Equalizer

Parallel OpenGL Application Framework

Latest version at http://www.equalizergraphics.com/documents/Equalizer.pdf

Outline

- Overview
  - High-Performance Visualization
  - Equalizer
  - Competitive Environment
- Equalizer
  - Features
  - Scalability
  - Outlook

HPV

- High-Performance Visualization - like HPC but for interactive 3D applications
- Address the demand to visualize huge data sets using COTS clusters
- Issue is to *scale* rendering performance using multiple GPU's and CPU's

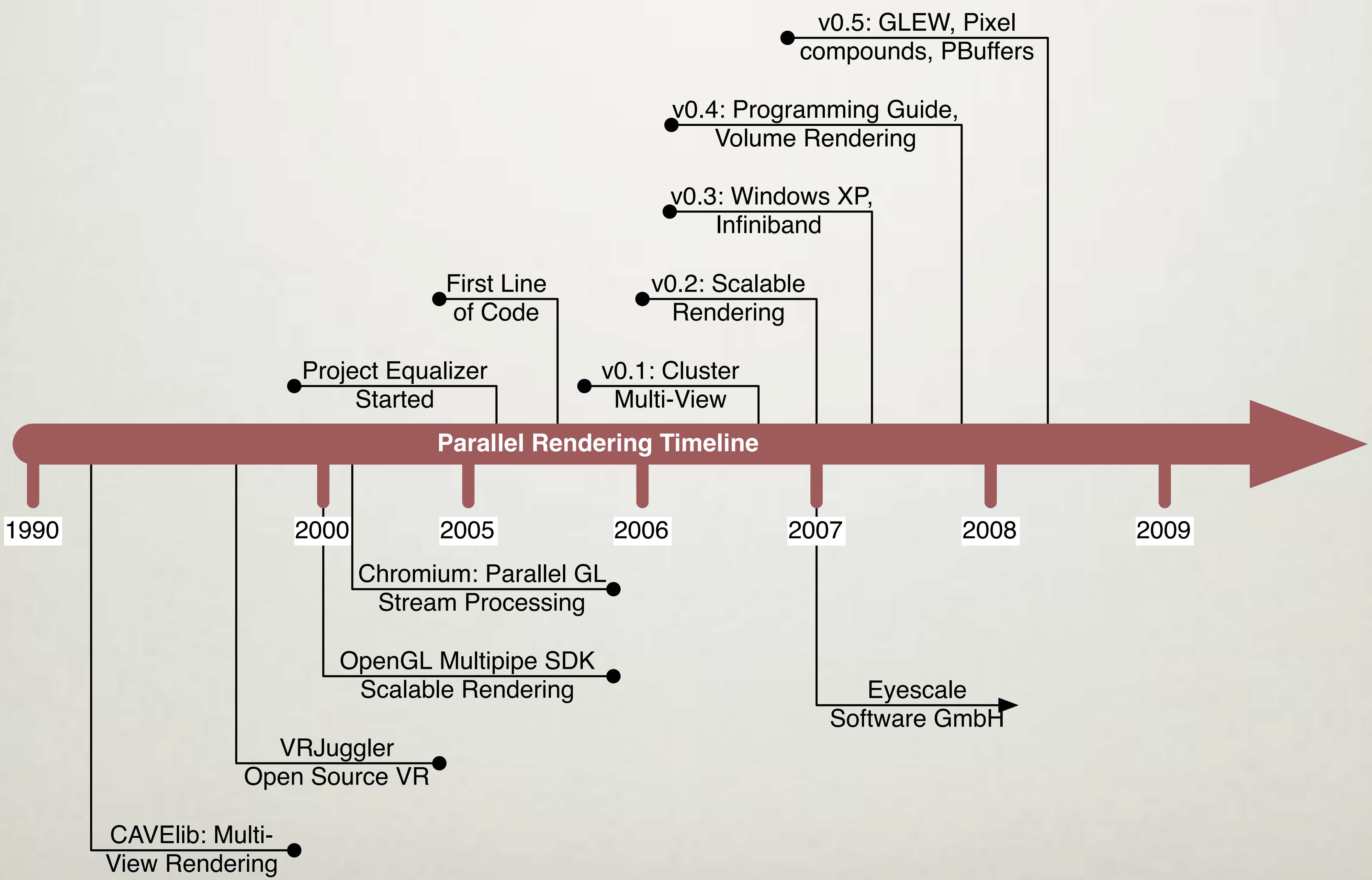
HPC Analogy

	HPC	HPV
What?	Parallel computation across multiple CPU's	Parallel 3D rendering across multiple GPU's and CPU's
How?	Mostly non-interactive batch processing	Highly interactive, real-time rendering
Hardware	Cluster or Supercomputers typically using fast interconnects	Graphics Cluster, Supercomputers, display hardware, input devices

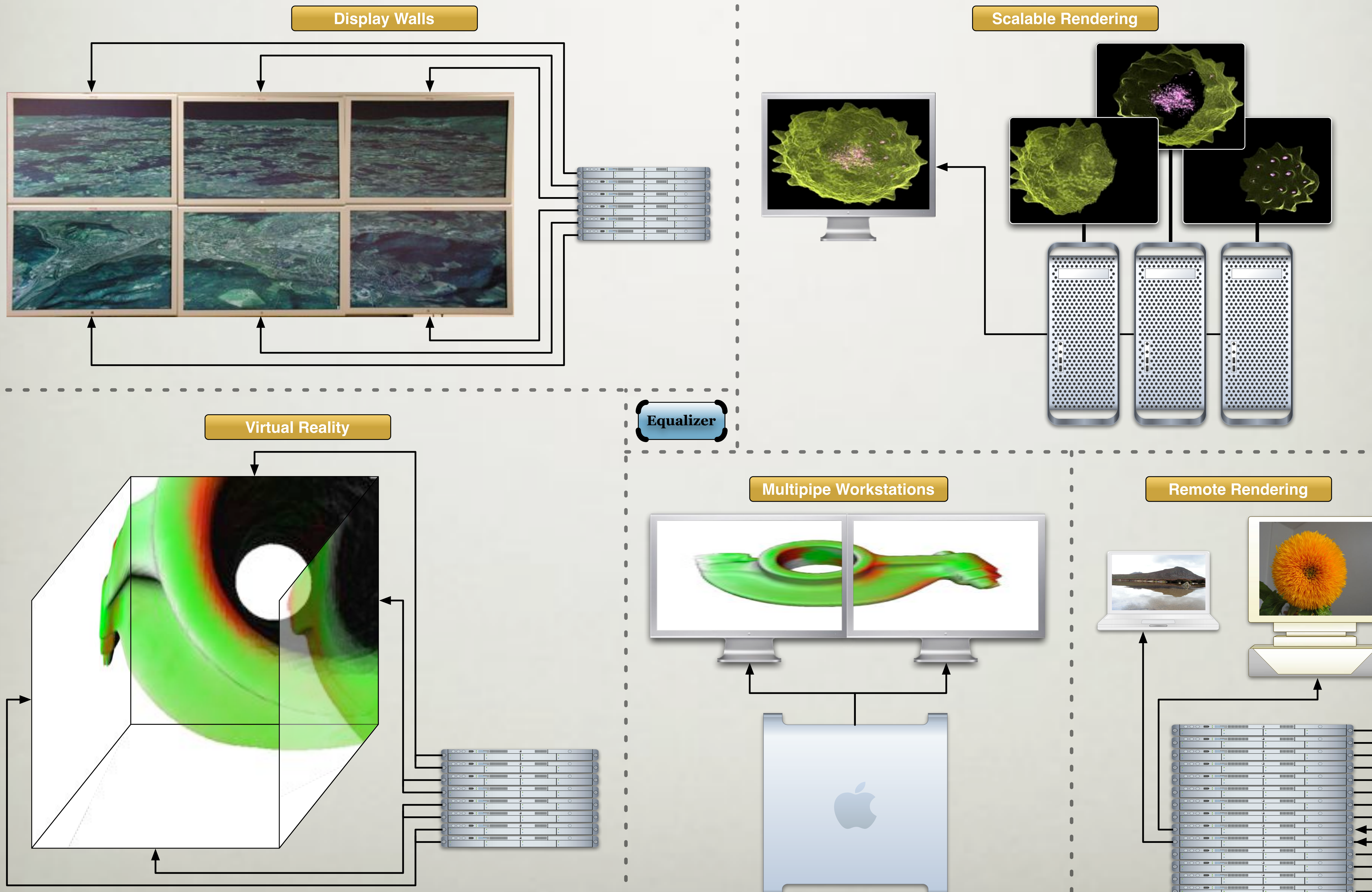
Equalizer

"GLUT for multi-GPU systems and visualization clusters"

