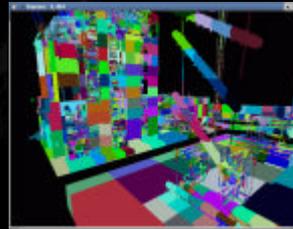
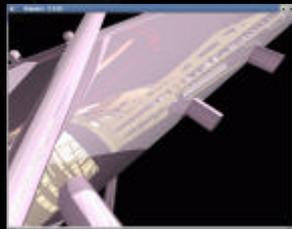
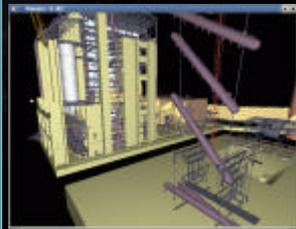


Distributed RT of Massive Models

Philipp Slusallek

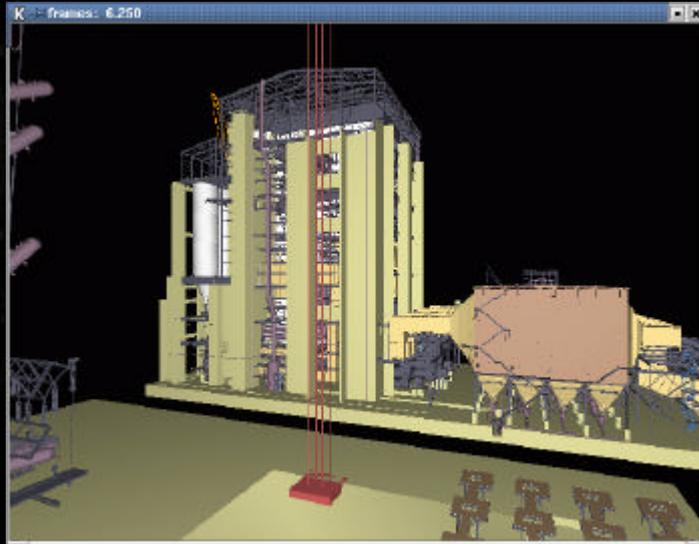


Overview

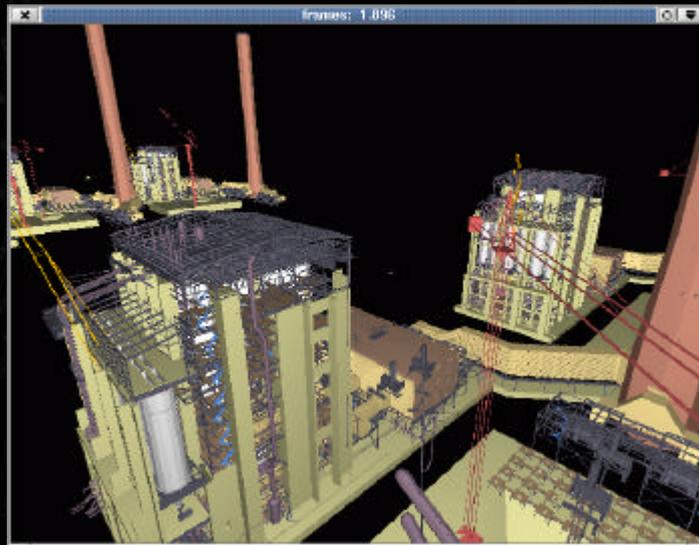
- Reference Model
- Previous Work
- Ray-Tracing Issues
- Distribution Issues
- Images & Demo

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY

Reference Model (12.5 Mtris)



Four Power Plants (50 Mtris)



Previous Work

- **Rendering of Massive Models (UNC)**
 - Framerate: 5 to 15 fps for single power plant
 - Framework of algorithms
 - Textured-depth-meshes (96% reduction in #tris)
 - View-Frustum Culling & LOD (50% each)
 - Hierarchical occlusion maps (10%)
 - Extensive preprocessing required
 - Entire model: ~3 weeks (estimated)
 - Needs shared-memory supercomputer

