Scalable Data Servers for Large Multivariate Volume Visualization

Presented by

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The University of Tennessee

SC07

UltraVis
SciDAC Institute for Ultrascale Visualization

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Computer Science Department

Motivation

- Volumetric multivariate time-varying datasets are often complex and massive in size.

- Efficient and interactive selection and visualization of subsets is not easily done, as datasets will not fit in core.

- Real-word example: astrophysics simulation of supernova generates 300 time steps of a spatial resolution of 864x864x864 with multiple attributes stored at each voxel.

- Few systems can adequately support (interactive) visualization of such enormous datasets.

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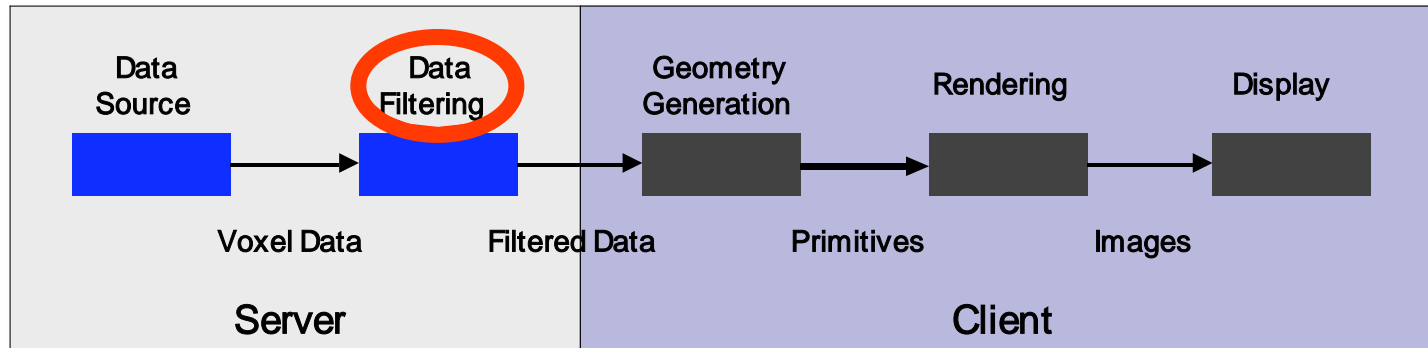Computer Science Department

Our approach: Overview

Parallel data management and effective data culling
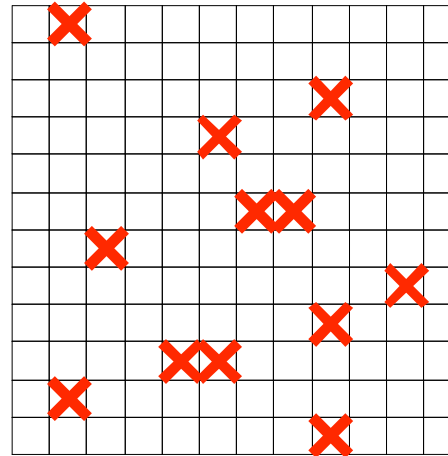
Data culling

- Parallel data culling on the granularity of individual voxels.

- Process is driven by compound boolean range queries.

- Cull unnecessary voxels as early in the visualization pipeline as possible, i.e., on the server side.

Parallel data management

- The entire dataset is distributed among a number of networked independent computers according to space filling curve order in the high-dimensional attribute space.

