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National Nuclear Security Administration

Examples of In Transit Visualization

Petascale Data Analytics: Challenges and Opportunities

November 14, 2011

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SAND 2011-XXXXP

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Collaborators

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- **Oak Ridge National Laboratory**
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  - Utkarsh Ayachit
  - Andrew C. Bauer
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  - Sebastien Jourdain
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Extreme scale computing

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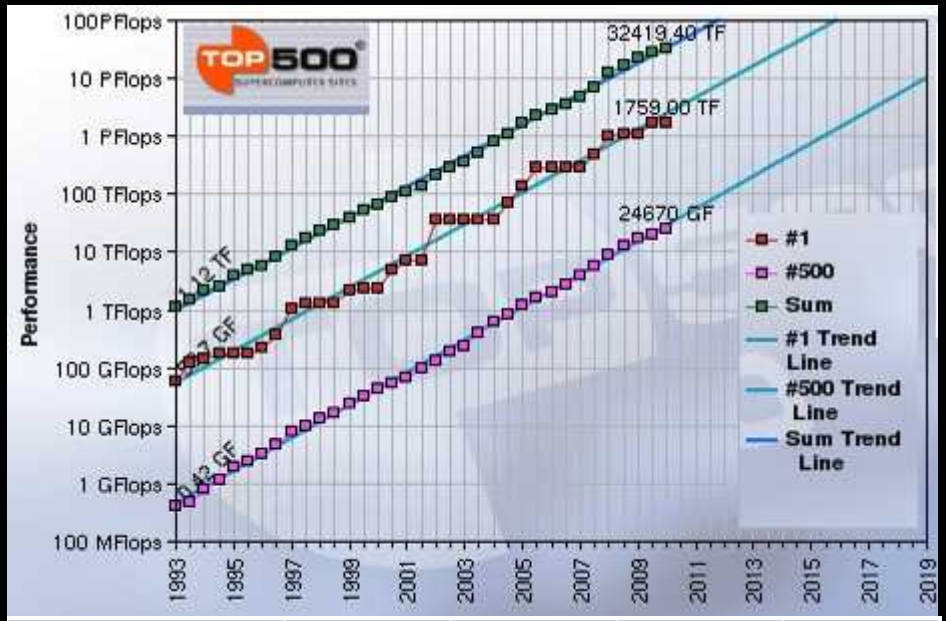
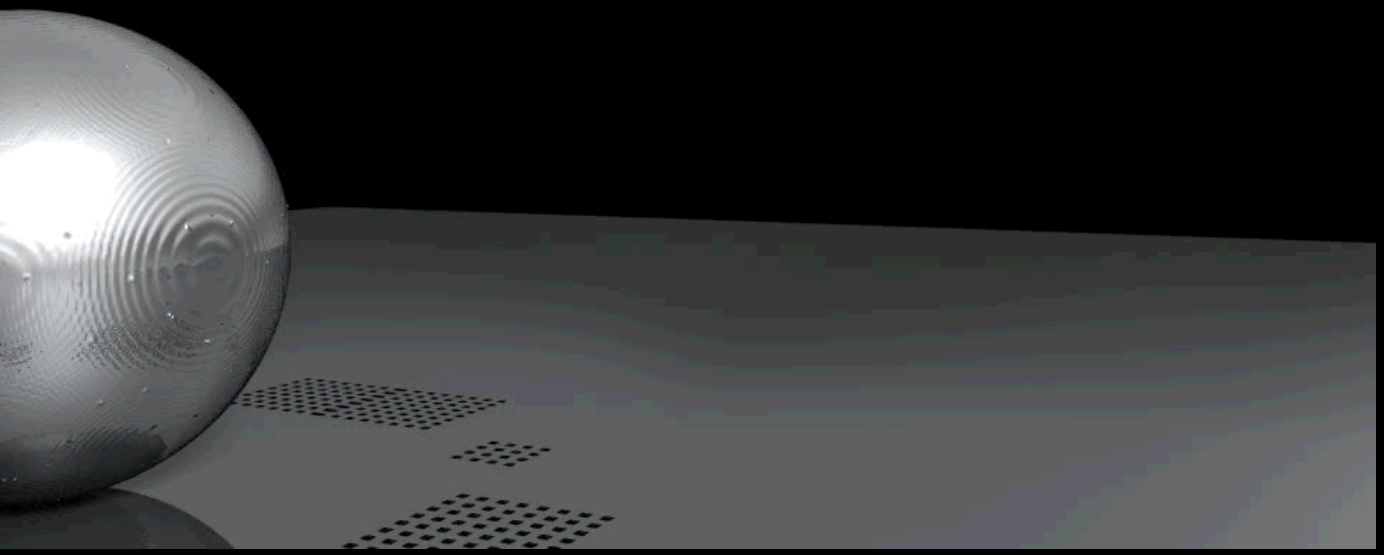
- Trends
  - More FLOPS
  - More concurrency
  - Comparatively less storage, I/O bandwidth
- ASCI purple (49 TB/140 GB/s) – JaguarPF (300 TB/200 GB/s)
  - Most people get < 5 GB/sec at scale