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY

Previous Work

- **Parallel Ray-Tracing, Parker et al. (Utah) & Muus (ARL)**
 - Needs shared-memory supercomputer
- **Memory Coherent RT, Pharr (Stanford)**
 - Explicit cache management for rays and geometry
 - Too slow for interactive rendering
 - Provides global illumination

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY

Ray-Tracing Issues

- **Distributed Scene Management**

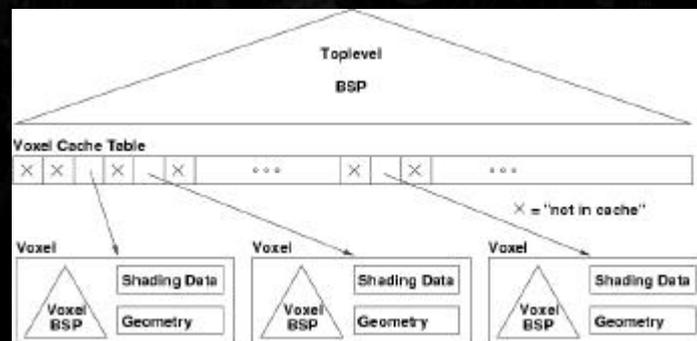
- Several GB of scene data
 - File size and address space
 - Network latency and bandwidth
- OS support
 - NFS + mmap: Process stalls due to demand paging
 - No control over memory management

SIGGRAPH
2001
EXPLORE INTERSECTION
AND DIGITAL IMAGERY

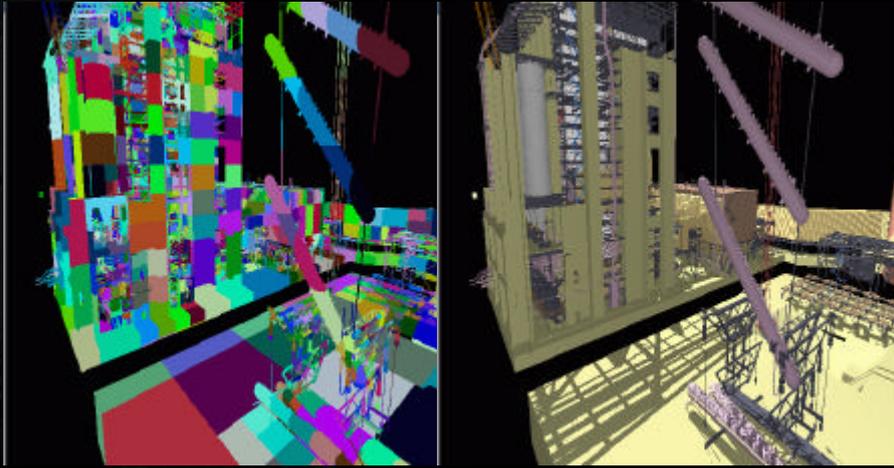
Ray-Tracing Issues

- **2-Level BSP-Trees**

- Caching based on "voxels"



Structure of the BSP-Tree



Ray-Tracing Issues

- **Compression of Voxel Data**
 - Latency is dominated by transmission time
 - Fast and space/cache efficient decompression
 - LZO-library provides for 3:1 compression
- **Sharing of Voxel Cache**
 - Dual-CPU: Shared-memory for voxel cache

Ray-Tracing Issues

- **Preprocessing**
 - Simple spatial sorting
 - Out-of-core algorithm due to model size
 - Simplistic implementation: 2.5 hours
 - Estimated with optimizations: < 30 min
- **Model Server**
 - Single server provides all model data
 - Could be distributed

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY

Distribution Issues

- **Load Balancing**
 - Demand driven distribution of tiles (32x32)
- **Frame-to-Frame Coherence**
 - Keep rays on the same client
 - Simple: Keep tiles on the same client
 - Better: Assign tiles based reprojected pixels
 - Larger effective cache size
 - Increases with number of clients

