GPU TECHNOLOGY CONFERENCE

State of the Art Application Development on GPUs

| Seoul, Korea | December 18, 2010 |

Phillip Miller, NVIDIA

Paul Arden, mental images

PRESENTED BY NVIDIA.

GPU TECHNOLOGY CONFERENCE

NVIDIA Resources for Application Developers

DEVELOPMENT TOOLS

CUDA Toolkit
Complete GPU computing development kit

cuda-gdb
GPU hardware debugging

Visual Profiler
GPU hardware profiler for CUDA C and OpenCL

Parallel Nsight
Integrated development environment for Visual Studio

NVPerfKit
OpenGL|D3D performance tools

FX Composer
Shader Authoring IDE

SDKs AND CODE SAMPLES

GPU Computing SDK
CUDA C, OpenCL, DirectCompute code samples and documentation

Graphics SDK
DirectX & OpenGL code samples

PhysX SDK
Complete game physics solution

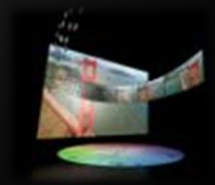
OpenAutomate
SDK for test automation

VIDEO LIBRARIES

Video Decode Acceleration
NVCUVID / NVCUVENC
DXVA
Win7 MFT

Video Encode Acceleration
NVCUVENC
Win7 MFT

Post Processing
Noise reduction / De-interlace/ Polyphase scaling / Color process



ENGINES & LIBRARIES

Math Libraries
CUFFT, CUBLAS, CUSPARSE, CURAND, …

NPP Image Libraries
Performance primitives for imaging

App Acceleration Engines
Optimized software modules for GPU acceleration

Shader Library
Shader and post processing

Optimization Guides
Best Practices for GPU computing and Graphics development

http://developer.nvidia.com

PRESENTED BY NVIDIA.

Licensed solutions from mental images

Integrated Renderers

mental ray
the world's most widely adopted professional ray tracing solution

iray
The world's first commercially available, physically correct rendering with GPU acceleration

More…
Numerous renderers to fill particular needs.

Material Workflows

metaSL
Shading language extending from mental ray to real-time shader APIs

mental mill
Visual shader editor for end users to create and edit MetaSL shaders

Application Building

RealityServer
A 3D web services development platform supporting collaboration and a wealth of rendering options

neuray
Application foundation for building 3D applications with native couplings to mental images rendering solutions

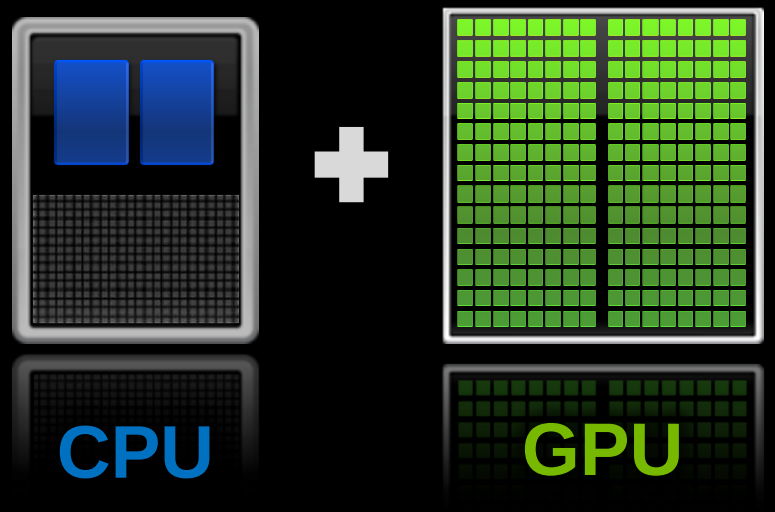
mental matter
Higher order surface definition & approximation

Distributed Processing

DiCE
Highly scalable distributed processing solution for neuray applications

“GPGPU or GPU Computing”

- Using all processors in the system for the things they are best at doing:
  - Evolution of CPUs makes them good at sequential, **serial** tasks
  - Evolution of GPUs makes them good at **parallel** processing



CUDA - NVIDIA's Architecture for GPU Computing

GPU Computing Applications

CUDA C/C++	OpenCL	Direct Compute	Fortran	Python, Java, .NET, more…
• +100k developers • In production usage since 2008 • SDK + Libs + Visual Profiler and Debugger	• Commercial OpenCL Conformant Driver • Publicly Available for all CUDA capable GPU's • SDK + Visual Profiler	• Microsoft API for GPU Computing • Supports all CUDA-Architecture GPUs (DX10 and DX11)	• PGI Accelerator • PGI CUDA Fortran	• PyCUDA • GPU.NET • jCUDA

NVIDIA GPU
with the CUDA Parallel Computing Architecture

Broad Adoption

- **+250M** CUDA-enabled GPUs in use
- **+650k** CUDA Toolkit downloads in last 2 Yrs
- **+350** Universities teaching GPU Computing on the CUDA Architecture
- **Cross Platform:** Linux, Windows, MacOS
- Uses span **HPC to Consumer**

Accelerating Existing Applications

Identify Possibilities	Profile for Bottlenecks, Inspect for Parallelism
Port Relevant Portion	A Debugger is a good starting point, Consider Libraries & Engines vs. Custom Code
Validate Gains	Benchmark vs. CPU version
Optimize	Parallel Nsight, Visual Profiler, GDB, Tau CUDA, etc.
Deploy	Maintain original as CPU fallback if desired.