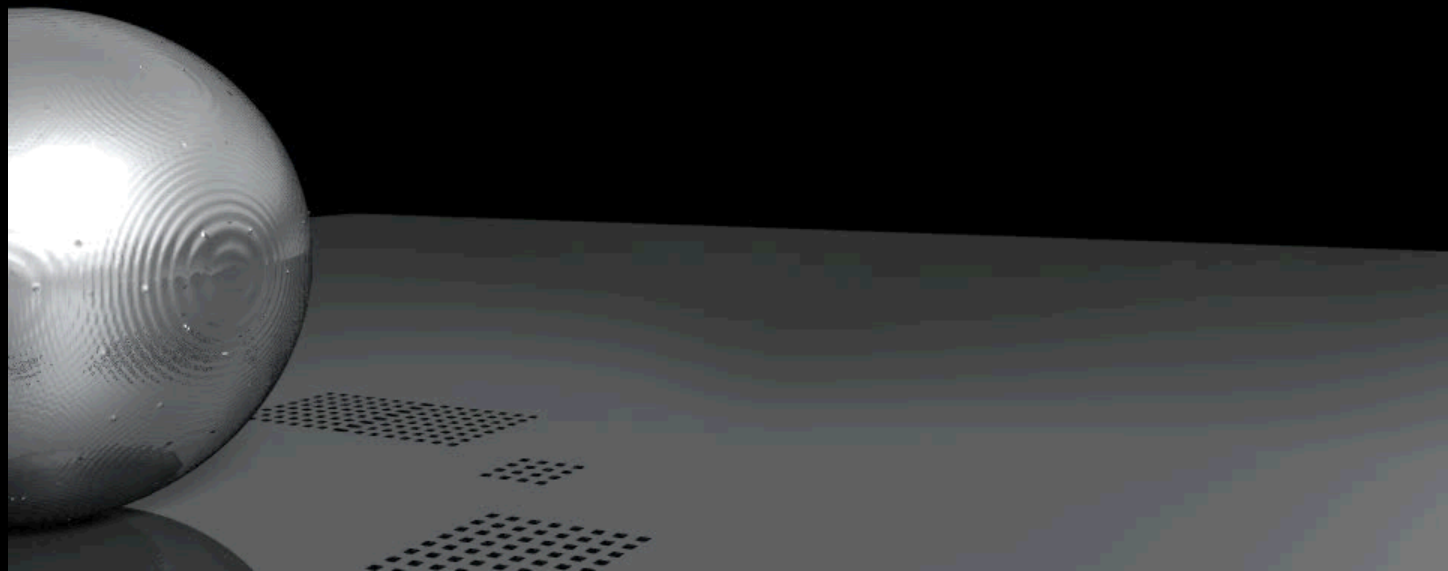
Systems	2009	2011	2015	2018
System Peak Flops/s	2 Peta	20 Peta	100-200 Peta	1 Exa
System Memory	0.3 PB	1 PB	5 PB	10 PB
Node Performance	125 GF	200 GF	400 GF	1-10 TF
Node Memory BW	25 GB/s	40 GB/s	100 GB/s	200-400 GB/s
Node Concurrency	12	32	O(100)	O(1000)
Interconnect BW	1.5 GB/s	10 GB/s	25 GB/s	50 GB/s
System Size (Nodes)	18,700	100,000	500,000	O(Million)
Total Concurrency	225,000	3 Million	50 Million	O(Billion)
Storage	15 PB	30 PB	150 PB	300 PB
I/O	0.2 TB/s	2 TB/s	10 TB/s	20 TB/s
MTTI	Days	Days	Days	O(1Day)
Power	6 MW	~10 MW	~10 MW	~20 MW

ILLUSTRATION: A. TOVEY

From J. Dongarra, "Impact of Architecture and Technology for Extreme Scale on Software and Algorithm Design," Cross-cutting Technologies for Computing at the Exascale, February 2-5, 2010.

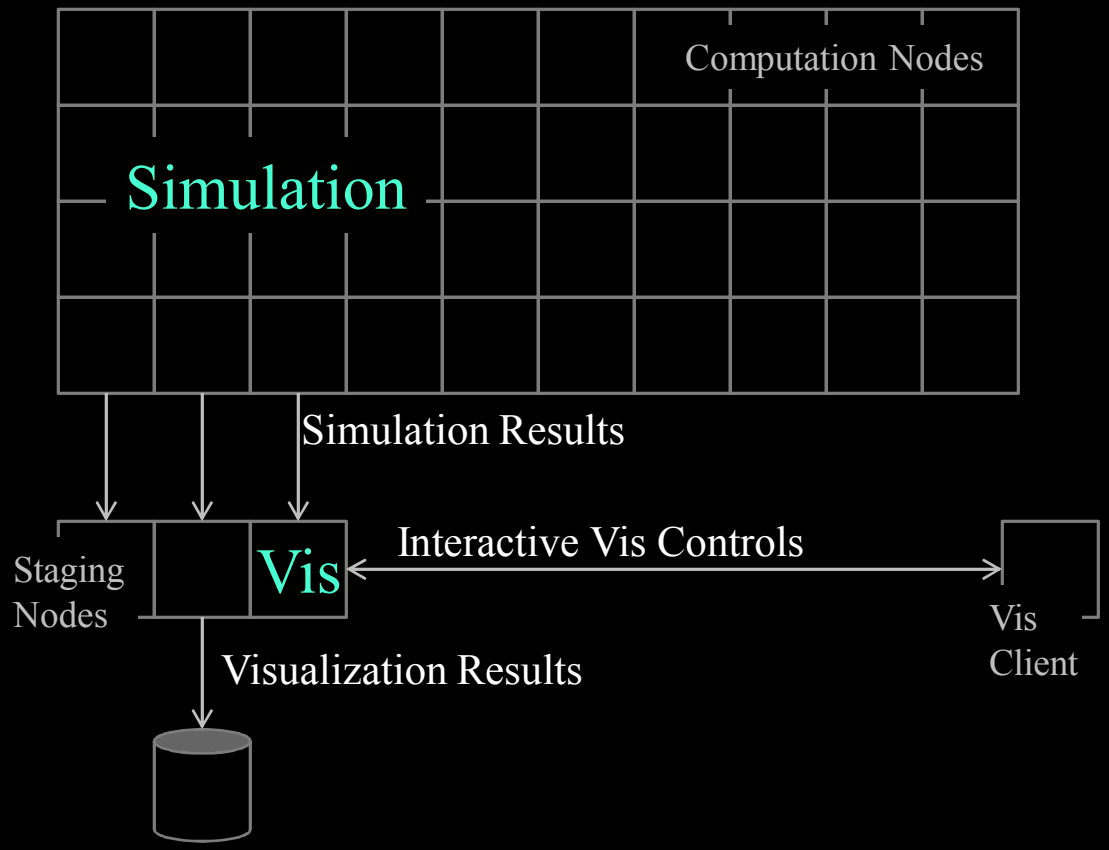


1 mesh per 100 steps
~1% write time



1 image per 1 step
~0.1% write time

	Capability	Coupling	Footprint	Transfer	Interactive
ParaView In Transit	**High**	**Loose**	~5% Extra Nodes	Hi Speed Transfer	**Yes**