History


v0.5: GLEW, Pixel compounds, PBuffers
v0.4: Programming Guide, Volume Rendering
v0.3: Windows XP, Infiniband
First Line of Code
v0.2: Scalable Rendering
Project Equalizer Started
v0.1: Cluster Multi-View
Parallel Rendering Timeline
1990
2000
2005
2006
2007
2008
2009
Chromium: Parallel GL Stream Processing
OpenGL Multipipe SDK Scalable Rendering
Eyescale Software GmbH
VRJuggler Open Source VR
CAVElib: Multi-View Rendering

Selected Use Cases



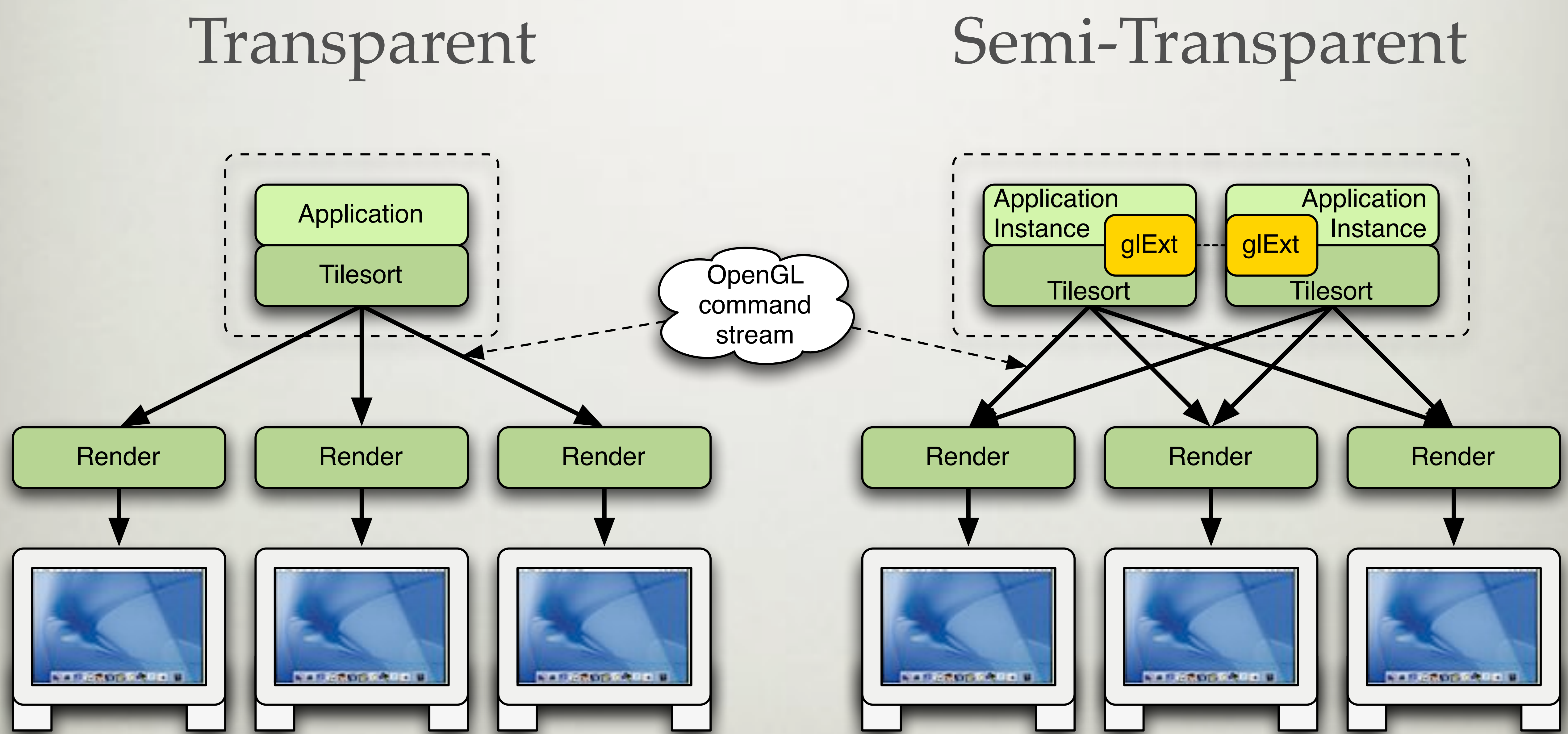
Competitive Environment

- Transparent solutions
  - Based on OpenGL interception
- Programming interfaces
  - Distributed Scene Graphs
  - Middleware

HPV Transparent Solutions

- Chromium, ModViz VGP, OMP, ...
  - Operate on OpenGL command stream (HPC analogy: auto-parallelizing compilers)
  - Provide programming extensions to improve performance and scalability (semi-transparent)
  - Performance and compatibility issues

HPV Transparent Solutions



HPV Programming Interfaces

- ScaleViz, Vega Prime, OpenSG
  - Impose invasive programming model and data structure (HPC analogy: CFD codes)
  - Best for developing from scratch
- **Equalizer**, Cavelib, VRJuggler, MPK
  - Limited to HPV-critical areas of the code (HPC analogy: MPI, PVM)
  - Best for porting existing applications

Compositing Libraries

- Paracomp, NVIDIA Multi-GPU SDK
  - Address the backend part of an HPV application
  - Equalizer makes use of these libraries

GPGPU Frameworks

- CUDA, RMDP, CTM
  - HPC tools to use GPUs for data processing
  - Do not address parallel rendering
  - Can be integrated with OpenGL and Equalizer

Equalizer

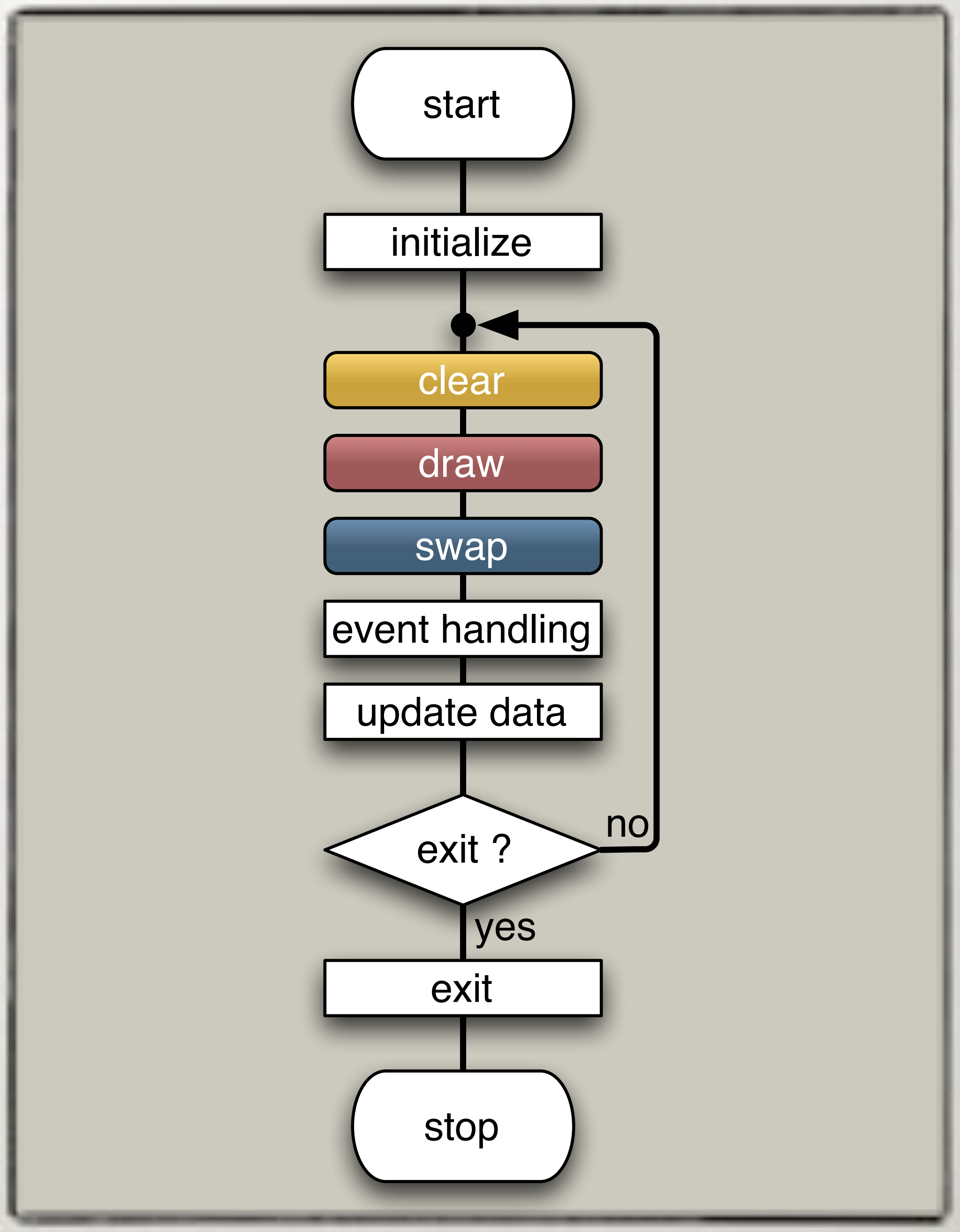
- Minimally invasive
- Runtime configuration
- Runtime scalability
- Asynchronous execution
- Clusters and SSI
- Open Source