Production Example

GPU Computing Software Stack

Your GPU Computing Application

Application Acceleration Engines
Middleware, Modules & Plug-ins

Foundation Libraries
Low-level Functional Libraries

Development Environment
Languages, Device APIs, Compilers, Debuggers, Profilers, etc.

CUDA Architecture

NVIDIA Application Acceleration Engines (AXE)

A family of highly optimized software modules, enabling software developers to supercharge applications with high performance capabilities that exploit NVIDIA GPUs.

- **Free to acquire, license and deploy**
- **Valuable features and superior performance are quick to add**
- **App's can evolve quickly, as API's abstract GPU advancements**

Application Acceleration Engines

PhysX *physics & dynamics engine*

– breathing life into real-time 3D; **Apex** enabling 3D animators

Cg/CgFX *programmable shading engine*

– enhancing realism across platforms and hardware

SceniX* *scene management engine*

– the basis of a real-time 3D system

CompleX scene scaling engine

– giving a broader/faster view on massive data

OptiX ray tracing engine

– making ray tracing ultra fast to execute and develop

*include bridges to external solutions –iray, MetaSL, OSG, OIV, etc.

Accelerating Application Development

App Example: Auto Styling

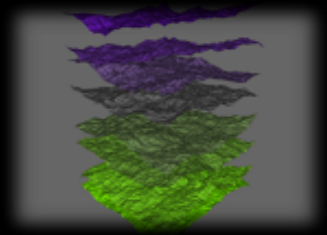
1. Establish the Scene
   = **SceniX**

2. Maximize interactive quality
   + **CgFX** + **OptiX**

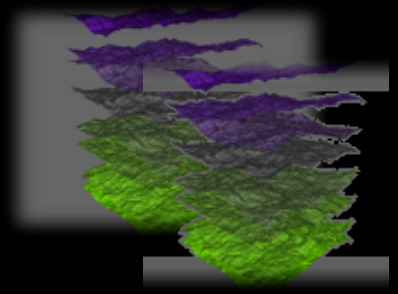
3. Maximize production quality
   + **iray** (licensed)

