Massively Parallel Visualization on Leadership Computing Resources

Core-collapse supernova X component of velocity

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Leadership Resources
storage, not computation, limited
Take, For Example, Astrophysics Data
terabytes and growing

Core collapse supernova shock wave simulation, on a structured grid of $1120^3$ data elements produces 27 GB per time step. Because this is a time-varying, multivariate dataset, the total is data size is $> 5$ TB

Same code (VH-1) will be used in CHIMERA, to produce petabytes of data soon

Datasets courtesy of John Blondin (NCSU) and Tony Mezzacappa (ORNL)
Large Data Problems in Traditional Analysis Workflow

What's wrong with this picture?

Wash, rinse, repeat

Simon → write → read → analysis/vis → write → read → view

Dataset

Supercomputer

Vis cluster

Desktop

Images
Breaking the Visualization Pipeline

Relying on leadership infrastructure, parallel scalable algorithms, and interactive viewing techniques

\[ \text{wash, rinse, repeat} \]

\[ \text{sim} \rightarrow \text{write} \rightarrow \text{read} \rightarrow \text{analysis/vis} \rightarrow \text{write} \rightarrow \text{read} \rightarrow \text{view} \]

\[ \text{dataset} \]

\[ \text{images} \]

\[ \text{supercomputer} \]

\[ \text{vis cluster} \]

\[ \text{desktop} \]
Parallel Volume Rendering
Divide and conquer: Input, render, compose, output.
Performance Results

Limiting the number of compositors improves compositing time by up to 30X.
Time Distribution

Reading the data from storage dominates the total cost of a time step.

The effect of raw rendering speed is minimal. Hence, s/w rendering rates are acceptable, compared to h/w rendering. The most critical factor is parallel I/O performance, followed by interconnection performance.
Efficiency
Welcome to the real world.
Multiple Parallel Pipelines

Hide I/O latency by extending concurrency between time steps.

Effect of Processing Time Steps Concurrently

Frame rate (Hz)

Number of parallel pipelines

- 512 cores per pipe
- 1024 cores per pipe
- 2048 cores per pipe
- 4096 cores per pipe
- 8192 cores per pipe

I/O = file read, R = render, C/S = composite / send
Multiple Writers Performance

Improve overall output time by selecting the optimal number of writers.

Composite, Gather, Write Times for Varying Numbers of Writers

64 writers best for most cases; writers need to be distributed among I/O nodes.
Getting the Results to the Scientist

Multipipe, multihop transmissions
Improving Perception Through VR Techniques
Autostereo viewing and natural interactions, from display wall to desktop.

35-panel Varrier display at EVL

6-panel Varrier display at MCS Vis. Lab

Desktop Varrier and Dynallax displays in scientist’s office
## Visualization on Leadership Resources

**Challenges, questions, looking ahead**

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