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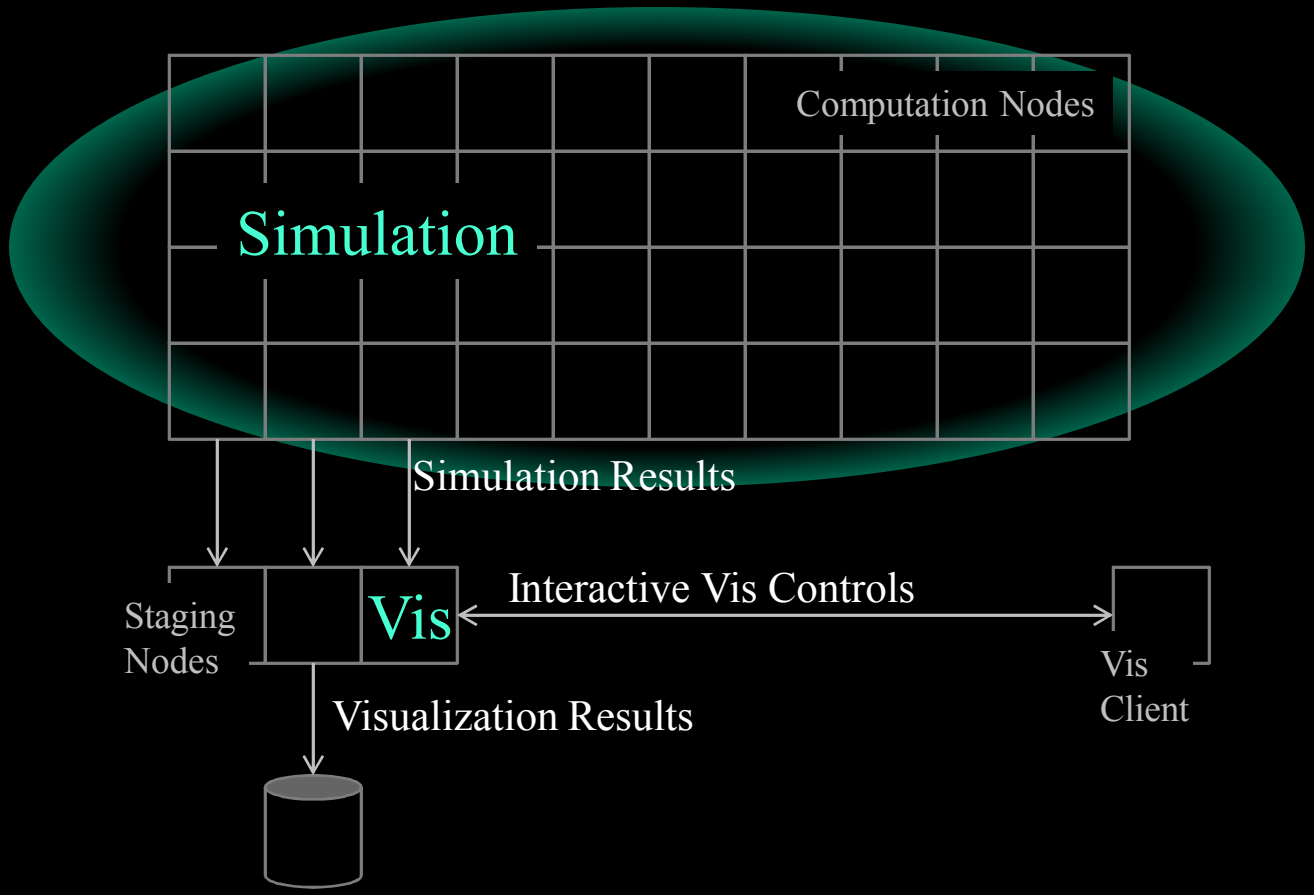

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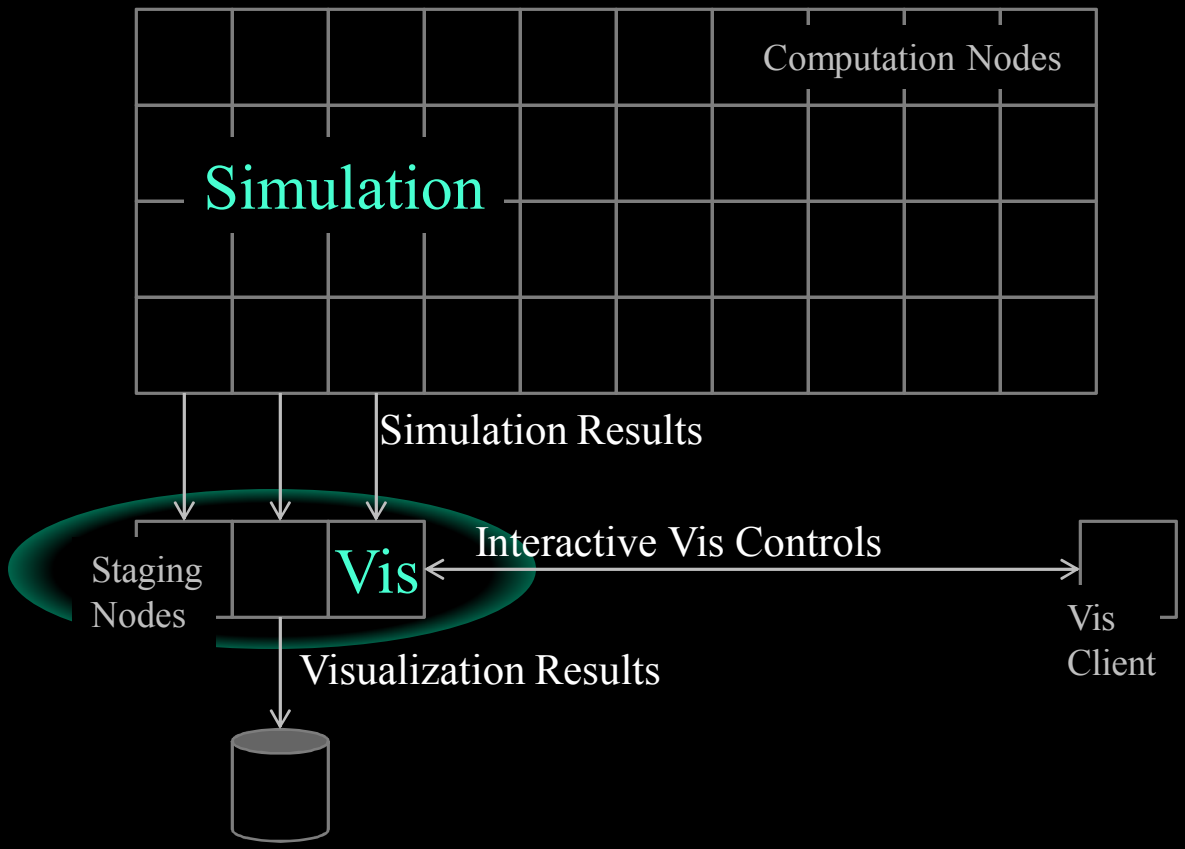