App Example: Seismic Interpretation

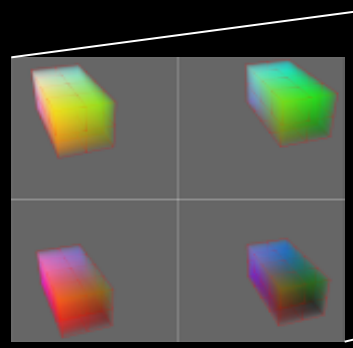
1. Establish the Scene
   = **SceniX**

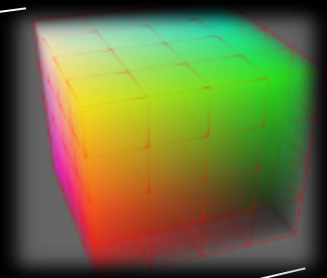


2. Maximize data visualization
   + **quad buffered stereo**
   + **volume rendering**
   + **ambient occlusion**



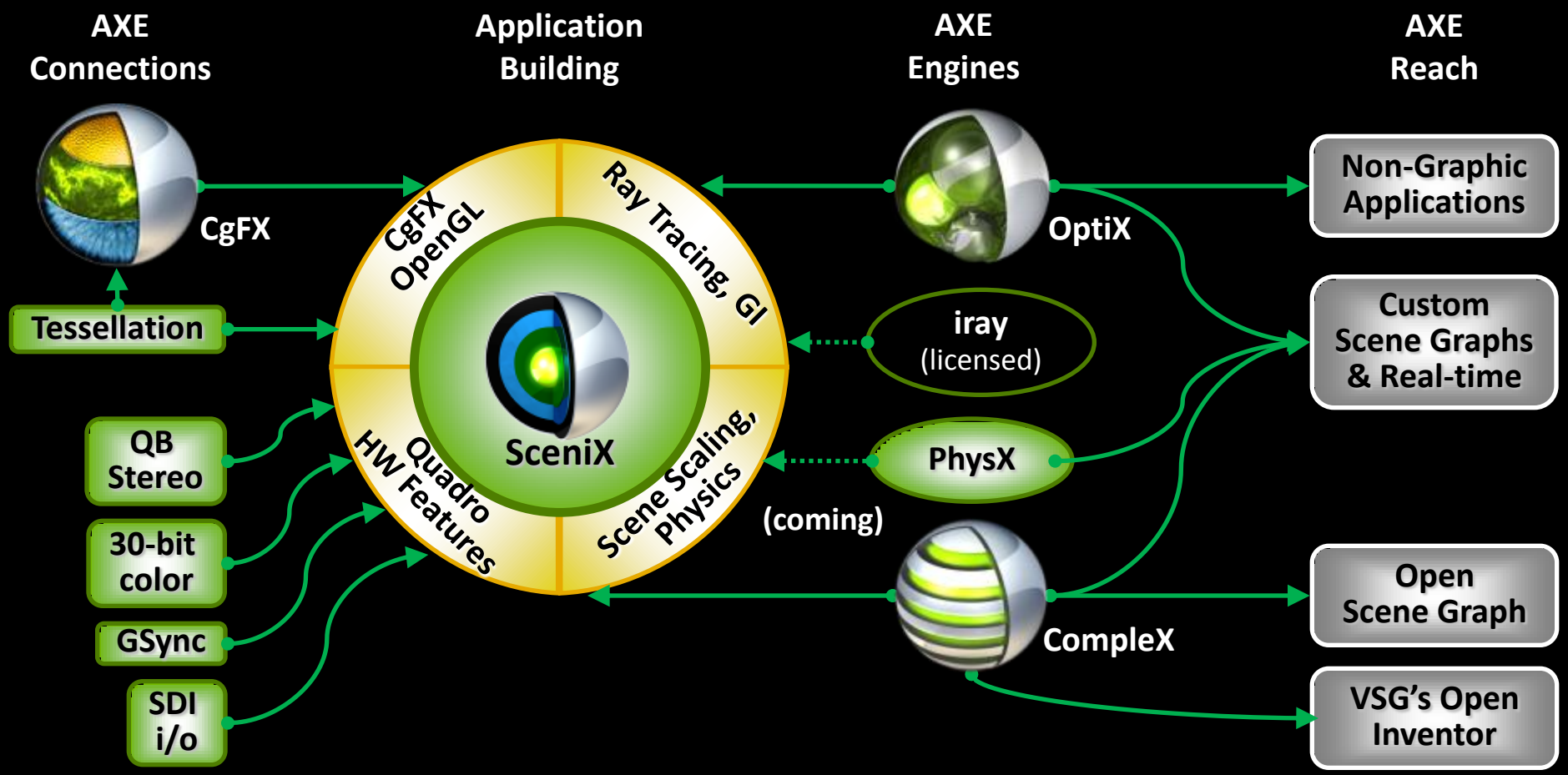
3. Maximize scene size
   + **CompleX**





GPU TECHNOLOGY CONFERENCE

Acceleration Engine Relationships 2010



SceniX™ Scene Management Engine

The fastest start for building a real-time 3D app – wherever there's a need to analyze 3D data, make decisions, and convey results in real-time

- Highly efficient scene graph for rapidly building real-time 3D app's for any OpenGL GPU on Windows/Linux
- Integration interface for using GUI frameworks (Qt, wxWidgets, etc.)
- Fast on-ramp to GPU capabilities & NVIDIA engines
  - Quad Buffered Stereo, SDI i/o, 30-bit color, etc.
  - CgFX, CompleX, OptiX, Tessellation
- Source Code license available (upon approval)
- Differentiator - Multiple Render Targets

