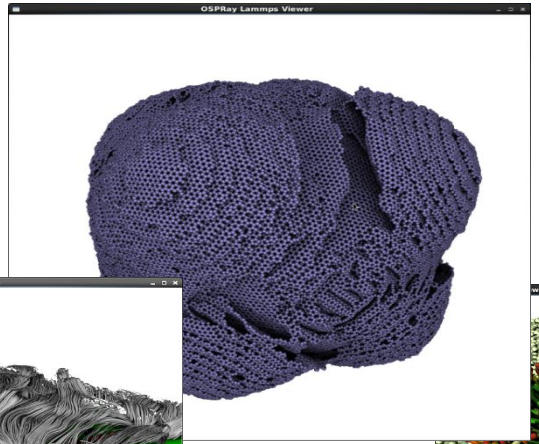
Interactive Visualization of **10TB** Walls Dataset



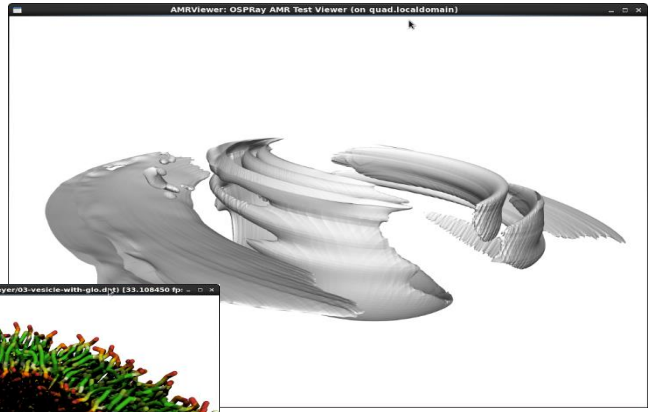
Data courtesy
Stephen Hawking CTC*

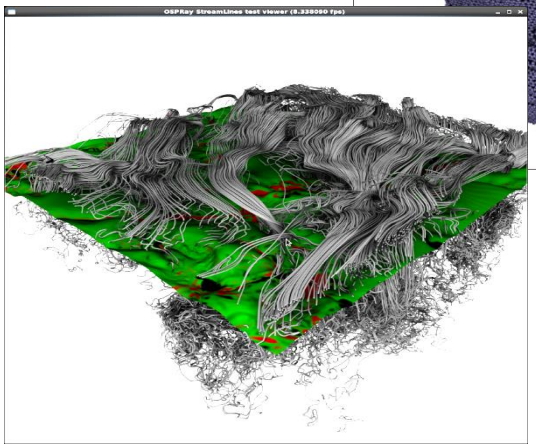
OSPRay: Non-polygonal Geometry

Materials Science: Particles (spheres)