Minimally Invasive

- “Make everything as simple as possible, but not simpler." -- Albert Einstein
- Porting is as easy as possible
- Work is limited to visualization-relevant parts
- Read Programming Guide or Parallel Graphics Programming presentation

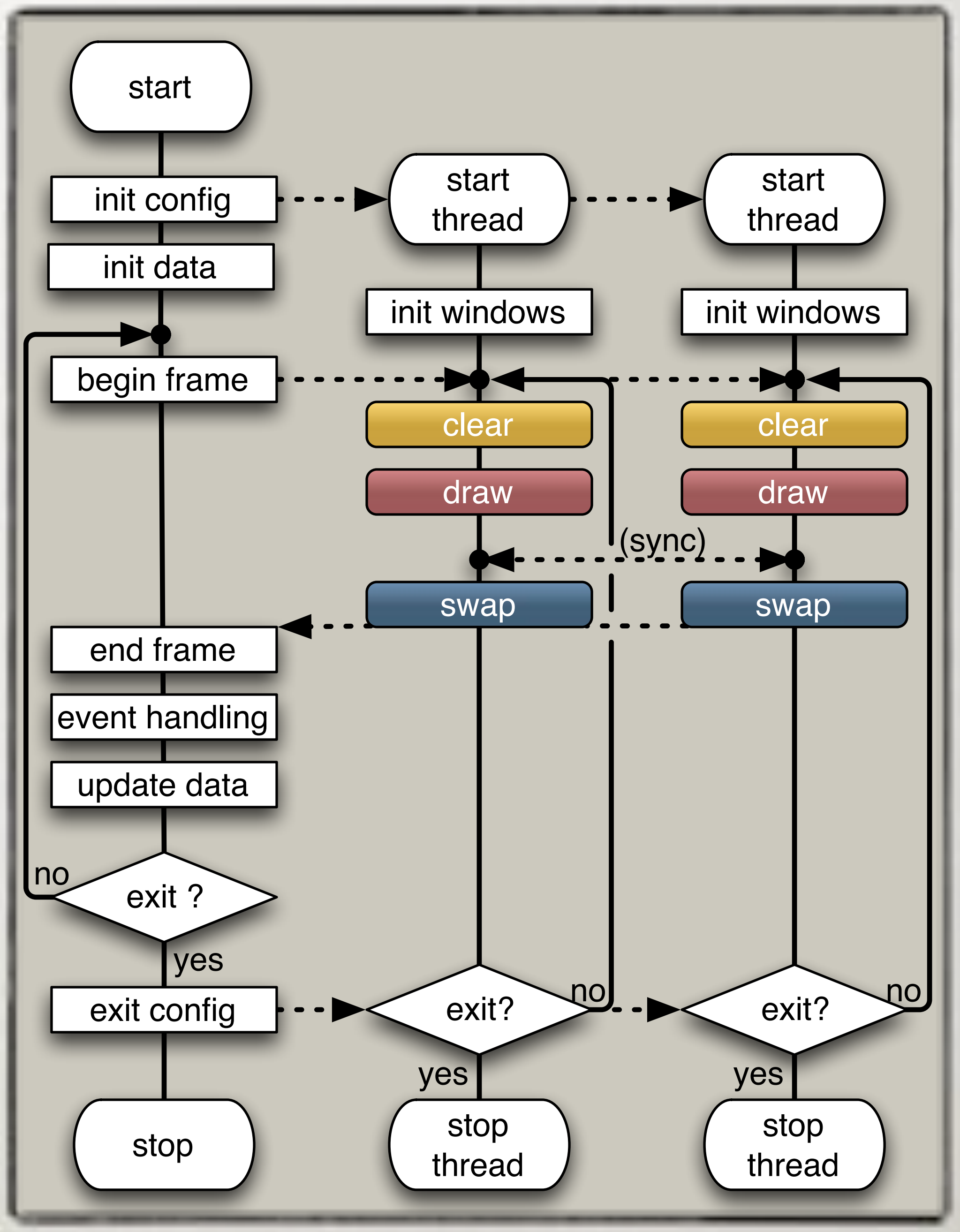
Equalizer Application

- Typical OpenGL application structure
- Separate rendering and application code



Equalizer Application

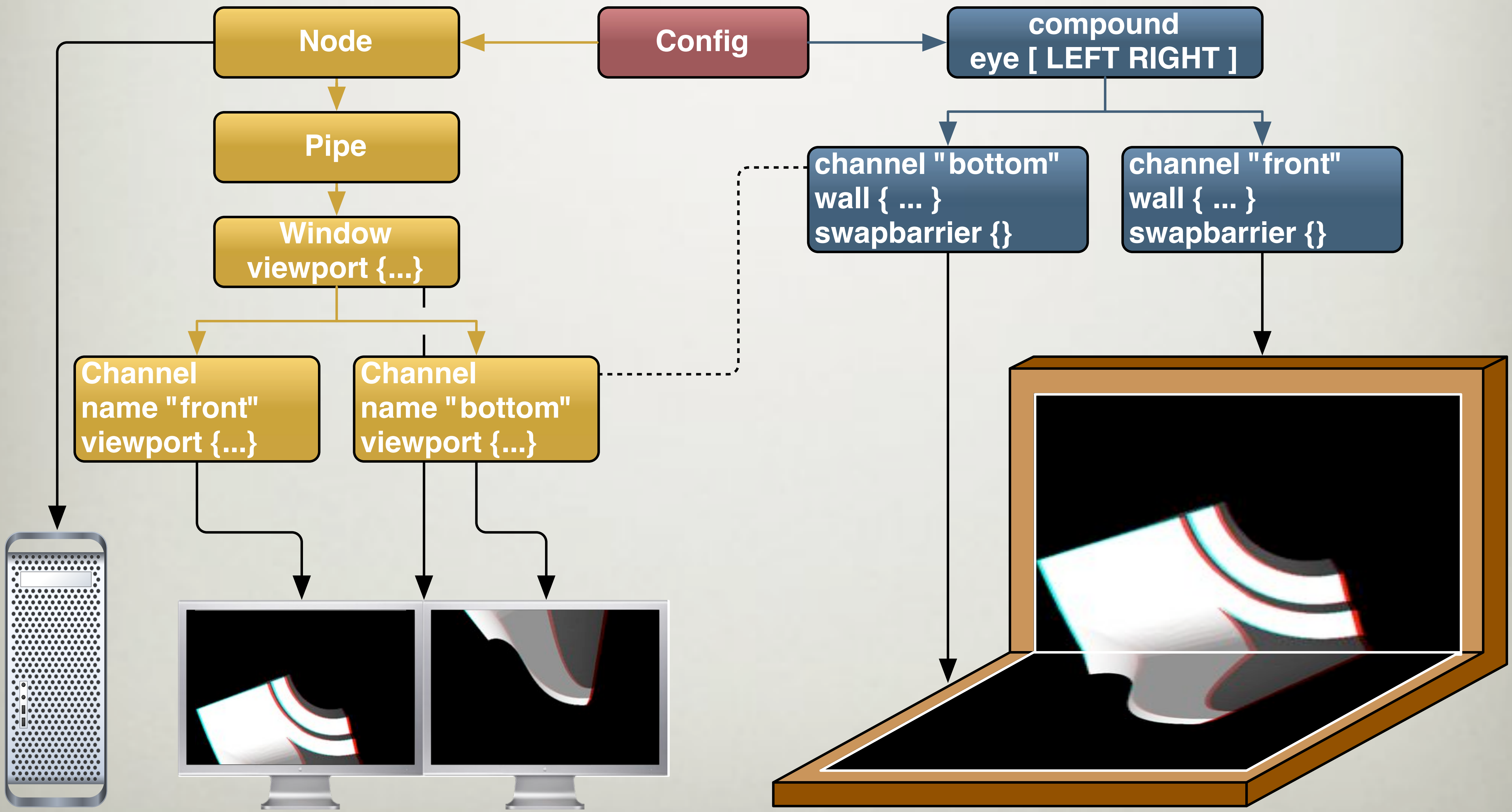
- Instantiate rendering multiple times
- Optional: data distribution for clusters