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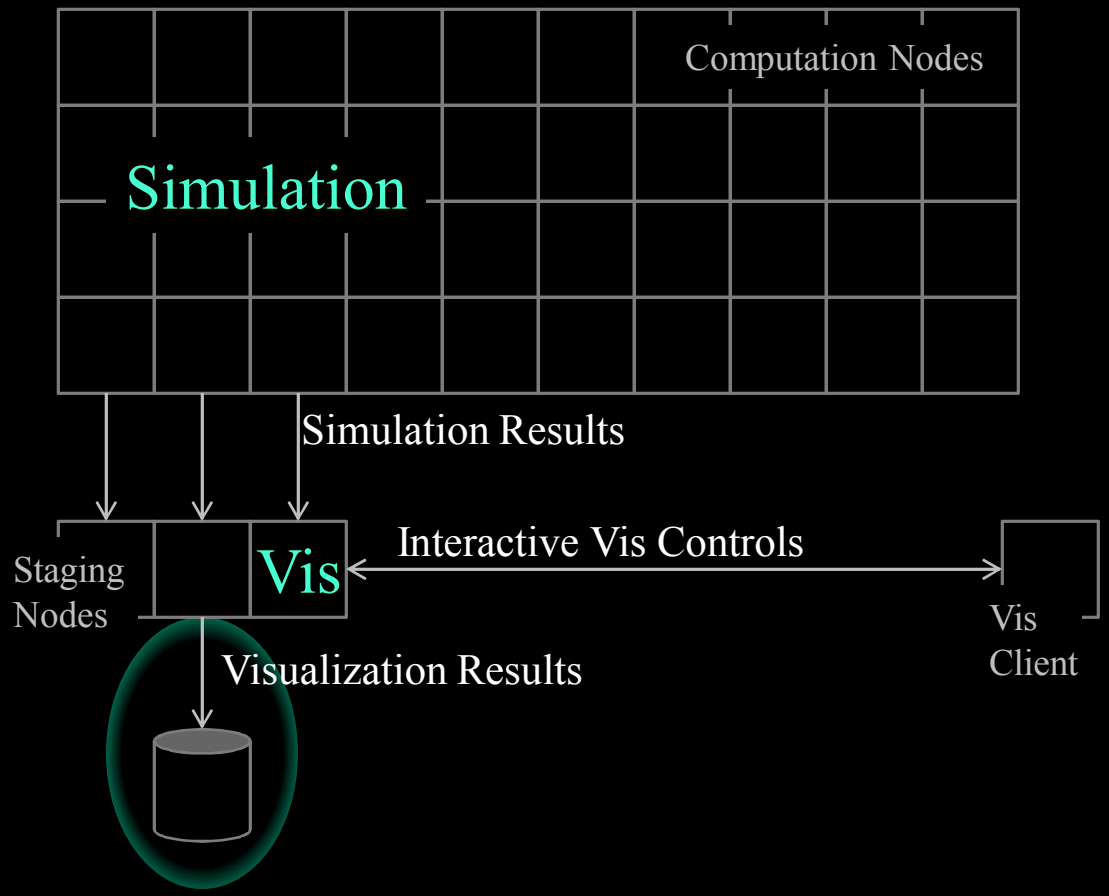

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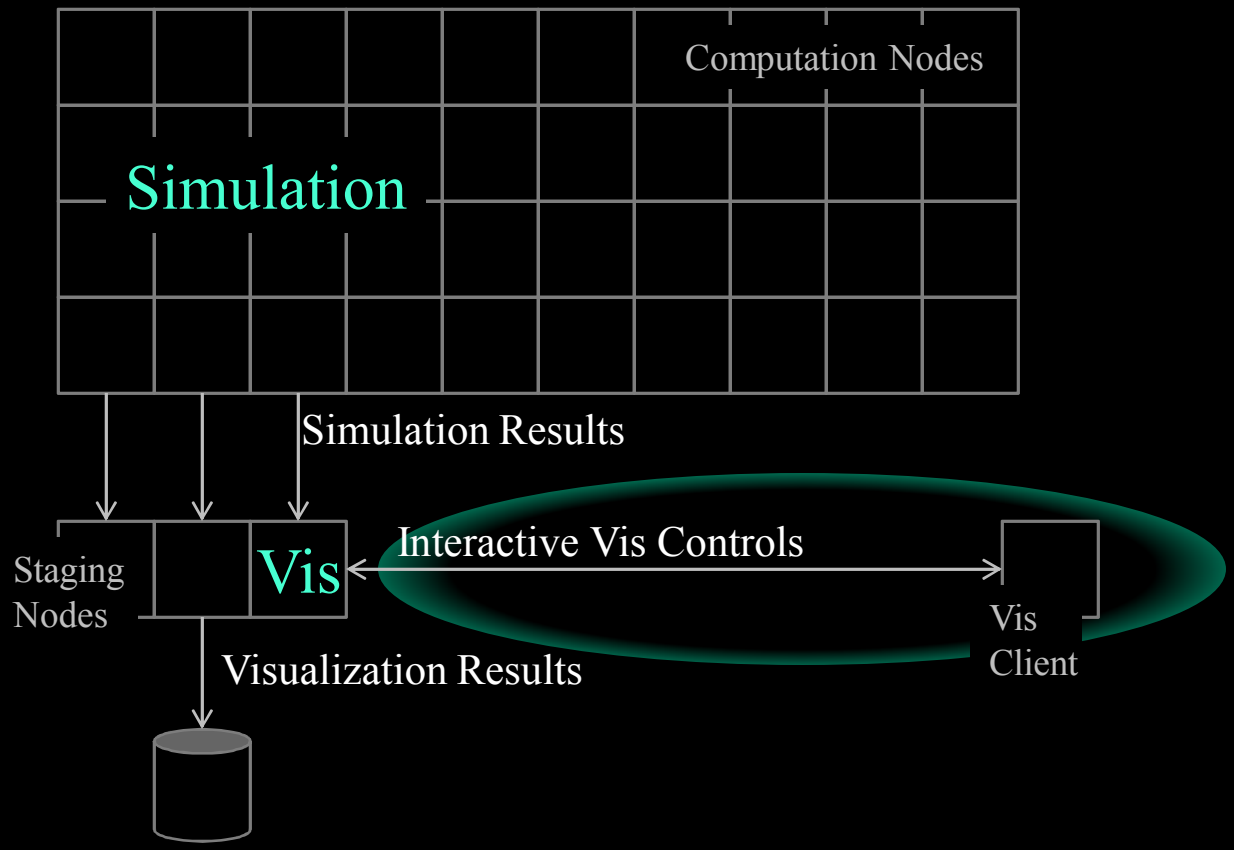