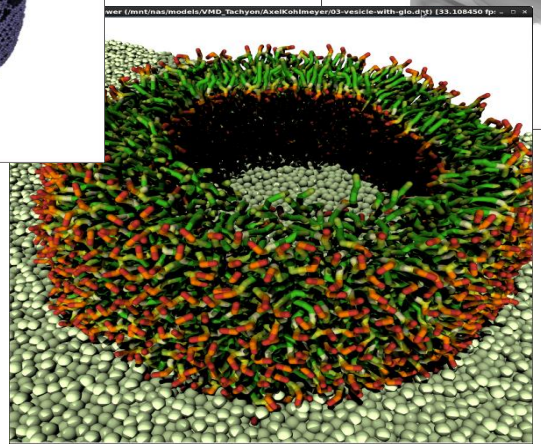


Implicit(!) Iso-Surfaces in Unstructured Volume Dataset





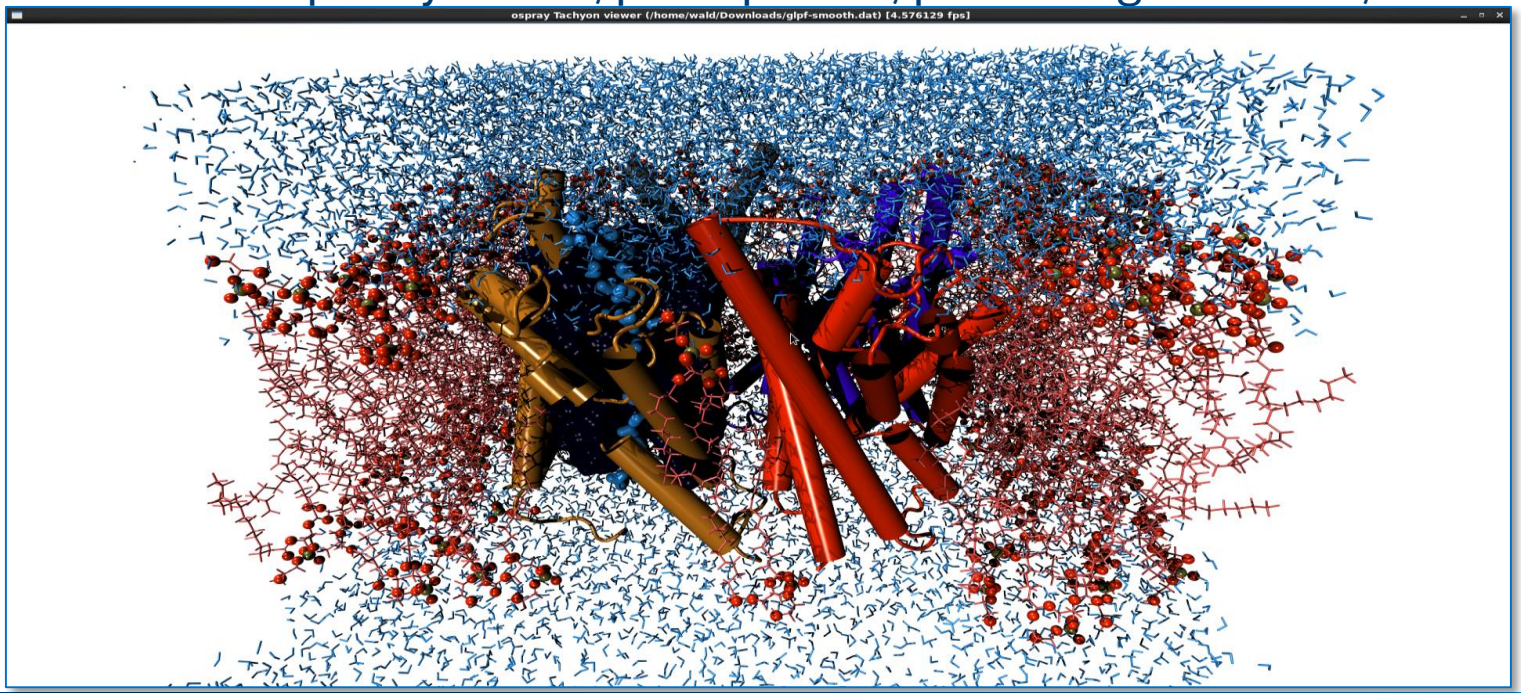
Stream Lines



Molecular Modelling: VMD “vesicle” model
Spheres + Cylinders + Triangles

OSPRay: Non-polygonal Geometry

- And of course, can easily mix-n-match it all together
  - "VMD" example: cylinders, plus spheres, plus triangle meshes, ….