Runtime Configuration

- Hierarchical resource description: Node→Pipe→Window→Channel
  - Node: single system of the cluster
  - Pipe: graphic card
  - Window: drawable and context
  - Channel: view
- Resource usage: compound tree

Runtime Configuration



Runtime Scalability

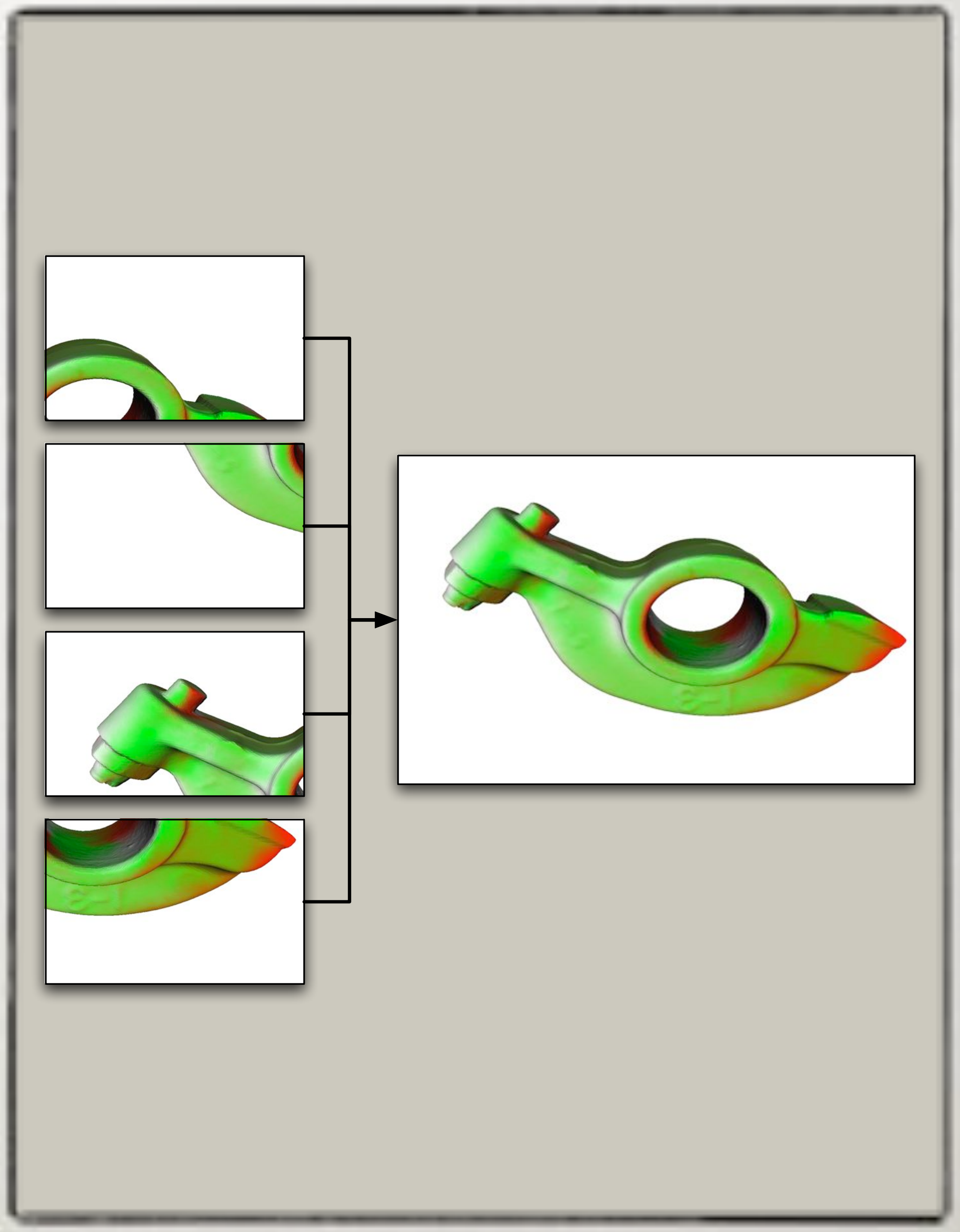
- Parallel execution of the application's rendering code
- One thread per graphics card, one process per node
- Decomposition of rendering for one view

Runtime Scalability

- 2D, DB, Stereo, DPlex, Pixel compounds
- Flexible configuration of decomposition and recomposition
- Compatible with compositing hardware
- Hardware-specific optimizations