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY

Results

- **Setup**

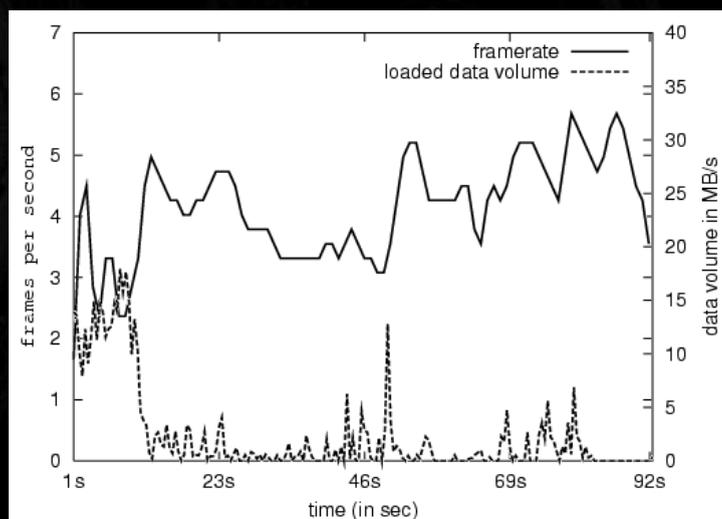
- Seven dual Pentium-III 800-866 MHz
- FastEthernet, Gigabit for display& model server

- **Performance for one Power Plant**

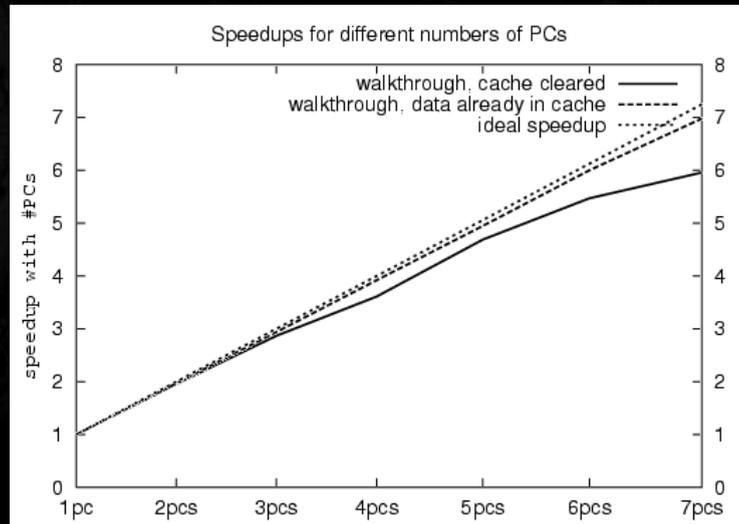
- 3-5 fps, without SSE optimization
- SSE support should give 6-12 fps
- Almost perfect scaling from 1 to 14 CPUs