OSPRay: High-Fidelity Shading

- OSPRay supports multiple renderers with different shading

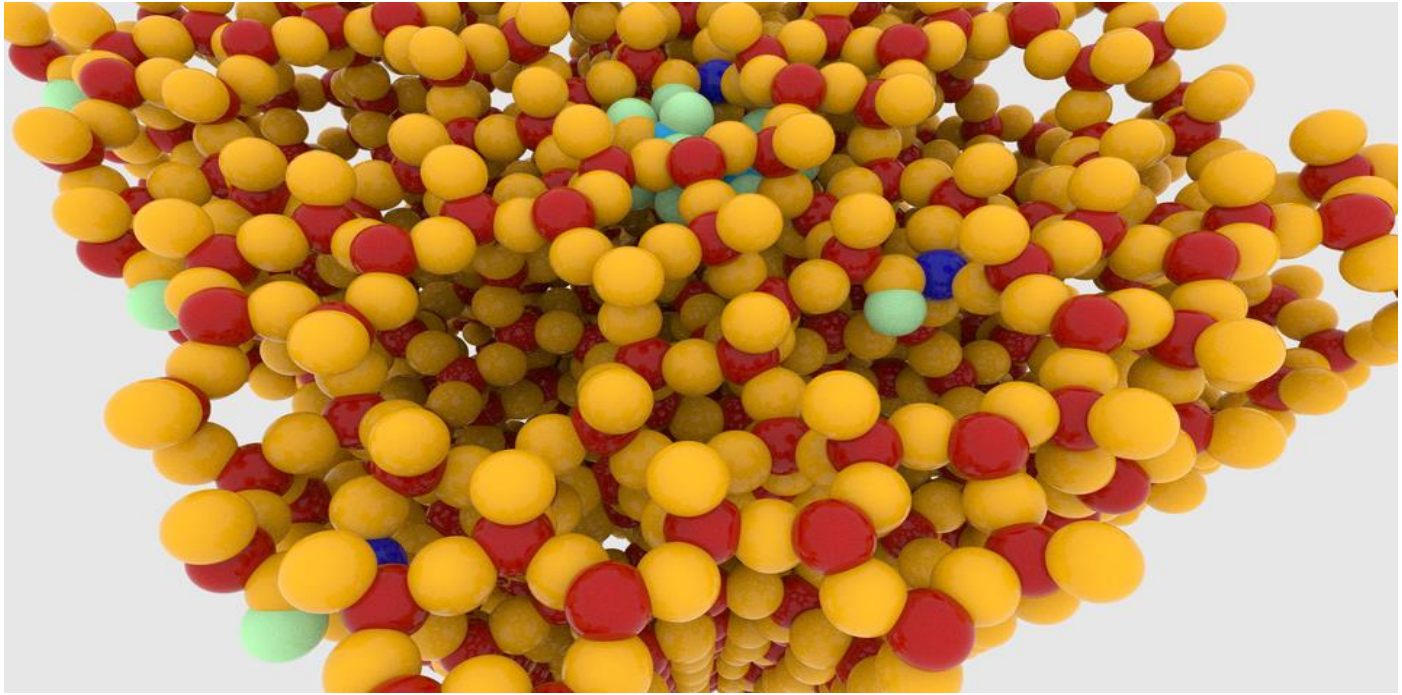
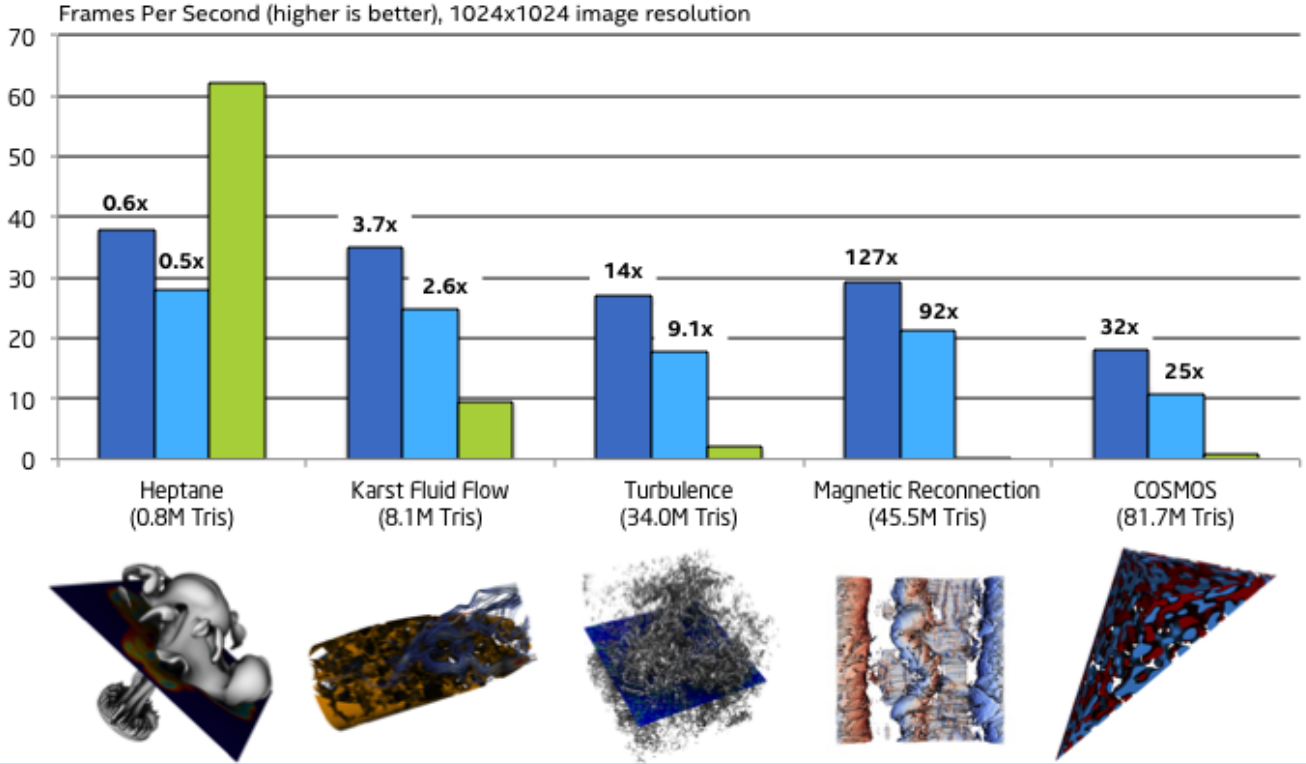