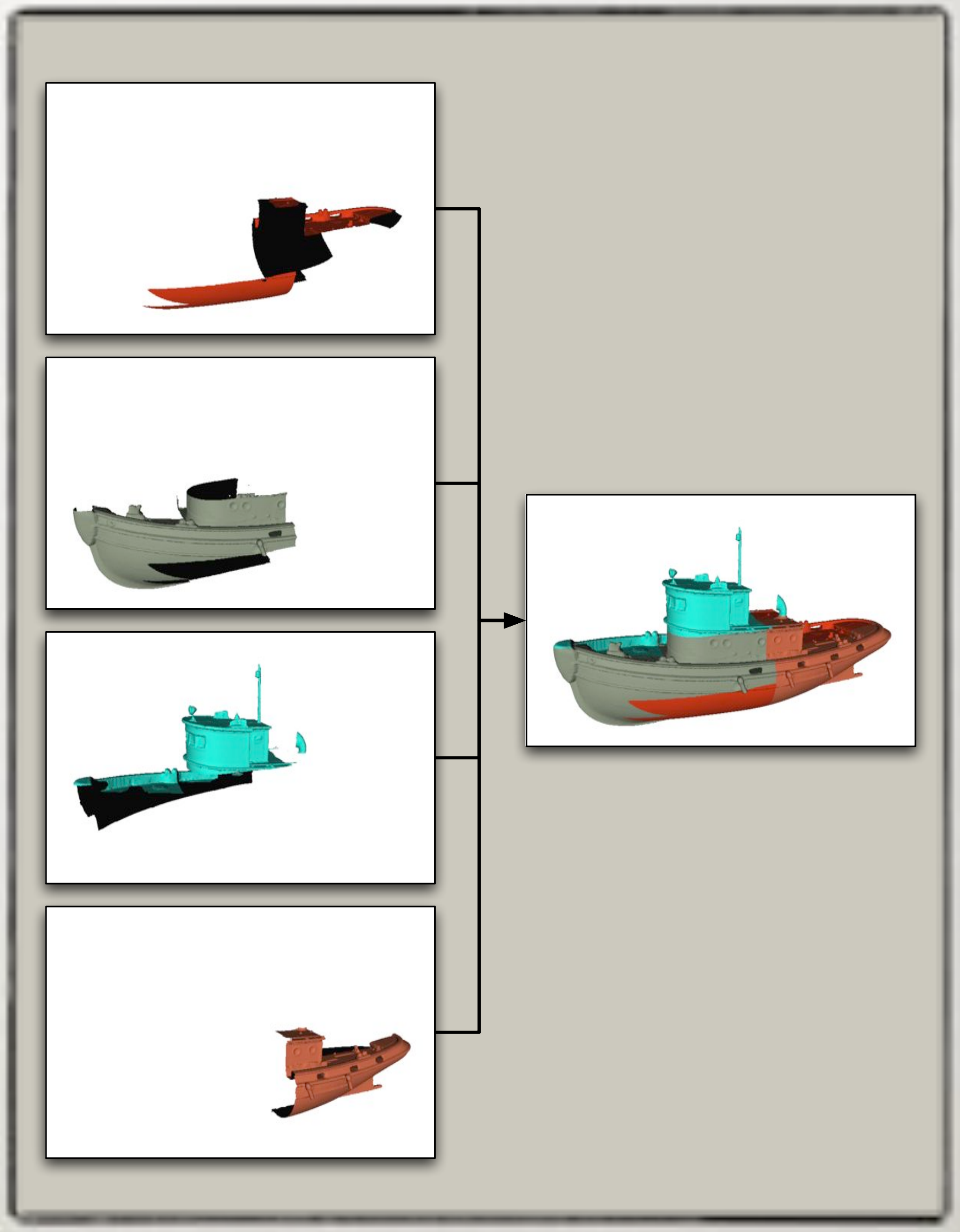
2D / Sort-First

- Scales fillrate
- Scales vertex processing if view frustum culling is efficient
- Parallel overhead due to primitive overlap limits scalability



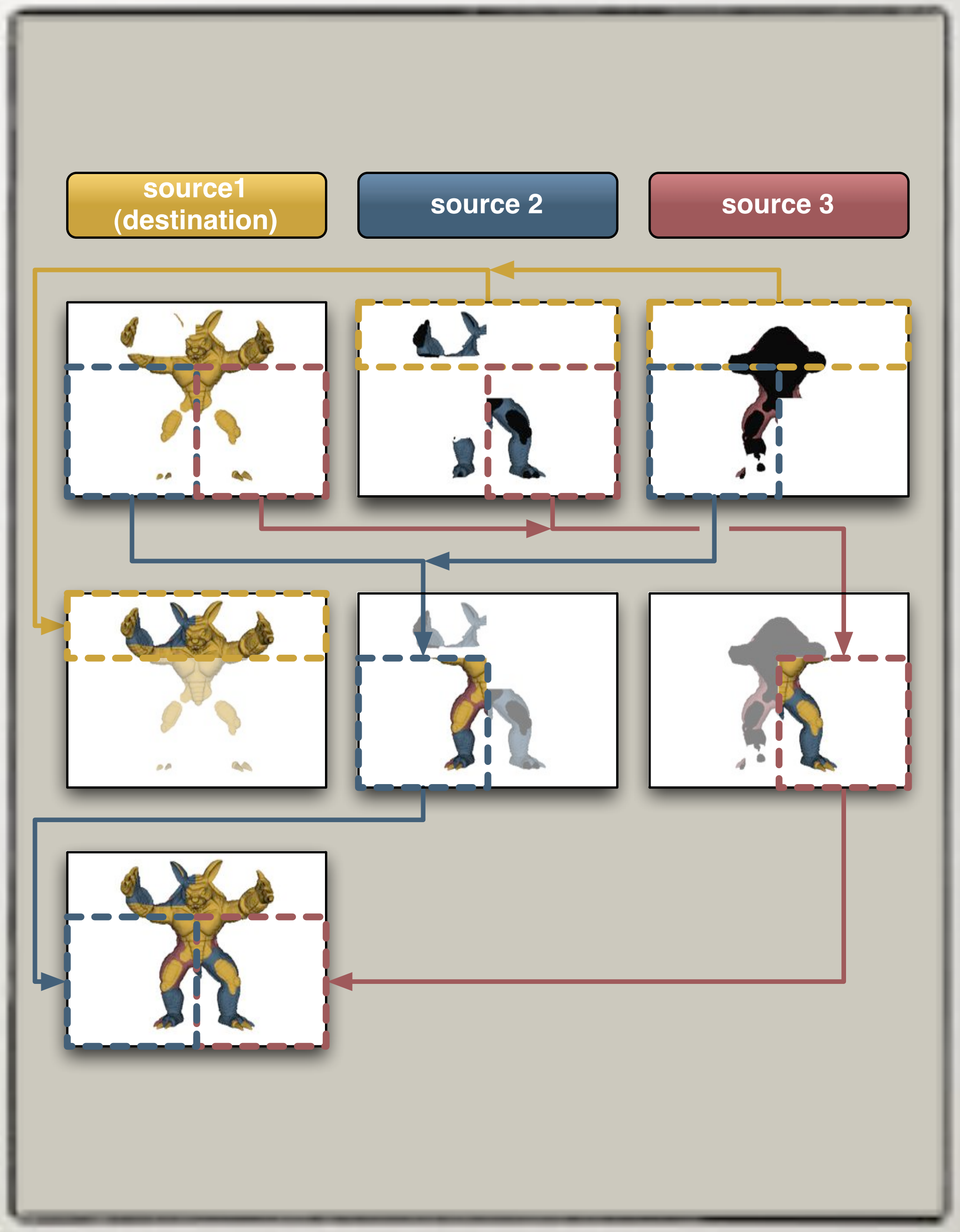
DB / Sort-Last

- Scales all aspects of rendering pipeline
- Application needs to be adapted to render subrange of data
- Recomposition relatively expensive



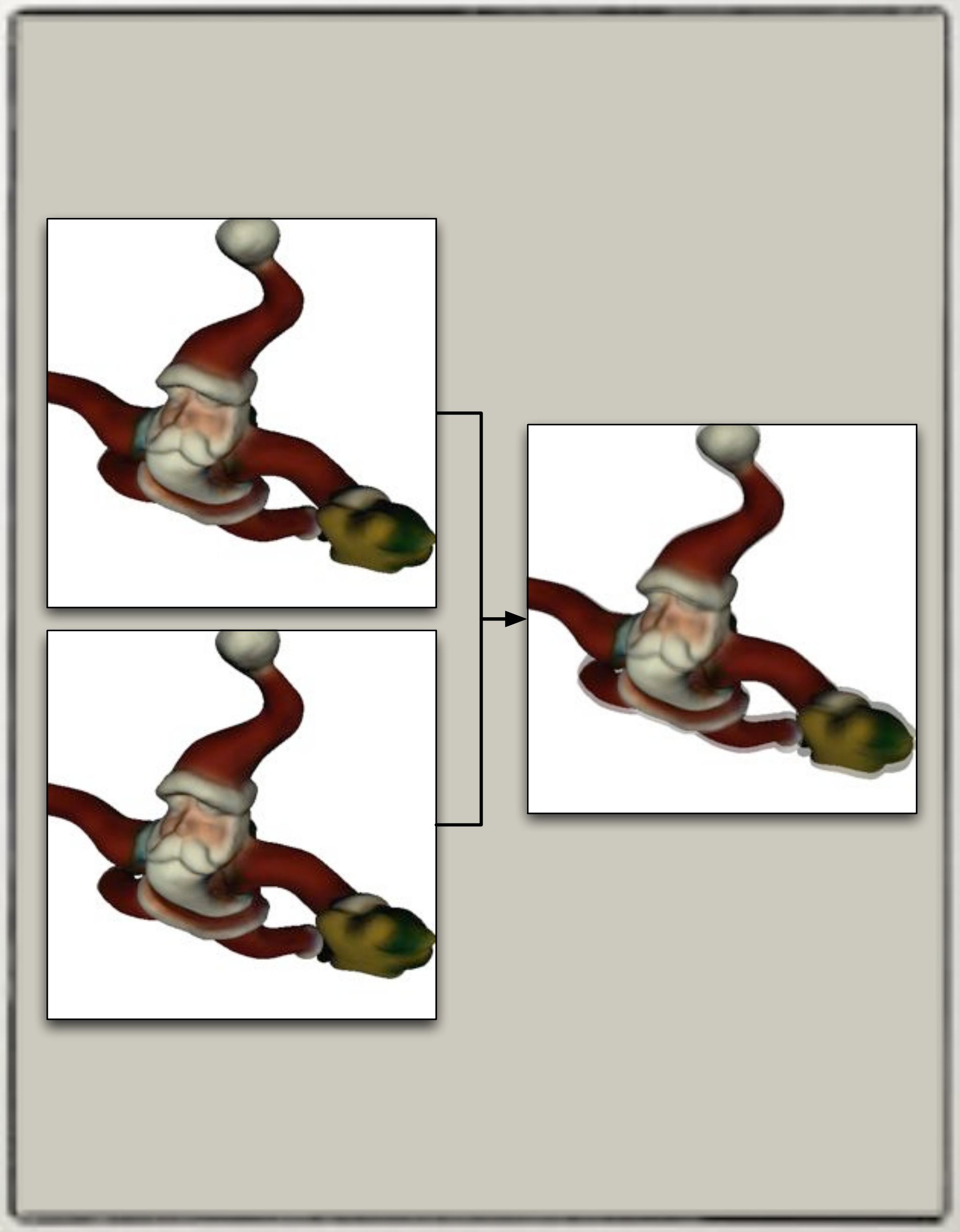
Parallel Compositing

- Compositing cost grows linearly for DB
- Parallelize compositing
- Flexible configuration
- Constant per-node cost
- Details in EGPGV'07 presentation