SIGGRAPH
2001
EXPLORE INTERSECTION
AND DIGITAL IMAGERY

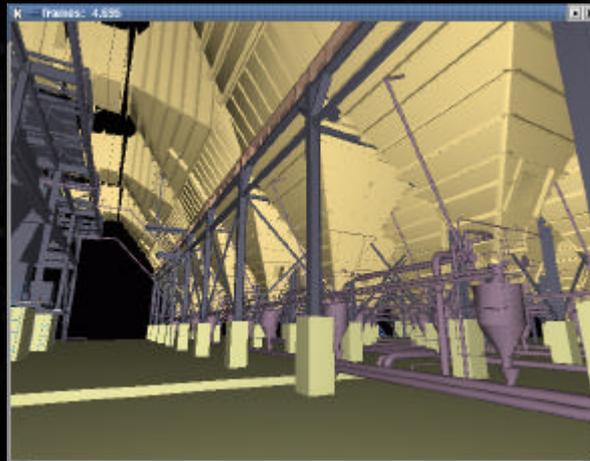
Animation: Framerate vs. Bandwidth



Speedup

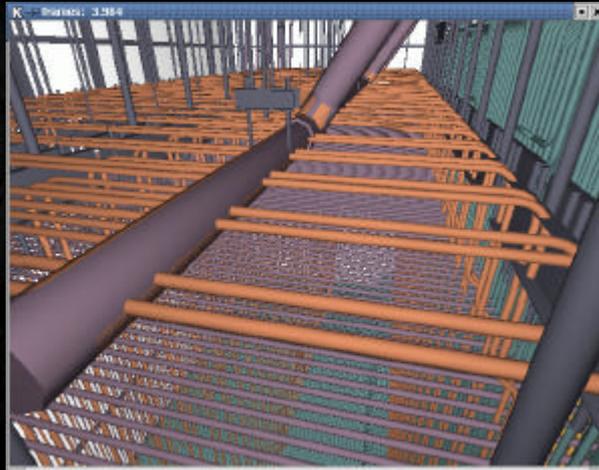


Detail View of Power Plant



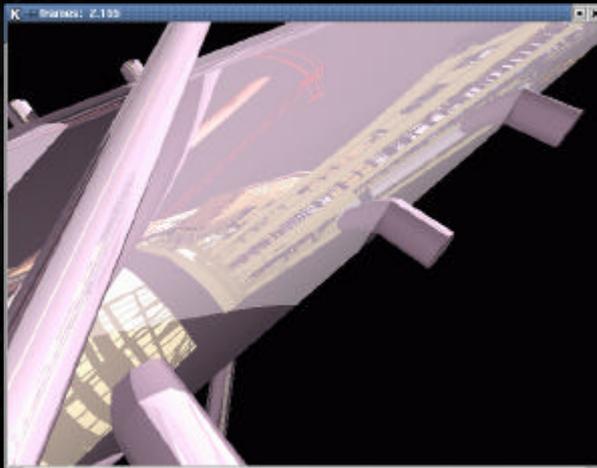
Framerate: 4.7 fps (seven dual P-III 800 Mhz CPUs)

Detail View: Furnace



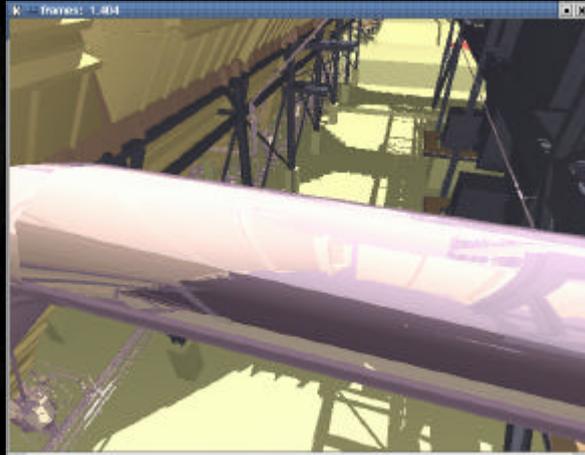
Framerate: 3.9 fps

Mirroring 12.5 Million Triangles



Framerate: 2.2 fps (with shadows and reflections)

Mirror and Shadows



Framerate: 1.4 fps

4.9 fps without shadows & reflections

Conclusions

- **Massive models are well manageable**
 - Drastically reduced preprocessing
 - Rendering time scales logarithmically with scene
 - Almost linear speedup with CPUs
- **IRT enables completely new applications**
 - Large scale visualization, design reviews
 - Interactive simulations

Future Work

- **Latency: Reducing scene granularity**
- **Bandwidth: Distributed scene server**
- **Dynamic scenes & instances**
- **Anti-aliasing**
- **Hardware support for ray-tracing**

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY

Acknowledgments

- **Ingo Wald & Carsten Benthin**
 - System design and implementation
- **Georg Demme & Markus Wagner**
 - System and programming support
- **Anselmo Lastra, UNC**
 - Power plant reference model

SIGGRAPH
2001
EXPLORE INTERACTIVITY
AND DIGITAL IMAGERY