Image courtesy
Aaron Knoll,
University of Utah

Performance: OSPRay (ray traced) vs GPU (OpenGL)



Intel® Xeon® Processor OSPRay renderer

Intel® Xeon® Processor OSPRay renderer (with ambient occlusion)

NVIDIA GeForce* GTX* Titan X Coprocessor 12 GB RAM

Intel® Xeon® Processor E5-2699 v3
2 x 18 cores, 2.3 GHz

ParaView 4.3.1
pvOSPRay plugin "alpha 2"
OSPRay 0.8.2

NVIDIA* Driver 346.46, default configuration

Source: Intel

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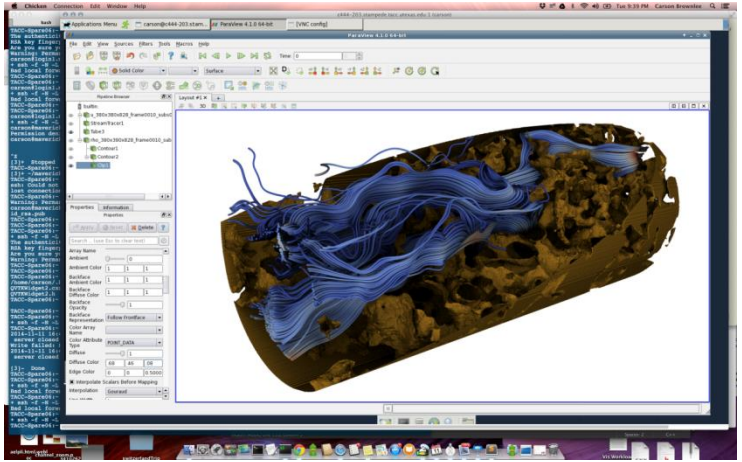
OSPRay Integration into Select Vis Applications