Showcase images courtesy Autodesk

SceniX - Example Companies/Products

+5k downloads/version

v6 in July

RTT
challenging reality

DeltaGen

Autodesk®

Showcase

LIGHTWORKS
Rendering Realism

AUTHOR LW

ASPECTS LW

ARTISAN LW

SceniX and CgFX example

- Quadro 6000 Demo Viewer

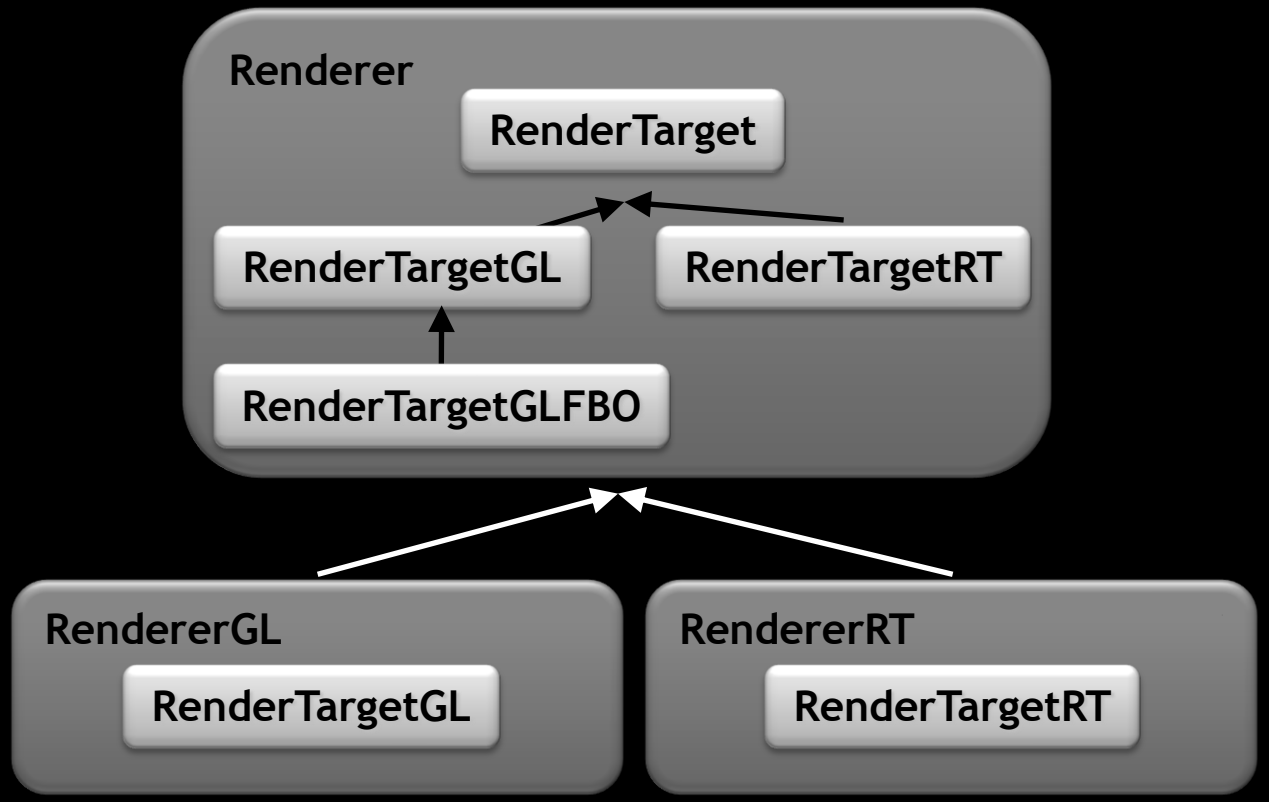
SceniX - Renderer Independency

- Separates rendering from destination
  (tiles, cameras, viewports, renderers, image gen, etc.)
- Multiple render engines
  within a single render window
- Together enabling:
  - Stack Rendering (multiple techniques and renderers)
  - Hybrid Rending (raster + ray tracing)
  - Post Processing
  - Platform Impendence

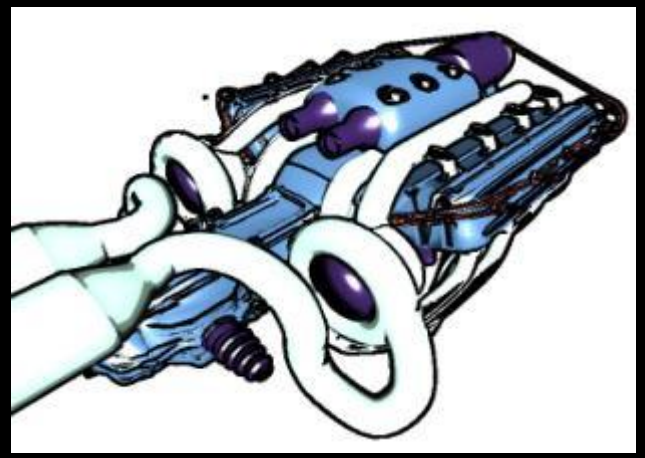
DeltaGen image courtesy RTT

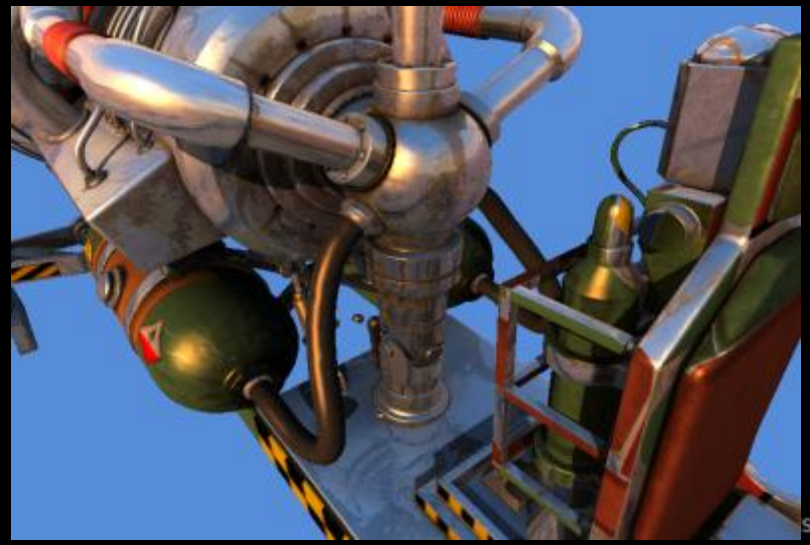
Stack Rendering Example

- Combining two different renderers to create realistic reflections on top of an OpenGL rendered object

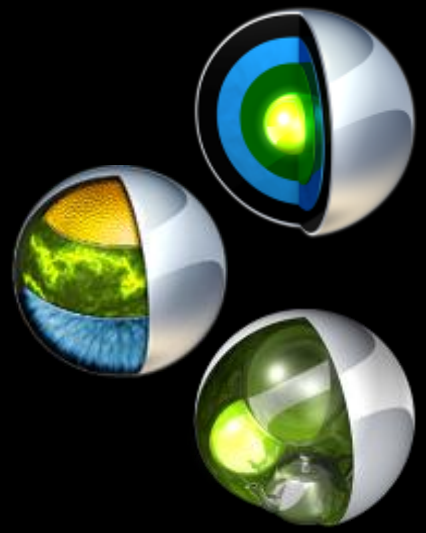


Hybrid Rendering - *more results*





Multiple Rendering Example



- New Demo Viewer coming in 2011 with Multiple Rendering Capabilities
- Coordinates shader usage between OpenGL, CgFX, OptiX and iray
- Cross platform, using Qt
- Source will be available to registered developers