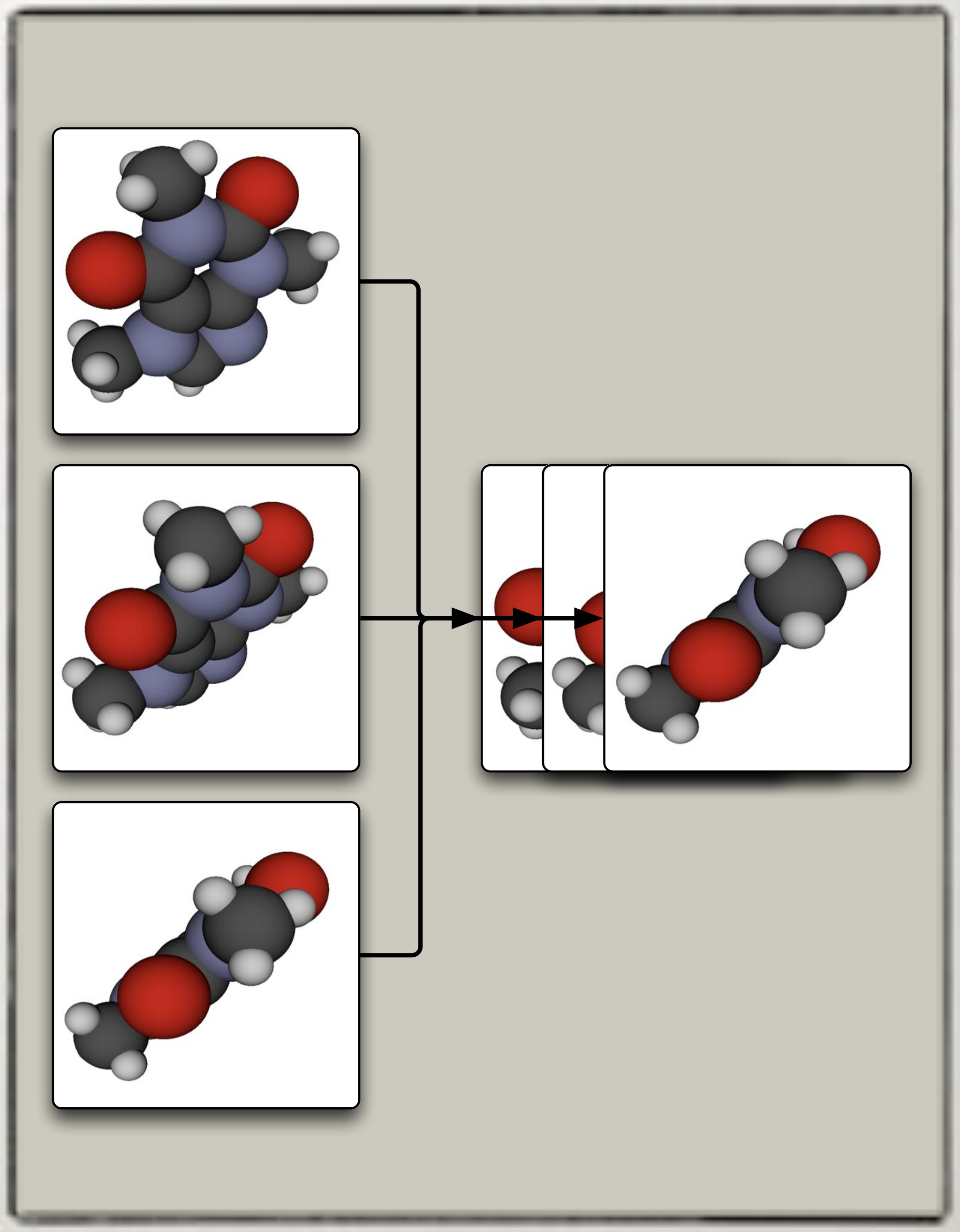
Eye/Stereo

- Stereo rendering
- Active, passive and anaglyphic stereo
- quasi-linear scalability and loadbalancing
- Limited by number of eye views



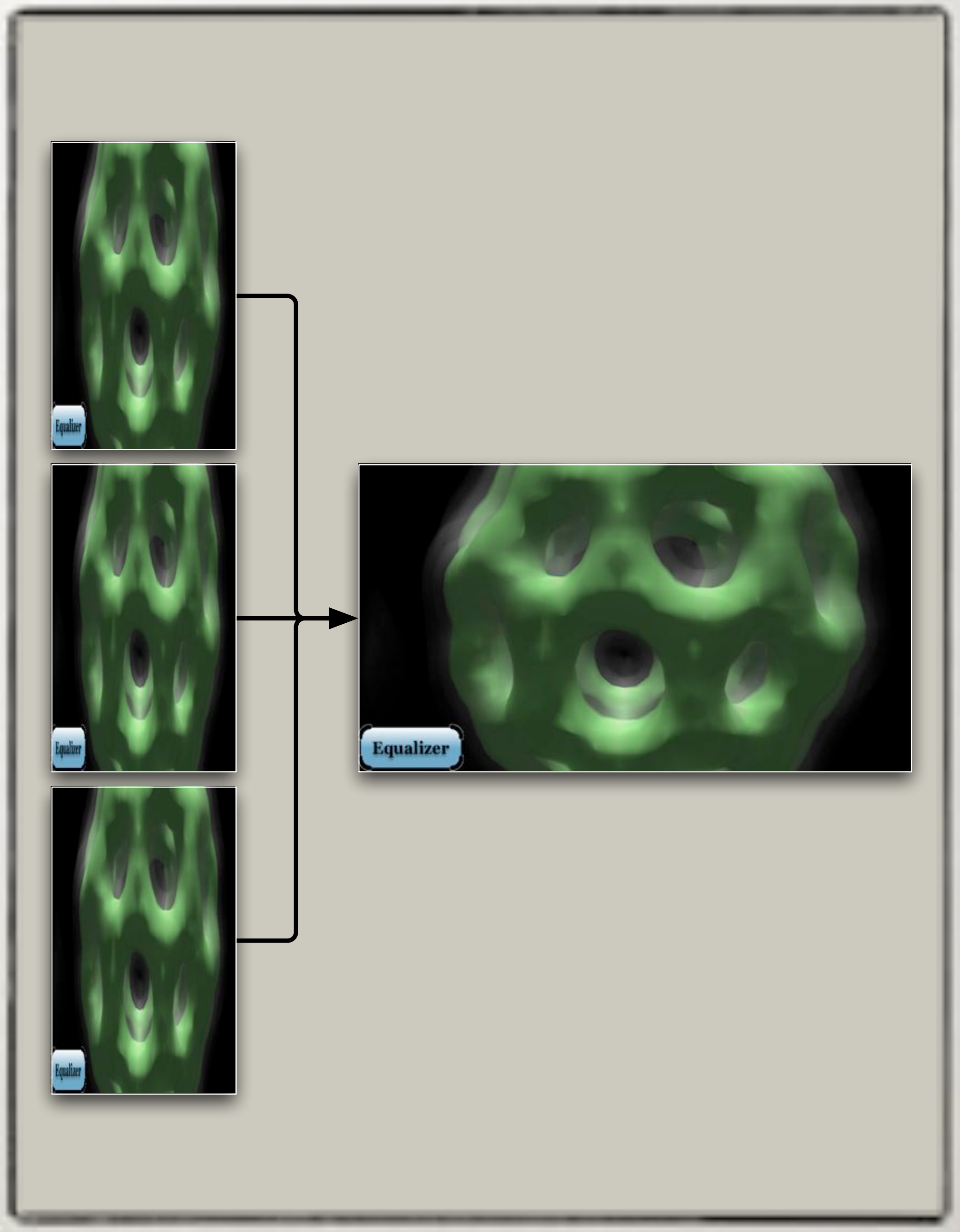
DPlex / Time-Multiplex

- quasi-linear scalability and loadbalancing
- Increased latency may be an issue
- Increased framerate often compensates for latency