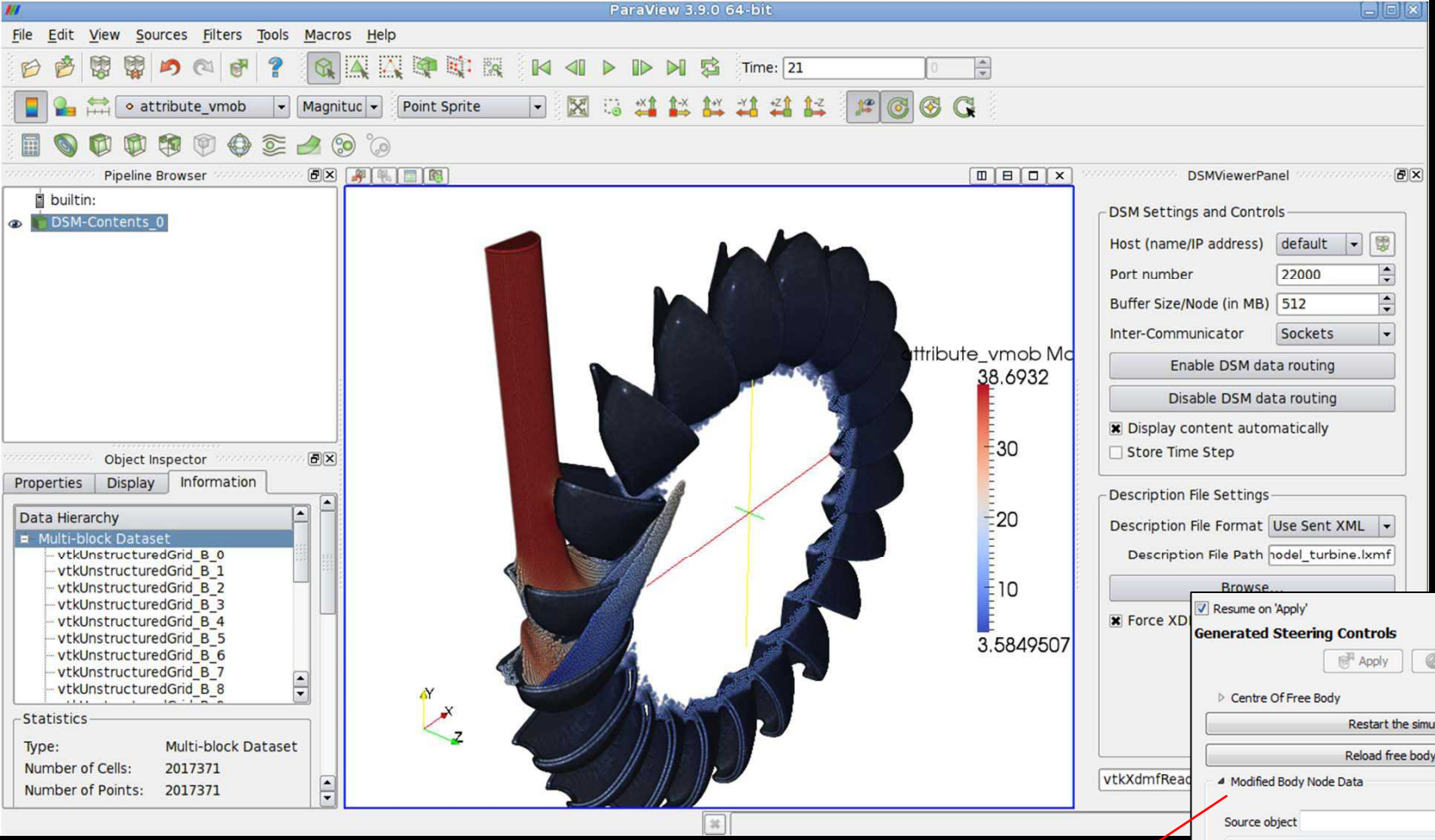

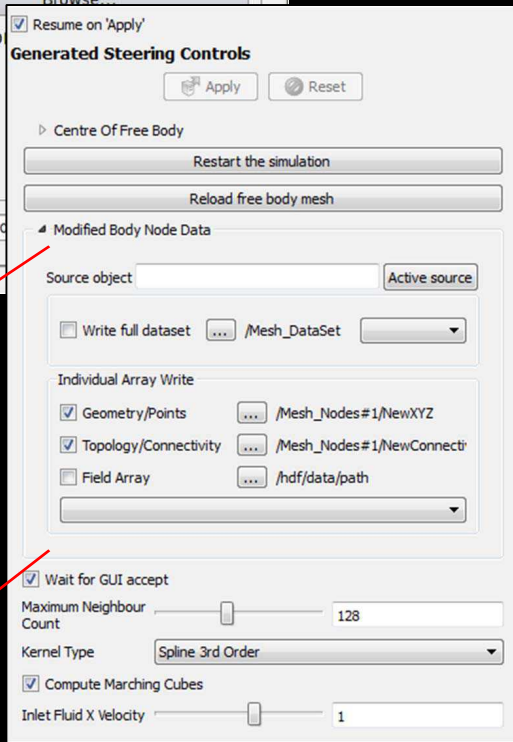


```
<DataExportProperty name="ModifiedBodyNodes"
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                    label="Modified Body Node Data">
  <DataExportDomain name="data_export"
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                    geometry_path="/Mesh_Nodes#1/NewXYZ"
                    topology_path="/Mesh_Nodes#1/NewCo..."
                    command_property="ReloadFreeBodyMesh" />
</DataExportProperty>
```

Biddiscombe, et al, "Parallel Computational Steering and Analysis for HPC Applications using a ParaView Interface and the HDF5 DSM Virtual File Driver."