GPU TECHNOLOGY CONFERENCE

CompleX™ Scene Scaling Engine

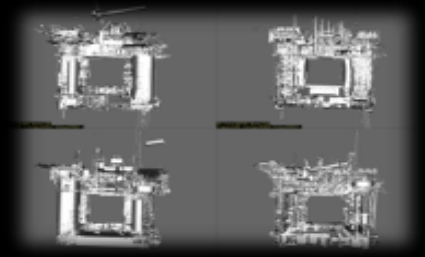
Keeps complex scenes interactive as they exceed single GPU memory, by managing the combined memory and performance of multiple GPUs

Delivers smooth performance on very large scenes:

- 32GB in size on Quadro FX 5800
- 48GB in size on Quadro 6000

SDK for any OGL application

- Ready to use in SceniX, OpenSceneGraph, and Open Inventor 8.1

SceniX and CgFX example

- Quadro 6000 Demo Viewer

CompleX™ Example Companies

National Institute of Health

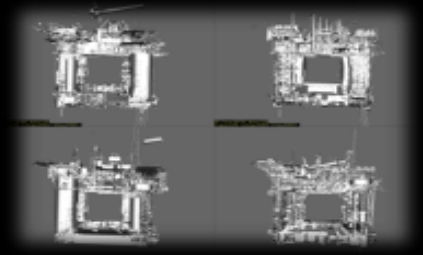
VSG Open Inventor

StormFjord & Statoil

CompleX™ - Distribute & Composite

Made of two components, that can be used independently:

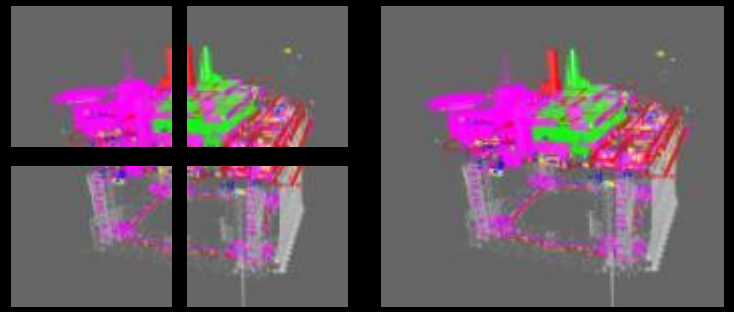
- Data Distribution
  - slicing scenes across GPUs to keep them within frame buffer memory
- Image Compositing
  - the fastest available image combination from multiple GPU outputs
- Multiple approaches for each component to accommodate different data and transparency needs

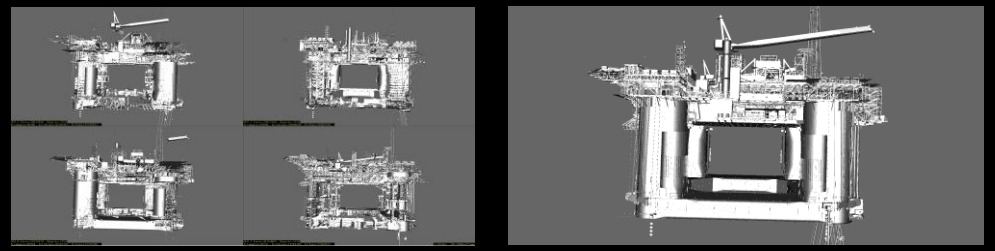
CompleX™ - Methods

>500 million pixels/second

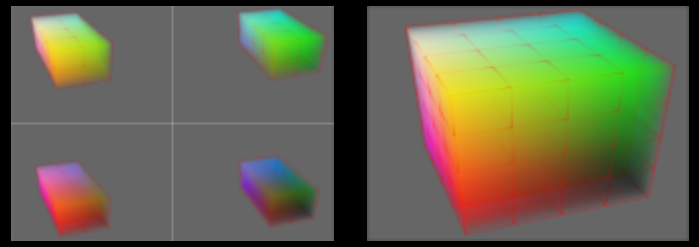
Screen Compositing



Depth Compositing



Alpha Compositing



CompleX™ - Composite

The industry's fastest multi-GPU compositor (no SLI req'd)

- Uses unique NVIDIA hw/driver features `copy_tex_image` across multiple GPUs
- Highly optimized for GPU to GPU: multiple transfer paths optimized for a wide variety of multi-GPU and chipset configurations.
- Results in the best performance for given HW
- Resulting event loop typically needs +2 lines of code

GPU TECHNOLOGY CONFERENCE

NVIDIA OptiX™ Ray Tracing Engine

A programmable ray tracing pipeline for accelerating interactive ray tracing applications – from functions, to tasks, to complete renderers.
In use within a wide variety of markets – not just rendering

- For Windows, Linux, and OSX on all CUDA capable GPUs
- C-based shaders/functions (minimal CUDA exp. needed)
- Ease of Development - you concentrate on writing ray tracing techniques, and OptiX makes them fast


ambient occlusion


implicit surfaces

Applications benefit immediately from GPU advances:

- Highly scalable on cores and GPUs - SLI not required
- GPU advances – GF100 is 2-4X of GT200 which is 2X of G80
- OptiX advances – 2.1 (this week) +30 to 80% faster than 2.0


global illumination

OptiX™ - SDK Examples

- Whitted
- Cook
- Photon Mapping
- Glass
- Fish Tank
- Collision Detection
- Modified SDK Example – MandleBulb
- Fast AO