- Load-balancing can be achieved among data servers, independent of the range queries.
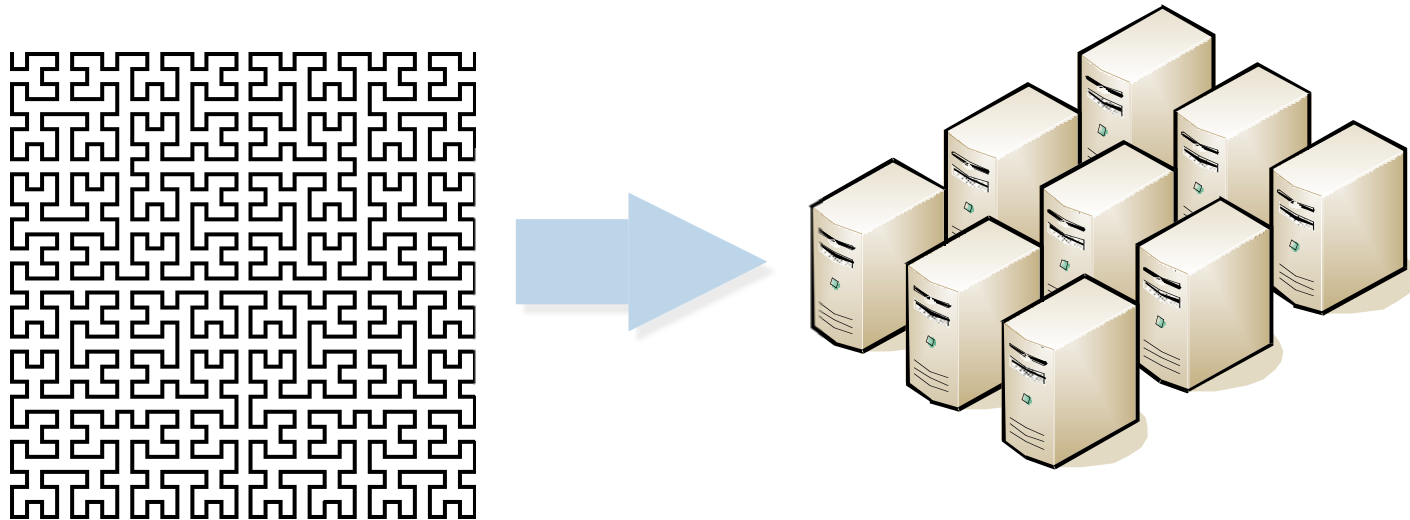
Parallel data management

- Each data server leverages a very compact data structure similar to B-tree to maintain all voxels distributed to it.

- Queries to a server can be responded to quickly with a query rate of 4.2 million relevant voxels per second across a local area network.


Voxel Data
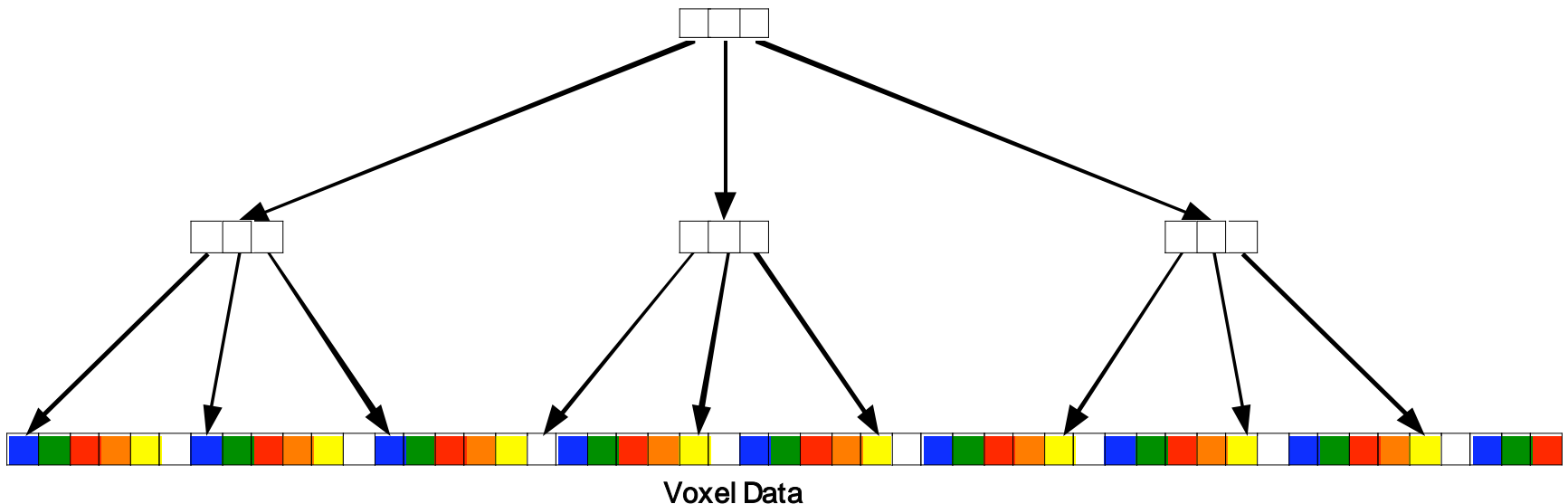
Requirements
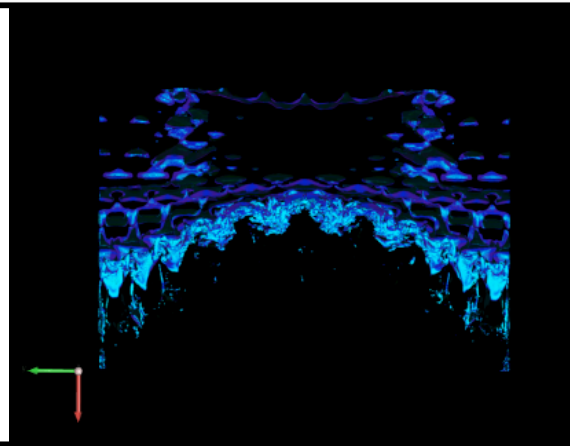
- System of networked workstations without any special hardware or software.