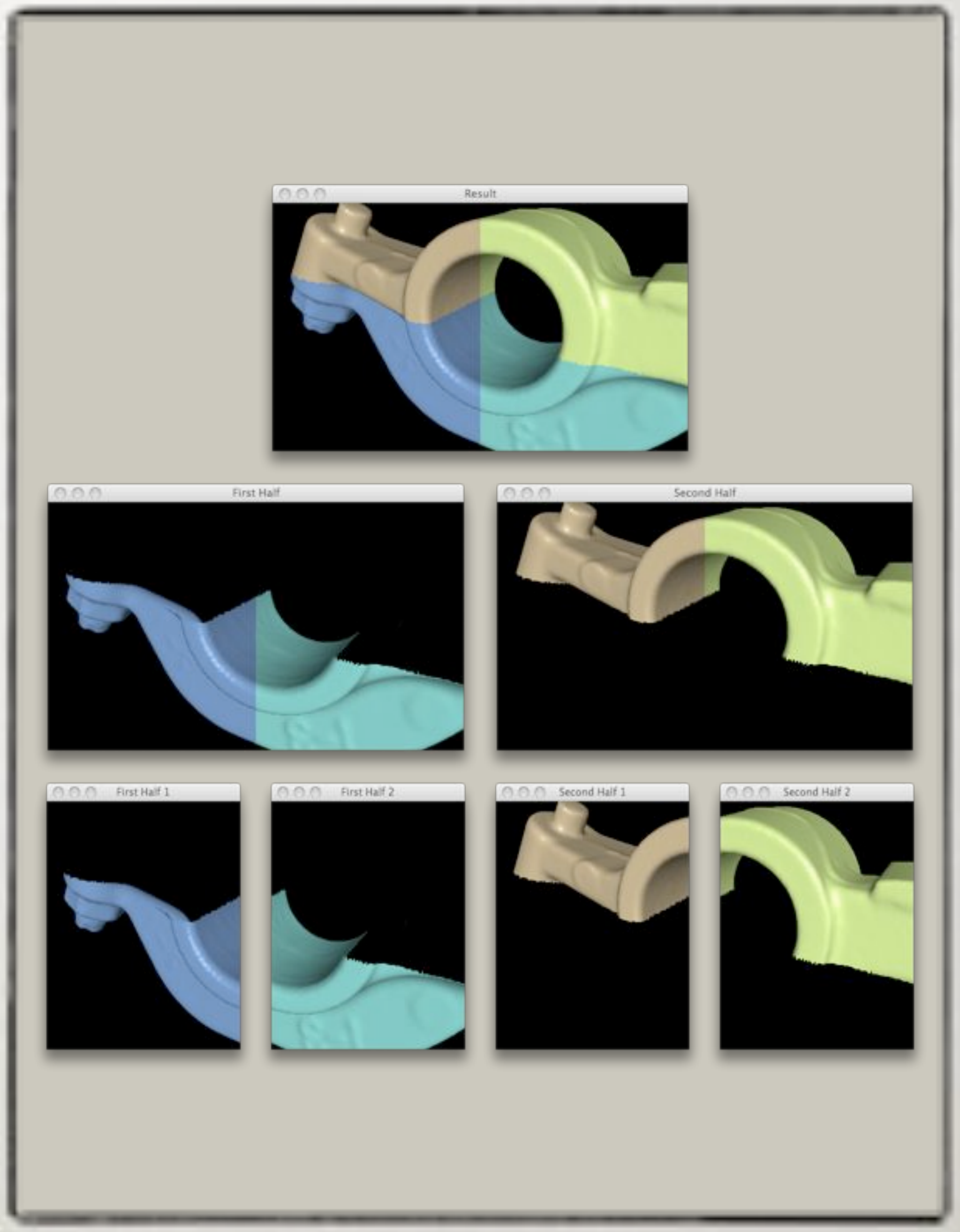
Pixel

- Scales fillrate perfectly
- Similar to 2D
- Raytracing, Volume Rendering



Multilevel Compounds

- Compounds allow any combination of modes
- Combine different algorithm to address and balance bottlenecks
- Example: use DB to fit data on GPU, then use 2D to scale further



Compounds

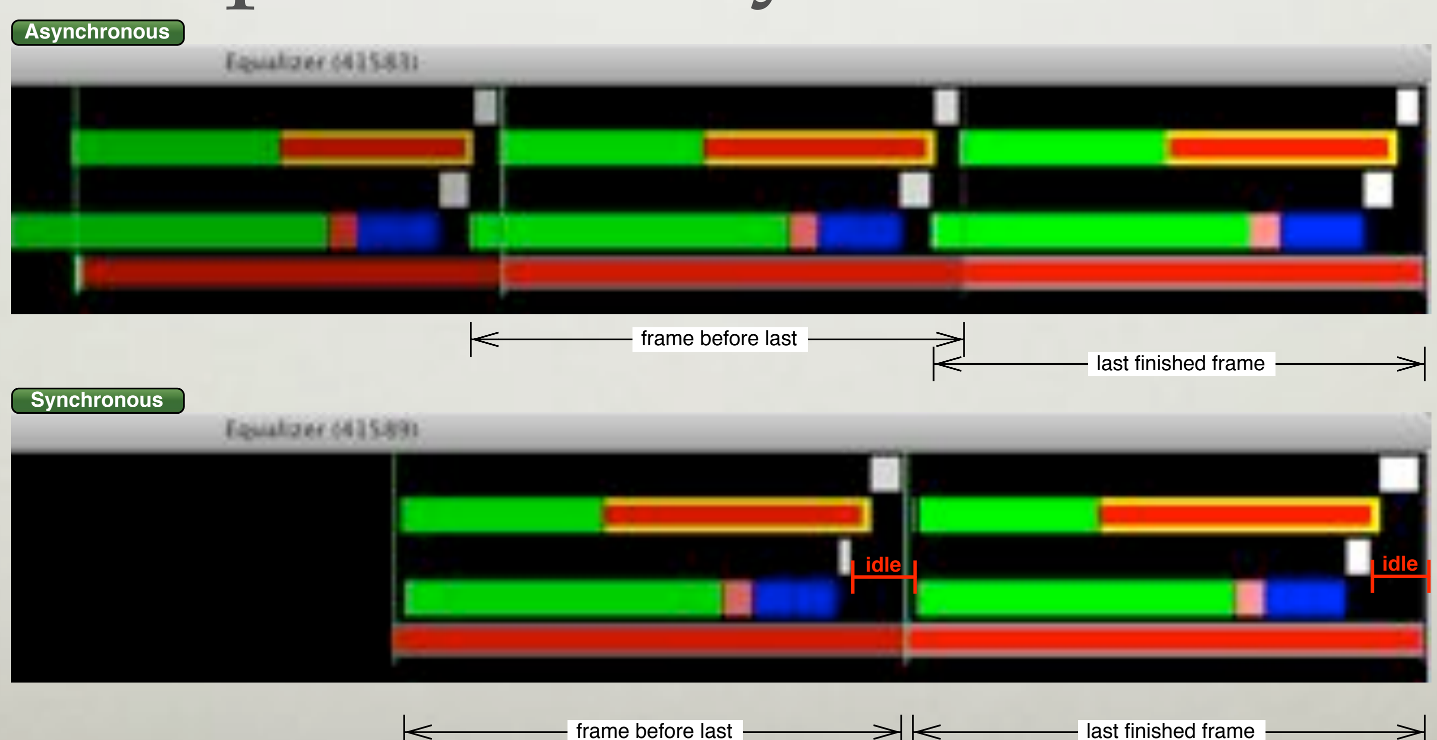
- 2D: low IO overhead, limited scalability
- DB: high IO overhead, great scalability
- Eye, DPlex: quasi-linear scalability
- Pixel: linear fill-rate scalability