Network Scalable Service Interface (NESSIE)

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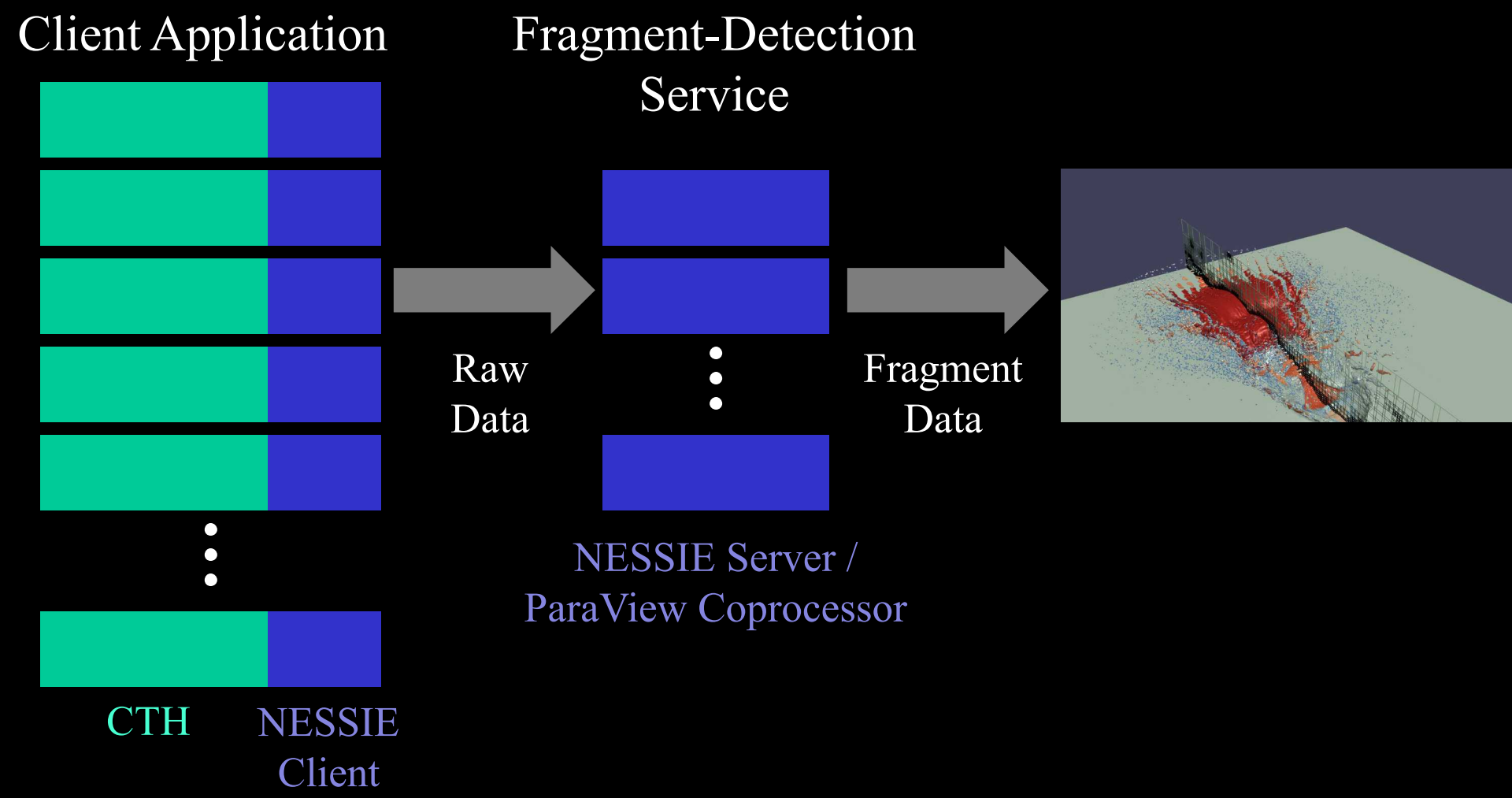
- Provides a remote-procedure call (RPC) abstraction.
- Relies on client/server stubs to marshal/unmarshal procedure call parameters.
  - Also supports data messages for raw data transfers.
- Server uses one-sided API for native remote direct-memory (RDMA).
- Used to implement:
  - File system services
  - HPC database access proxies
  - PnetCDF data staging
- Our work leverages PnetCDF data staging for in transit analysis of CTH.