- All data servers combined need to hold the entire dataset in main memory in a compressed form.

- Queries will need to fit into client's main memory to render.

- If requirements cannot be met, the system will still be operational, but performance will be hampered.

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Results—Datasets

TSI—Time-varying (6 time steps),
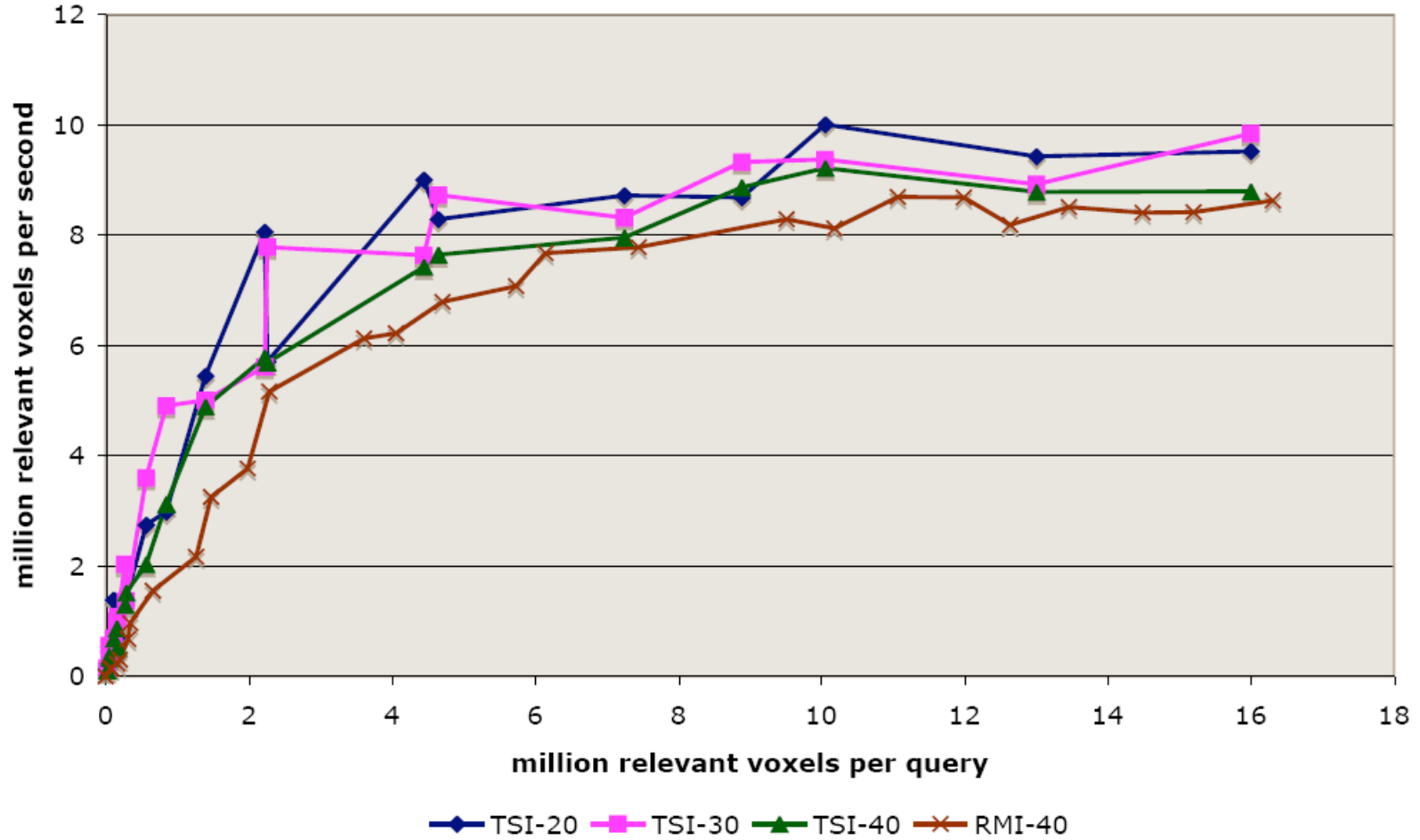Multivariate (11 attributes),
864x864x864
105 GB of raw data
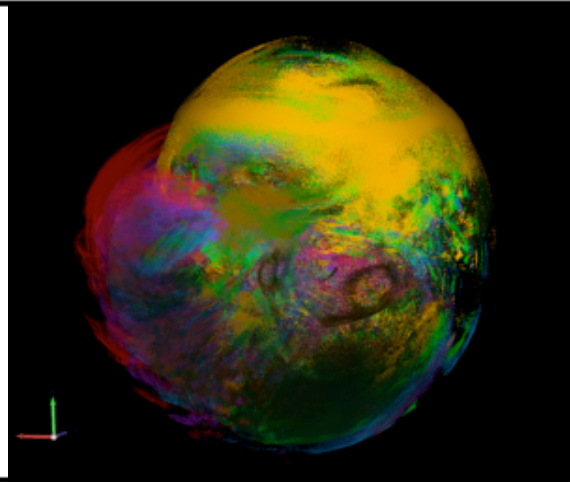
RMI—Time-varying (3 time steps),
Multivariate (11 attributes),
1024x1024x960
82 GB of raw data