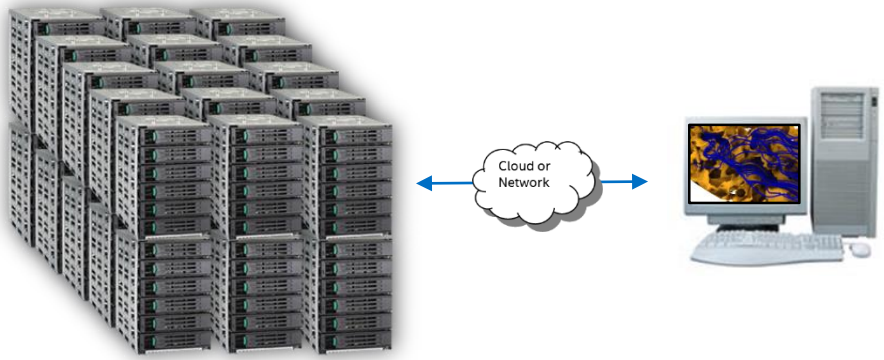
- Visualization ToolKit (VTK)
- ParaView (natively in v5.1)
- VisIt
- VMD

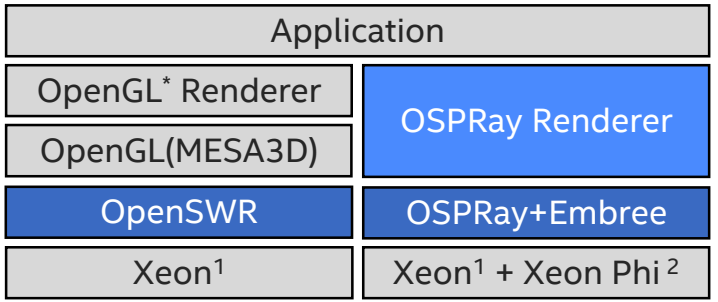


WRAP UP

Summary

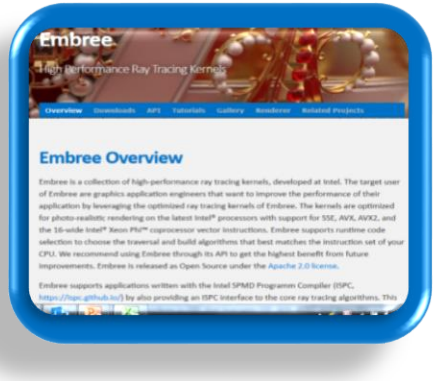
- Software Defined Visualization: utilizes general purpose CPUs – no GPUs needed
- Provides interactive performance and higher fidelity for Big Data
- Integration into prominent Vis tools, ParaView*, VisIt, EnSight*, VMD*
- Open source reduces hurdles to integrate and use





[1] Intel® Xeon® processor, [2] Intel® Xeon Phi™ coprocessor and processor.

For More Information: www.sdvis.org



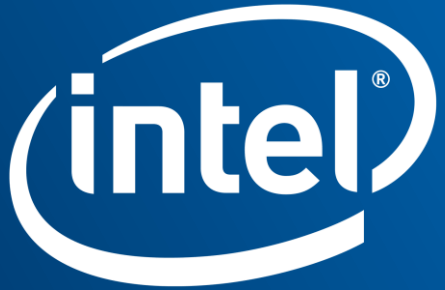
Embree - http://embree.github.io

OSPRay - http://ospray.org

OpenSWR - http://openswr.org

Join the community and provide input/feedback

- Open Source projects with Academic, industry, ISV contributors


intel

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