OptiX™ -Example Customers

+3k downloads / version

LIGHTWORKS
Rendering Realism

AUTHOR LW
ASPECTS LW
ARTISAN LW

WORKS ZEBRA

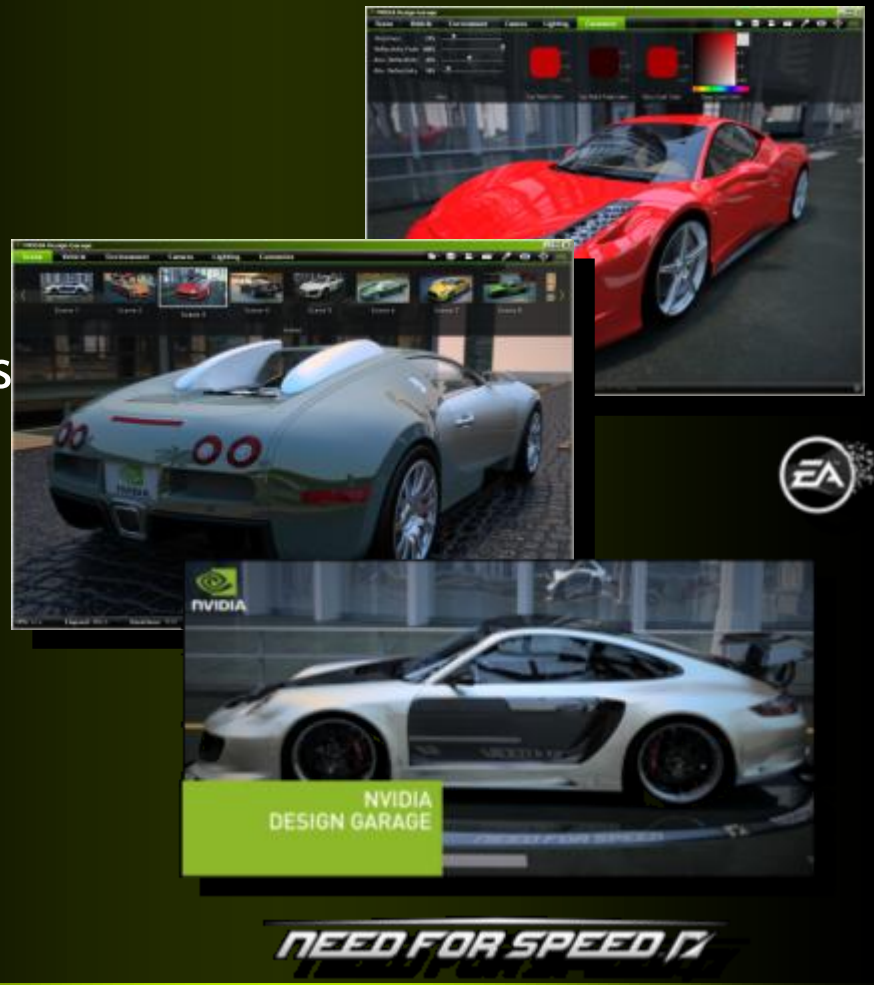
NEED FOR SPEED

Privately at major companies doing:

- Radiation & Magnetic Reflection
- Acoustics and Ballistics
- Multi-Spectral Simulation
- Motion Picture production
- Massive On-Line Player Games

NVIDIA Design Garage Demo

- Photorealistic car configurator in the hands of millions of consumers
- Uses pure GPU ray tracing
  - 3-4X faster on GF100 than on GT200
  - Linear scaling over GPUs & CUDA Cores
  - Est. 40-50X faster vs. a CPU core
- Built on SceniX with OptiX shaders
  - similar to other apps in development
- Rendering development speed
  - 6 weeks