Tests run with 20, 30, and 40 servers

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Results

Querying Rates

Results

- Network seems to be the bottleneck of the system:
  - Even with a Quadrics Elan3 network (single-direction bandwidth of 400 MB per second).

- We can query at 144 MB/s or about 9 million voxels per second in parallel.

- The load imbalance among servers ranged between a mere 0.012% to 0.155% for medium and large queries.

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Integration into VisIt

Scalable data servers have been integrated into the free interactive parallel visualization and graphical analysis tool VisIt as a module in version 1.7

http://www.llnl.gov/visit
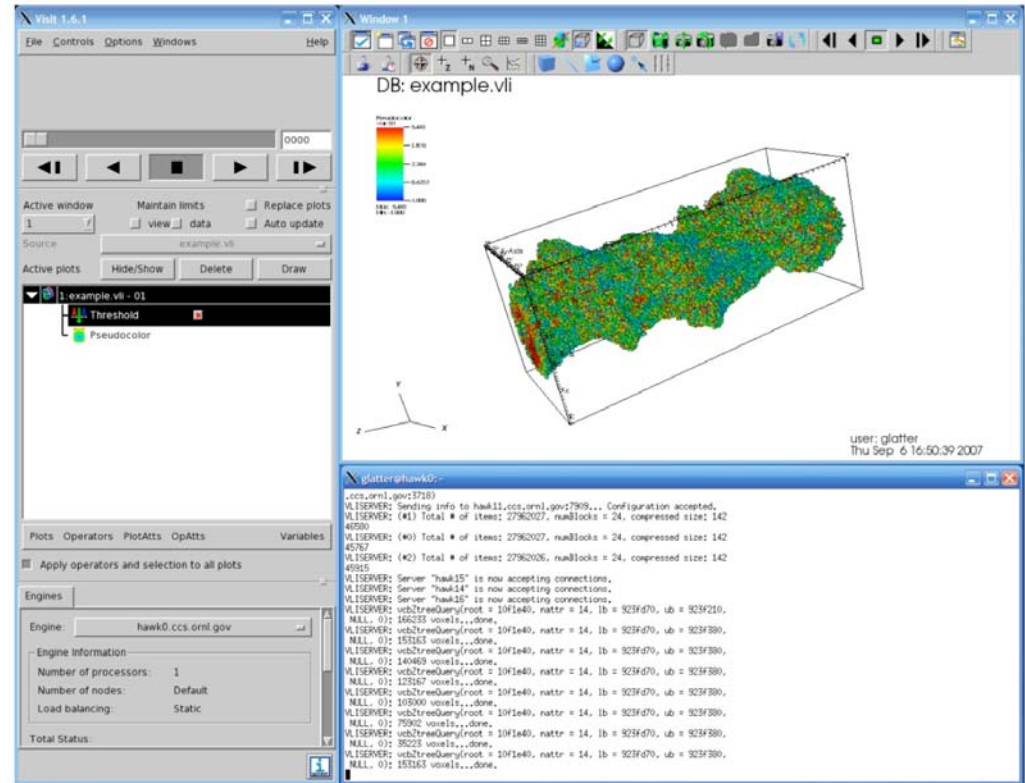
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