➡ Combine modes

➡ DB: use parallel compositing

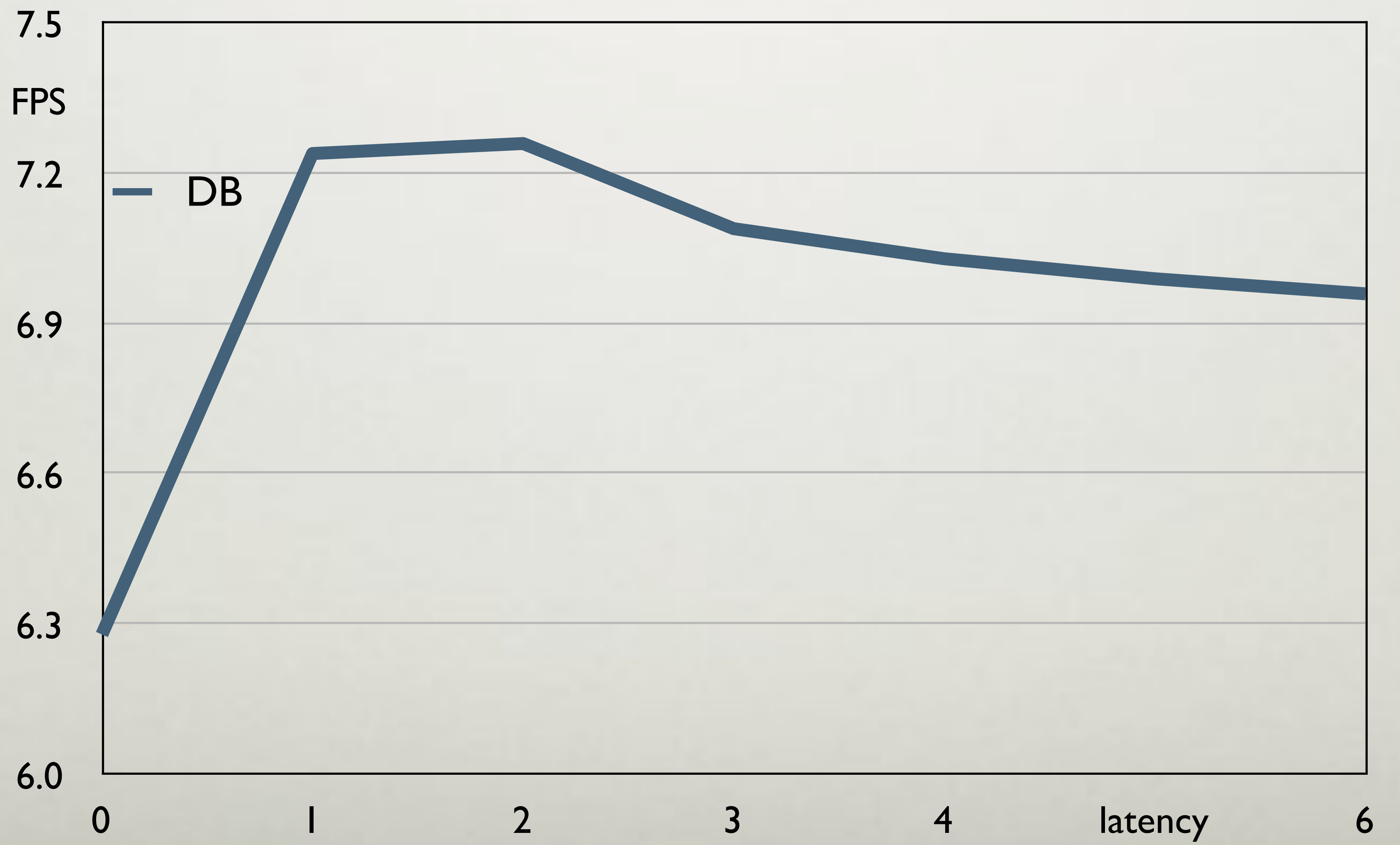
Asynchronous Execution

- Improves scalability on bigger clusters
- Latency between last draw and main
- Hides imbalance in load distribution
- Optional per-node synchronization



Asynchronous Execution

- Example: 5-node sort-last, direct-send
- 15% speedup

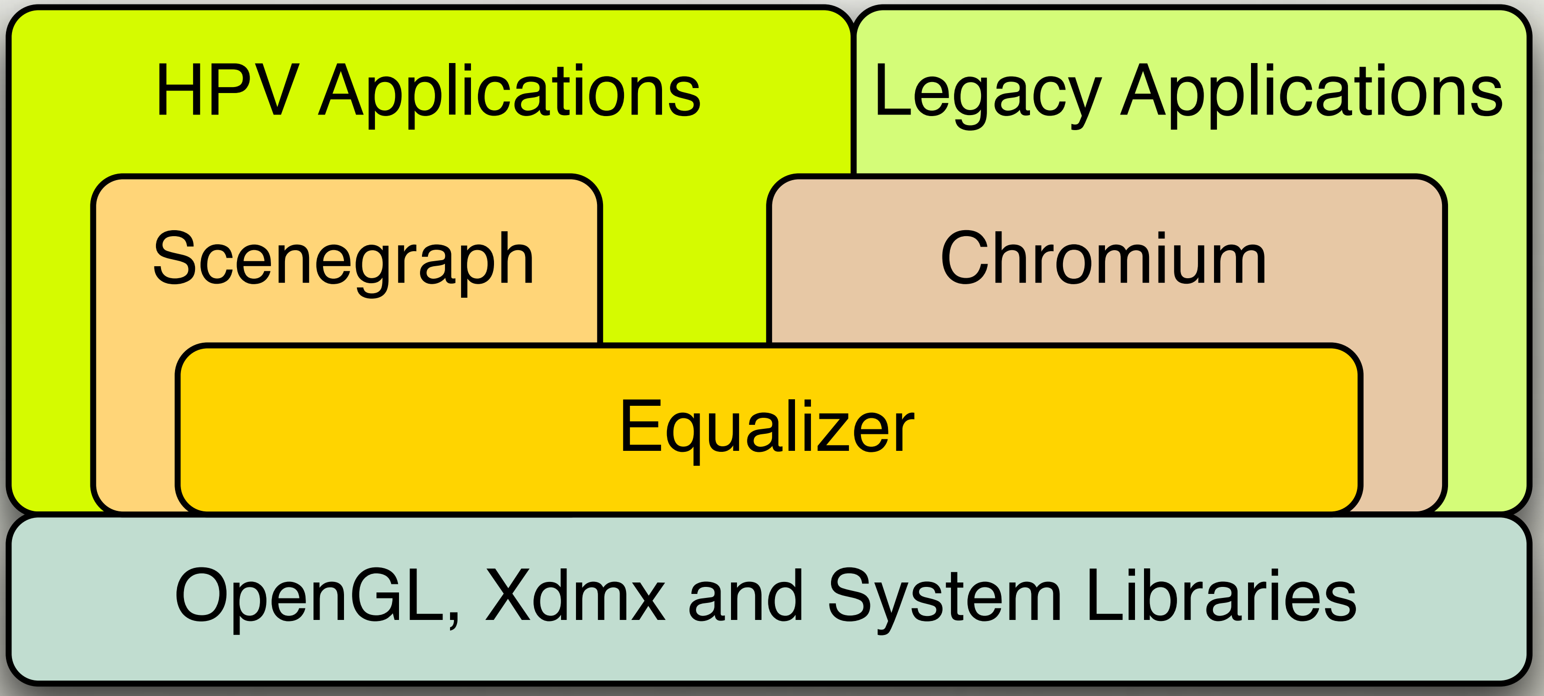


Multi-GPU and Clusters

- Equalizer runs on both architectures
- Execution model is the same
- Shared memory systems allow additional optimisations
- Porting for SSI simpler than full port

Equalizer Vision

- Equalizer: Scalable rendering engine
- Chromium: OpenGL single virtual screen
- Scenegraphs: Distributed data management



Near Future

- DB compositing optimizations
- Examples, demos, applications
- Server extensions
- Failure robustness

Open Source

- LGPL license: commercial use welcome
- Open standard for scalable graphics
- Minimally invasive: easy porting
- Clusters and shared memory systems
- Linux, Windows, Mac OS X
- More on: www.equalizergraphics.com