Application Engine Availability

nvidia.com

Developer Zone

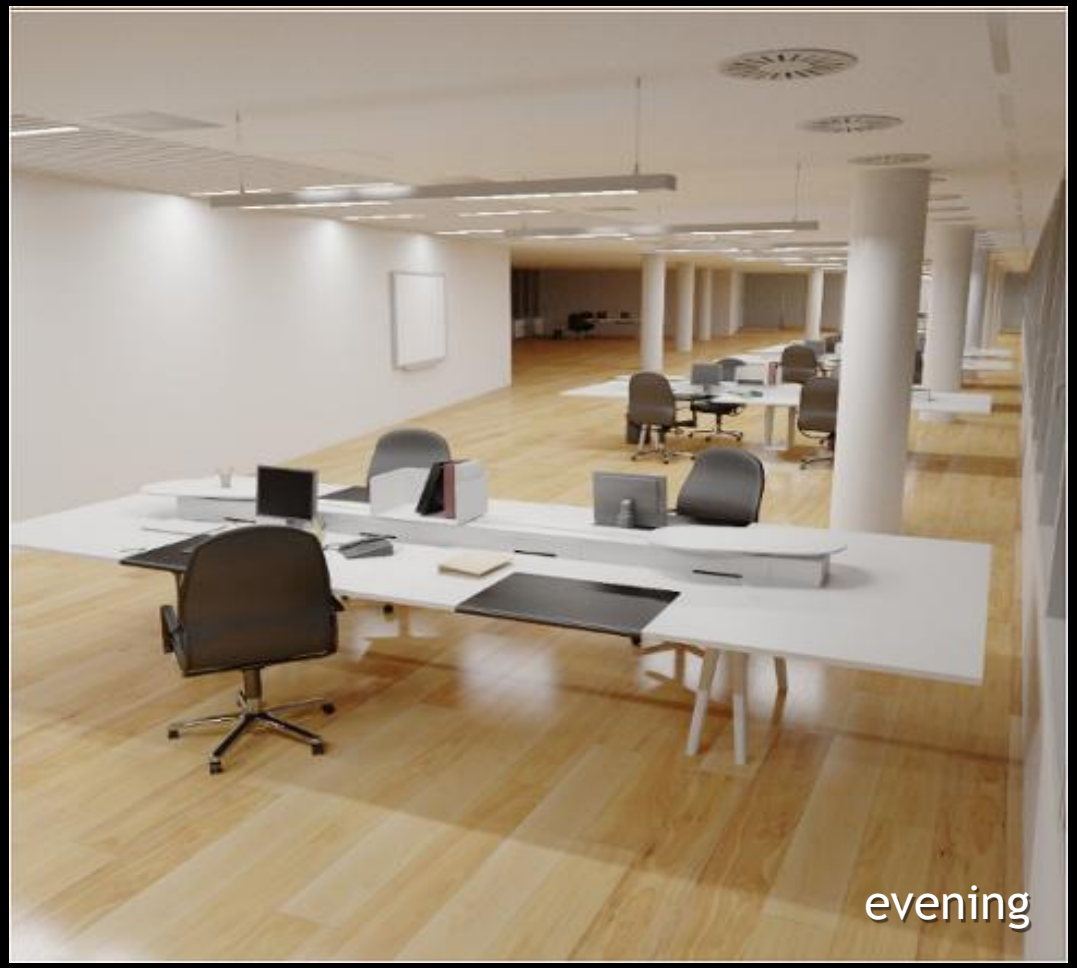
GPU TECHNOLOGY CONFERENCE

iray® *from mental images*

World's first commercial, physically correct, interactive global illumination renderer - greatly speeding the creative workflow for designers with intuitive results that match the real world.

- Scalable across processors and nodes for maximum interactivity. Many times faster on GPUs than CPU.

- Availability:
  - w/ mental ray® 3.8 & RealityServer
  - stand-alone Integrator Edition
  - Coming to SceniX in 2011
  - Integrated in Bunkspeed Shot, Autodesk 3ds Max 2011, DS Catia v6



mental images®

Worldwide Leader in Photorealistic Rendering

AutoCAD
SolidWorks
CATIA
PTC
SOFTIMAGE|XSI
MAYA
3ds Max
Bunkspeed Shot

DreamWorks Animation SKG
Ford
HONDA The Power of Dreams
Industrial Light & Magic A Lucasfilm Company
Mercedes-Benz
GM
Lucasfilm Ltd
BMW
AIRBUS
BOEING
EA
STANFORD UNIVERSITY

iray®

mental images®

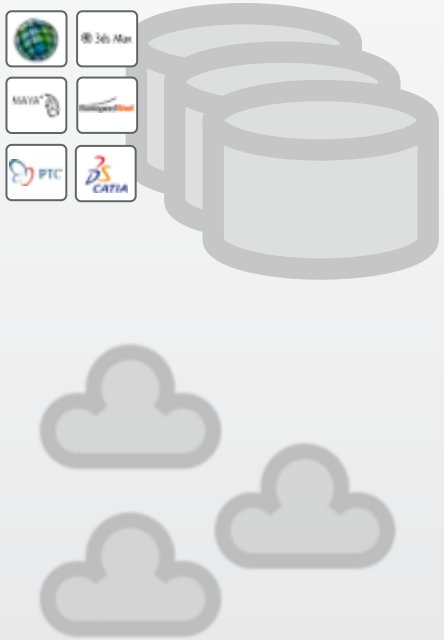
iray is the new CUDA-accelerated rendering mode inside mental ray 3.8, RealityServer 3.0 and other products.

- See full global illumination effects in seconds
- Quickly preview final frame quality in selected image areas
- Work without learning render-specific parameters
- Render final frames with complex global illumination effects much faster than CPU renderers
- Less overhead from tuning scenes and shaders

RealityServer®

mental images®

Data



ODBC

.DAE
.OBJ
.DWF
.MI

Web services

Databases, Cloud Data, Files

Visual Computing

mental images®

NVIDIA

RealityServer

GPU Cloud Servers

REST
JSON-RPC
SOAP

HTTP
RTMP

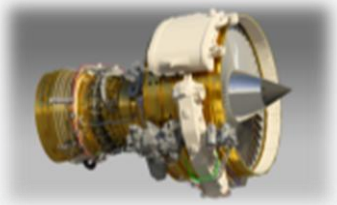
JPEG
H.264

Results

Any Device with Network Access

The server based architecture of RealityServer give the following key advantages over traditional client-side technologies:

- Independence from Data Complexity
- Thin Clients
- Collaboration
- Data security
- Scalability
- Development Choice
- State of the art Rendering



GPU Cloud Computing

mental images®

A significant trend is arising towards Cloud Computing for large scale deployments. RealityServer is ideal for Cloud Computing:

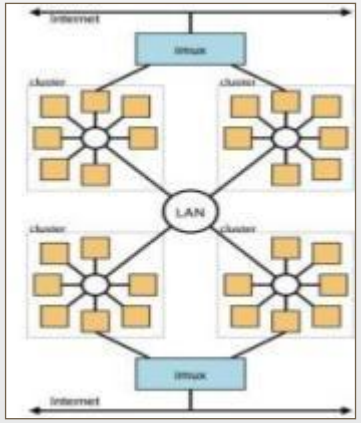
- Successfully deployed on:
  - **Amazon EC2**
  - **PEER 1**
  - **Penguin Computing**
- Web Services significantly ease communication with other Cloud resources or off-Cloud resources
- Straightforward way to scale with RealityServer resource requirements

DiCE™ Distributed Computing Environment

mental images®

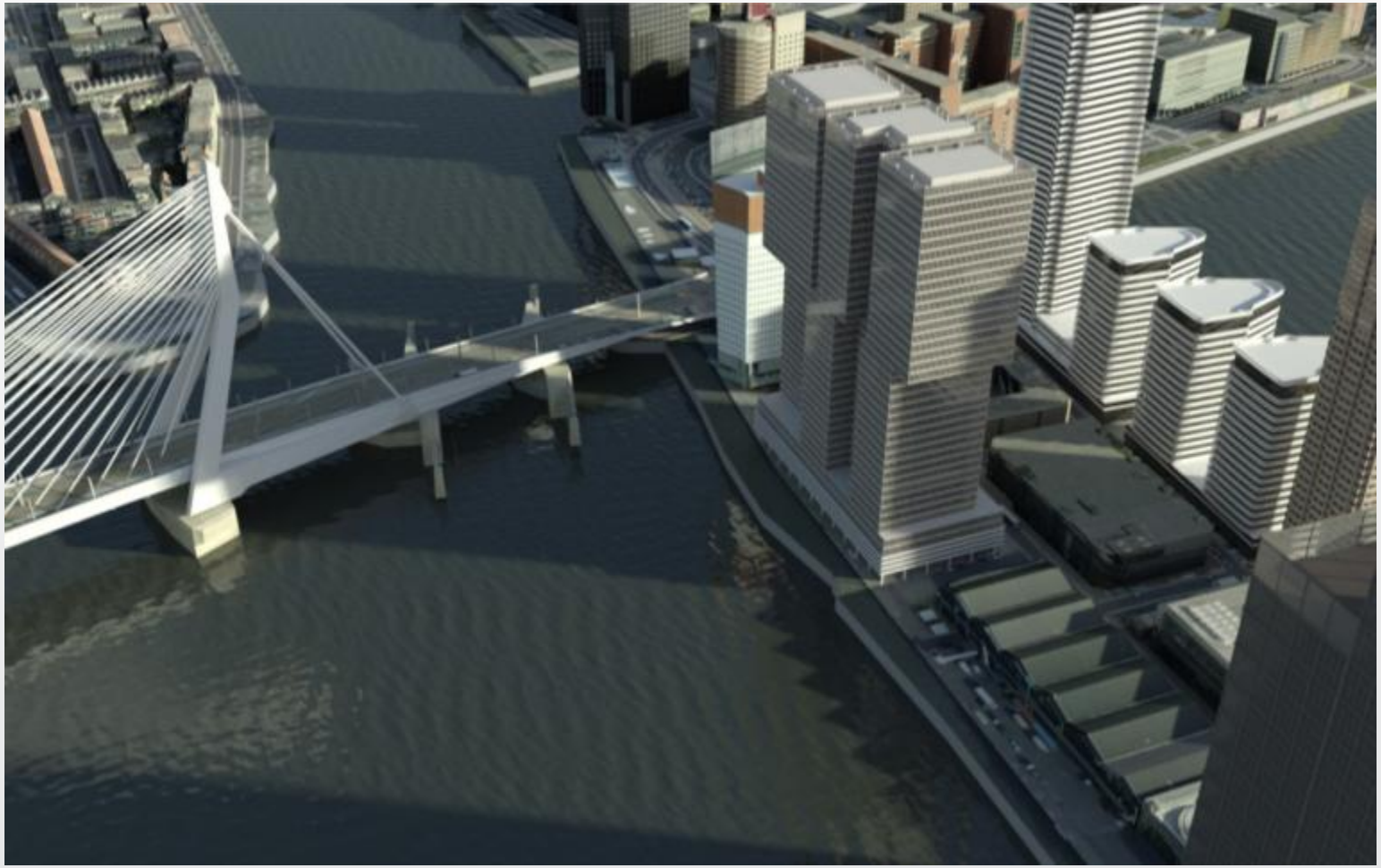
RealityServer is built on our proprietary DiCE technology.
It is ideally suited to Cloud based deployments:

- Master-less self-organizing cluster architecture
- Fault-tolerant in-memory distributed database
- Automated load balancing across resources (CPUs, GPUs)
- Dynamically add and remove computing resources
- Large scale clustering over GbE and 10GbE networks
- Multi-user by design
- Targeting very low latencies and large numbers of jobs
- Cloud specific clustering modes for Unicast only networks



Demo

mental images®



mental images®

NVIDIA

Thank you!

- Questions?