NESSIE-CTH-ParaView Integration



GLEAN

- Flexible/extensible framework for simulation-time data analysis and I/O acceleration.
- Adjusts to analysis and system characteristics.
- Client/server architecture.
  - Data streams from running solver (client) to dedicated staging nodes (server).
- Integrated in ParaView via VTK reader/writer components.
  - ParaView coprocessing (in situ) library (integrated with server) uses VTK GLEAN writer (“client,” compute nodes).
  - ParaView pvserver (interactive vis service) uses VTK GLEAN reader (“server,” staging nodes).
  - Behaves like file read/write from ParaView perspective.

ParaView In Situ + Covis + Interactive Vis with GLEAN

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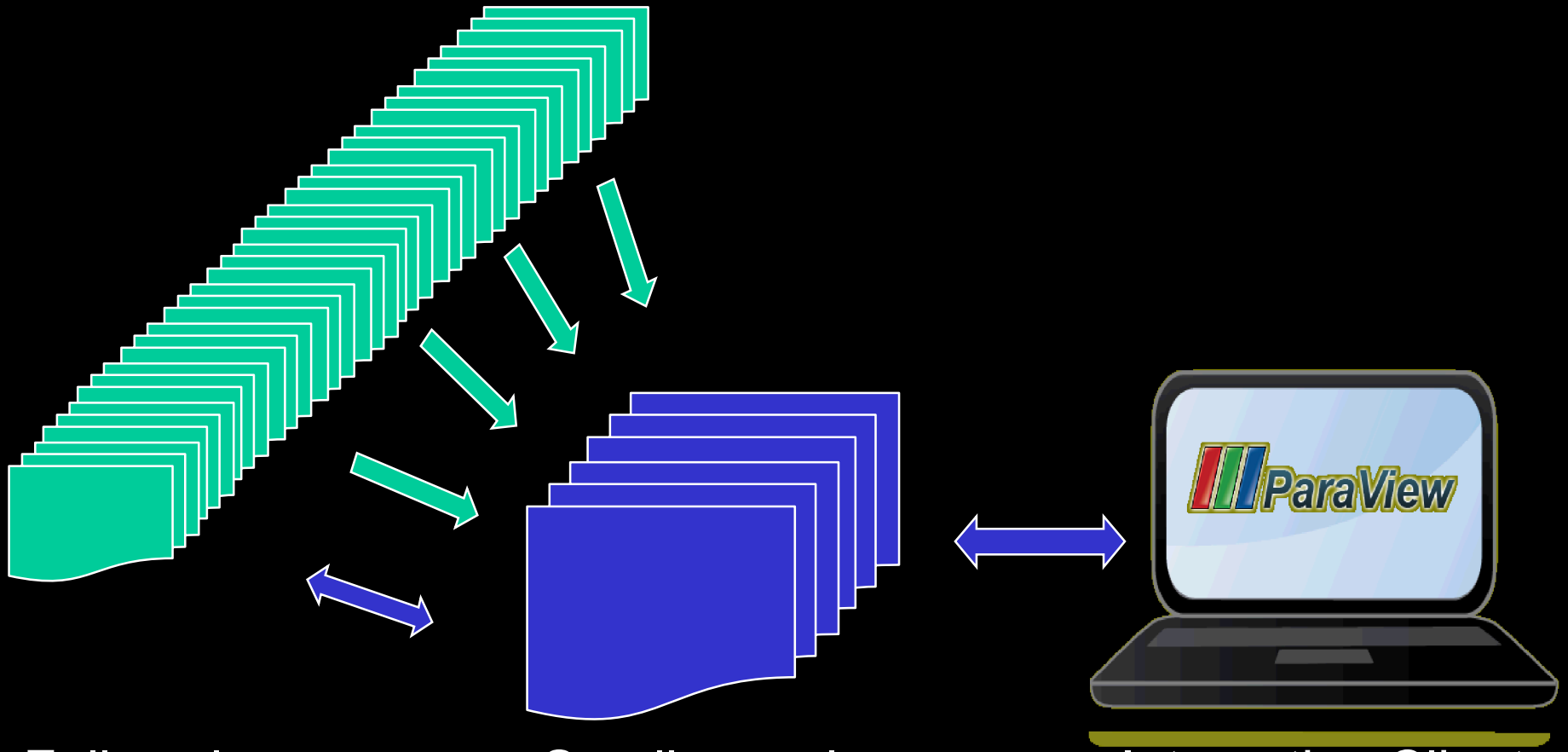
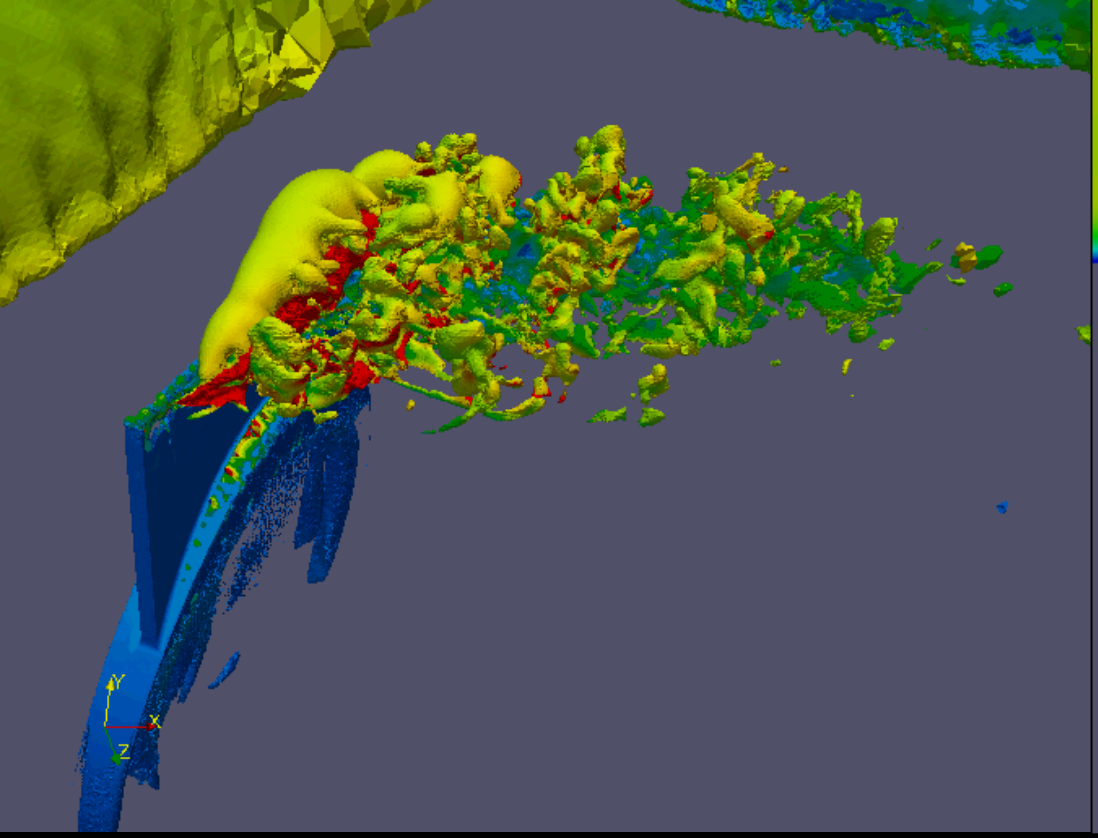
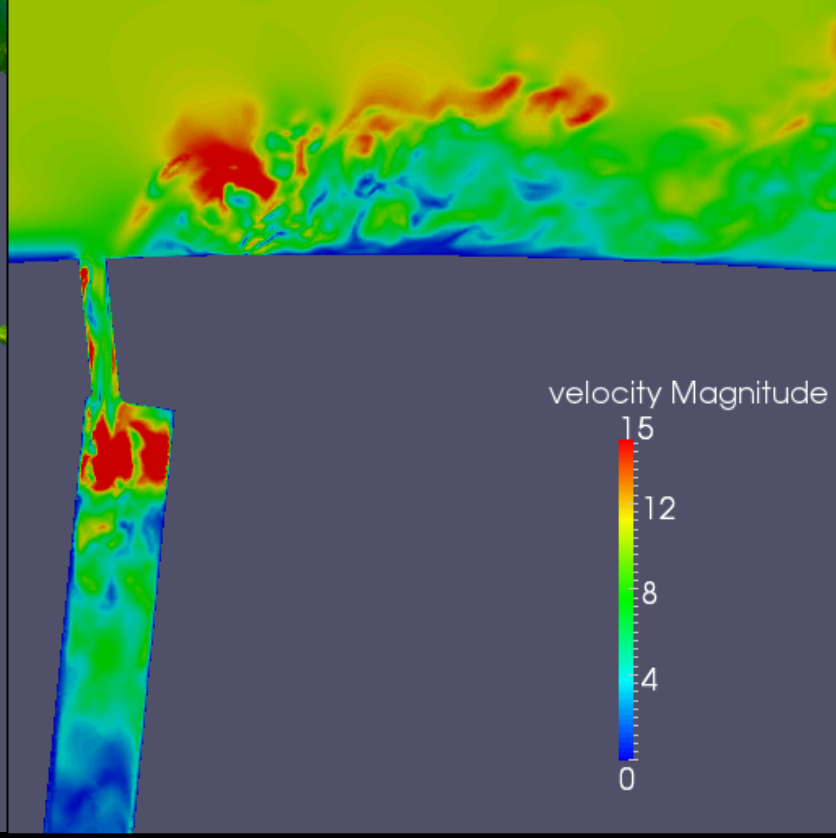


