Performance Analysis of a 3D Parallel Volume Rendering Application on Scalable Tiled Displays

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Outline

- Scalable Tiled Display Infrastructure
- 3D Parallel Volume Rendering Application: Volatile
- Performance Analysis
- Summary and Future Work
Scalable Tiled Display Infrastructure

- Take advantage of advanced graphics pipeline technology and graphics clusters
  - Programmable GPU
  - Off-the-shelf, inexpensive PCs, high-speed networks

- Tightly couple inexpensive LCD/TFT monitors to build a high-resolution display system
  - Replace the limited output resolution of standard devices such as monitors, video projectors
  - For detailed scientific visualizations with increased pixel density
Scalable Tiled Display Infrastructure

CPU (dual Opteron) → Application → driver → Video Memory → On-chip Cache Memory

GPU (nVidia Quadro FX 3000) → Video Memory

Gigabit Network

Graphics Cluster

OPT1 → Gigabit Network → OPT2 → OPT3 → OPT4

Optiputer
Snapshot of Tiled Display System

12/09/2004
Scalability

- Linux Graphics Cluster
  - Easy to scale up the number of nodes

- Tiled displays
  - Easy to scale up the number of LCD monitors with the number of nodes

- Visualization Application: Volatile
  - Messages that are broadcasted to nodes are small in size and independent of the scene size and number of tiles
OptIPuter Project

- Optiputer: named for its use of Optical networking, Internet Protocol, computer storage, processing and visualization technologies
- Central architectural element is optical networking, not computers – creating "supernetworks"
- Goal: enable scientists who are generating terabytes and petabytes of data to interactively visualize, analyze, and correlate their data from multiple storage sites connected to optical networks
OptIPuter Scalable Display Systems
Outline

- Scalable Tiled Display Infrastructure
- **3D Parallel Volume Rendering Application:** Volatile
- Performance Analysis
- Summary and Future Work
Three Components of Volatile

- **Volvis: main program**
  - Rendering
  - Scalable displaying
  - User interaction

- **Optistore: data server**
  - Assist visualization dataset handling such as data management, processing, representation and transport
  - Filter raw volumetric data and produce visual objects

- **Transfer Function Editor (tfUI)**
  - User interface for transfer function selection
Different Access Scenarios

**Scenario 1**

**Scenario 2**
Different Access Scenarios

Scenario 3
Sort-first Partitioning

- Divide the raw volumetric data into smaller sub-volumes,
- Distribute them to multiple nodes,
- Render them independently and locally
- Combine the resulting images on scalable tiled displays
Tiled Display Configuration

1. \((M_X + R_X, 100)\)
2. \((M_X, 3M_Y + R_Y)\)
3. \((3M_X + R_X, 3M_Y + R_Y)\)
4. \((100, M_Y + R_Y)\)

- \(R_X\)
- \(R_Y\)
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Raw Datasets

- Protein 64x64x64
- Fuel 64x64x64
- FurDave 160x255x75

- Foot 256x256x256
- Geo 256x256x256
- Geo 440x290x198
Total Startup Time

**Scenario 1**

- **Number of Nodes:** 1+1, 1+2, 1+3, 1+4
- **Total Startup Time (secs):** 0, 1, 2, 3, 4, 5, 6, 7, 8
- **Graphs:**
  - protein64x64x64
  - fuel64x64x64
  - foot256x256x256
  - geo256x256x256
  - geo440x290x198
  - furdave160x255x75

**Scenario 2**

- **Number of Nodes:** 1+1, 1+2, 1+3, 1+4
- **Total Startup Time (secs):** 0, 2, 4, 6, 8, 10
- **Graphs:**
  - protein64x64x64
  - fuel64x64x64
  - foot256x256x256
  - geo256x256x256
  - geo440x290x198
  - furdave160x255x75

**Scenario 3**

- **Number of Nodes:** 1+1, 1+2, 1+3, 1+4
- **Total Startup Time (secs):** 0, 5, 10, 15, 20, 25
- **Graphs:**
  - protein64x64x64
  - fuel64x64x64
  - foot256x256x256
  - geo256x256x256
  - geo440x290x198
  - furdave160x255x75
Percentage of Data access time

Percentage of the data access time vs total startup time (Scenario 1)

Percentage of the data access time vs total startup time (Scenario 2)

Percentage of the data access time vs total startup time (Scenario 3)
Comparison of three scenarios

Data access time on 1+4 nodes

- protein64x64x64
- fuel64x64x64
- foot256x256x256
- geo256x256x256
- geo440x290x198
- furdave160x255x75
Comparison of three scenarios

Percentage of the data access time vs total startup time on 1+4 nodes

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Snapshot of Performance Monitoring
Snapshot of Geological Image

12/09/2004
Snapshot Using tfUI

12/09/2004
Demo Using tfUI
Summary and Future Work

- Scalable Tiled Display Infrastructure
- 3D Parallel Volume Rendering Application: Volatile
- Performance Analysis using Prophesy system

Future Work

- Experiments on large-scale OptIPuter testbeds
- Using kernel coupling techniques to explore and quantify the interactions among the three components