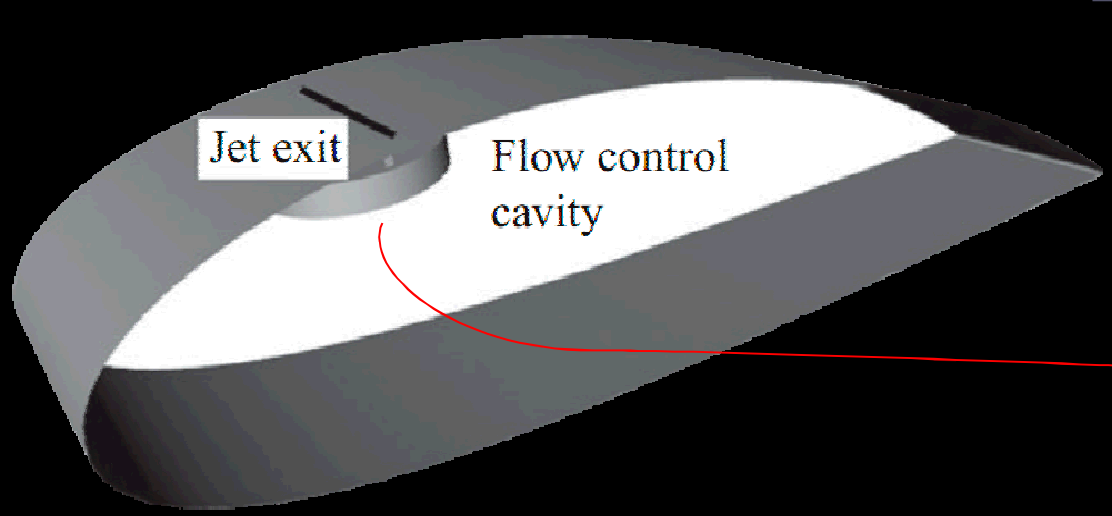
Full scale Simulation w/ In situ

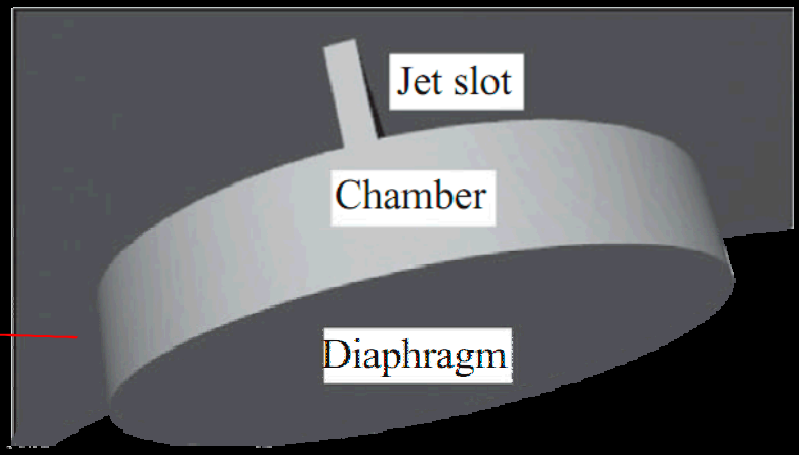
Smaller scale Covisualization

Interactive Client



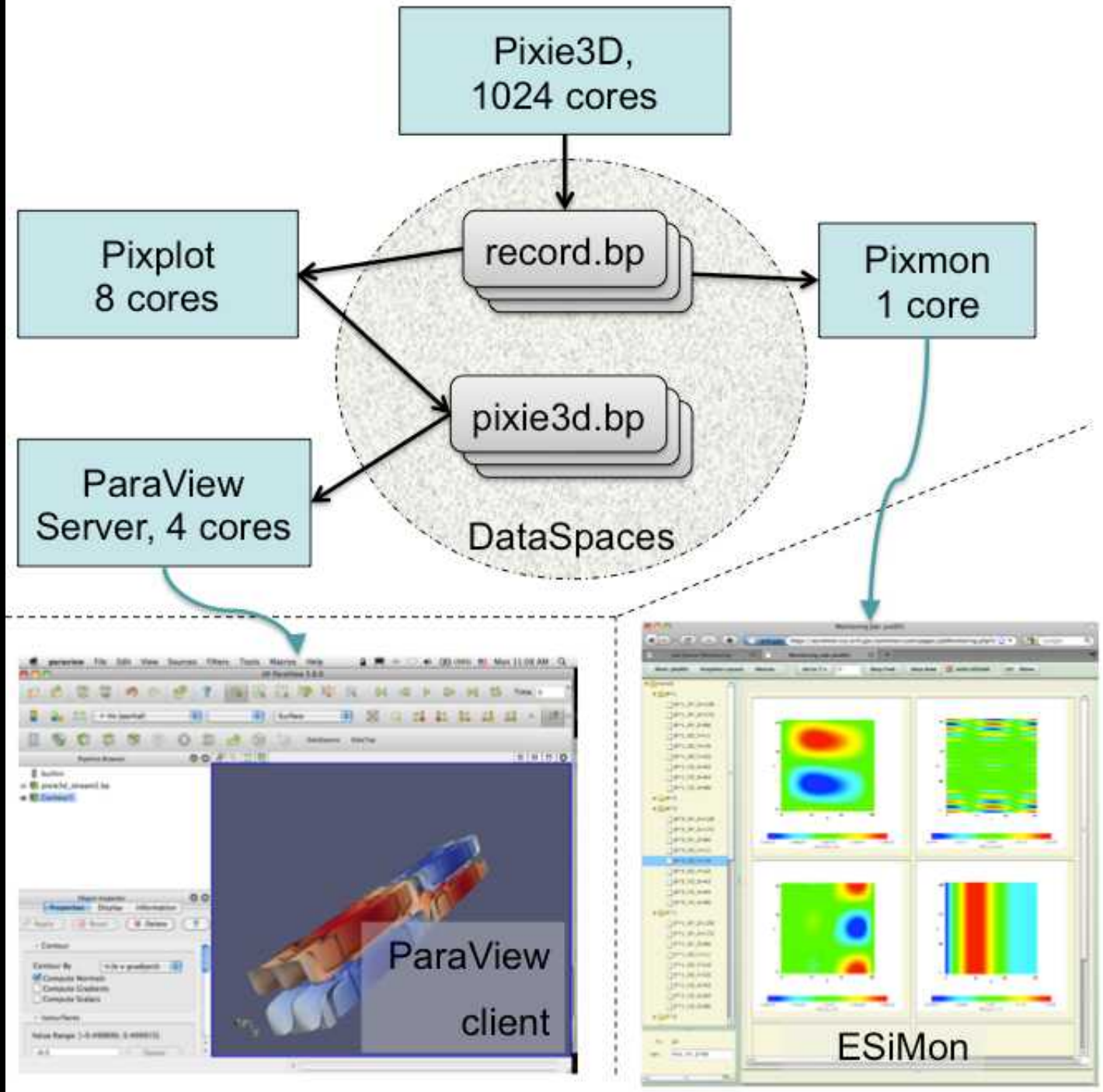

velocity Magnitude
15
12
8
4
0


Jet exit
Flow control
cavity


Jet slot
Chamber
Diaphragm

Adaptable I/O System (ADIOS)

- Separates I/O API from I/O implementation.
  - Abstracts I/O transport, destination, format.
  - Can be changed at runtime through XML file.
- Uses DataSpaces for virtual semantically-specialized shared space.
  - Location/distribution agnostic.
  - Accessed with asynchronous operations.
  - Exists as separate application – provides fault isolation.
    - Coupled codes do not bring each other down.
  - Manages multiple versions of dataset (e.g. timesteps).
    - Autonomous buffering and eviction.
- Using ADIOS for files automatically enables in transit.
  - But, change read semantics for unavailable timesteps.


Pixie3D,
1024 cores
Pixplot
8 cores
record.bp
Pixmon
1 core
pixie3d.bp
ParaView
Server, 4 cores
DataSpaces
ParaView
client
ESiMon

Conclusion

- Potential advantages of in transit visualization.
  - About everything in situ has going for it.
  - Loose coupling between simulation and visualization.
  - Fault isolation.
  - Multiple event loops / asynchronous operation.
  - Federated environment.
- Should stop thinking of I/O in terms of “files.”
  - I/O libraries should (will) progress to more general.
  - Application should stop considering data sources/sinks as static collections.
  - Applications should *not* go low level (POSIX, MPI/IO).

Shameless Promotion of Other Presentations

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Sun	1:30	TCC 205	ParaView In Situ Tutorial
Tue	10:00	ASC Booth	In Situ Visualization and Analysis
Tue	11-1	ASC Booth	ParaView Demonstrations
Tue	5:15	Poster Reception	Co-visualization of full data and in situ data extracts from unstructured grid CFD at 160k cores
Tue	5:30	TCC LL1	BoF: Next Generation I/O and visualization requirements for in situ processing
Thu	10-12	ASC Booth	ParaView Demonstrations
Thu	10:30	ASC Booth	ASC Tri-Lab Visualization on the Cielo Platform

Questions?