In Situ Visualization and Analysis

Argonne Leadership Computing Facility

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Five orders of magnitude between compute and I/O capacity on Titan Cray system at ORNL

O(2)

O(2)

O(1)

Computation
125 PB/s

Node memory
4.5 PB/s

On Node Visualization

Node memory
4.5 PB/s

Interconnect
24 TB/s

Off Node Visualization

Interconnect
24 TB/s

Interconnect
24 TB/s

Storage
1.4 TB/s

Post Hoc Visualization

Storage
1.4 TB/s

Image courtesy Ken Moreland
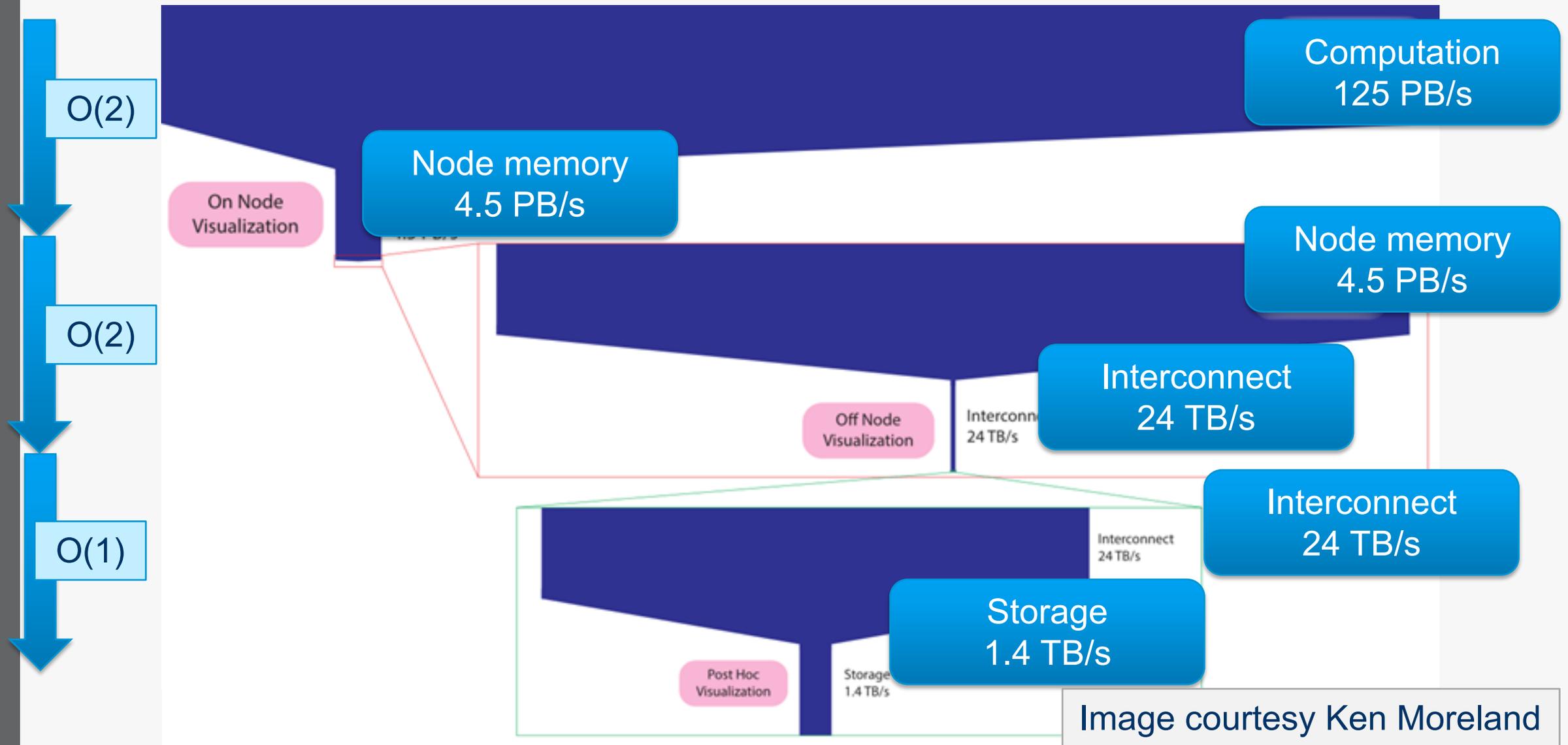
What are the problems?

- Not enough I/O capacity on current HPC systems, and the trend is getting worse.
- If there's not enough I/O, you can't write data to storage, so you can't analyze it: <u>lost science.</u>
- Energy consumption: it costs a lot of power to write data to disk.
- Opportunity for doing better science (analysis) when have access to full spatiotemporal resolution data.

Slide courtesy the SENSEI team www.sensei-insitu.org

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Two Frameworks for In Situ Vis and Analysis at ALCF

SENSEI insitu

Ascent

- "Write once, run everywhere" design
- Data model based on VTK from Kitware
- Supports a variety of backends, including ParaView/Catalyst, VisIt/LibSim, ADIOS, Python

- Flyweight design, minimizes dependencies
- Data model based on Conduit from LLNL
- Vis and analysis algorithms implemented in VTK-m

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Instrumenting Simulation Codes


```
1. initialize sim
2. if do_insitu bridge::initialize
3. do
4.    compute new state
5.    if do_io write plot file
6.    if do_insitu bridge::execute
7. while !done
8. if do_insitu bridge::finalize
9. finalize sim
```

```
//
// Run Ascent
//

Ascent ascent;
ascent.open();
ascent.publish(data);
ascent.execute(actions);
ascent.close();
```

SENSEI + ASCENT tutorial at SC19 and SC20

Slides and Virtual Machine available here:

https://sensei-insitu.org/tutorials/sc19.html

https://ix.cs.uoregon.edu/~hank/sc20/

In Situ Analysis and Visualization with

SENSEI + ASCENT tutorial accepted at SC21

Date and time TBD

Exascale Computing Project
# Software Technology Data and Visualization

Slide courtesy of the ECP ALPINE project
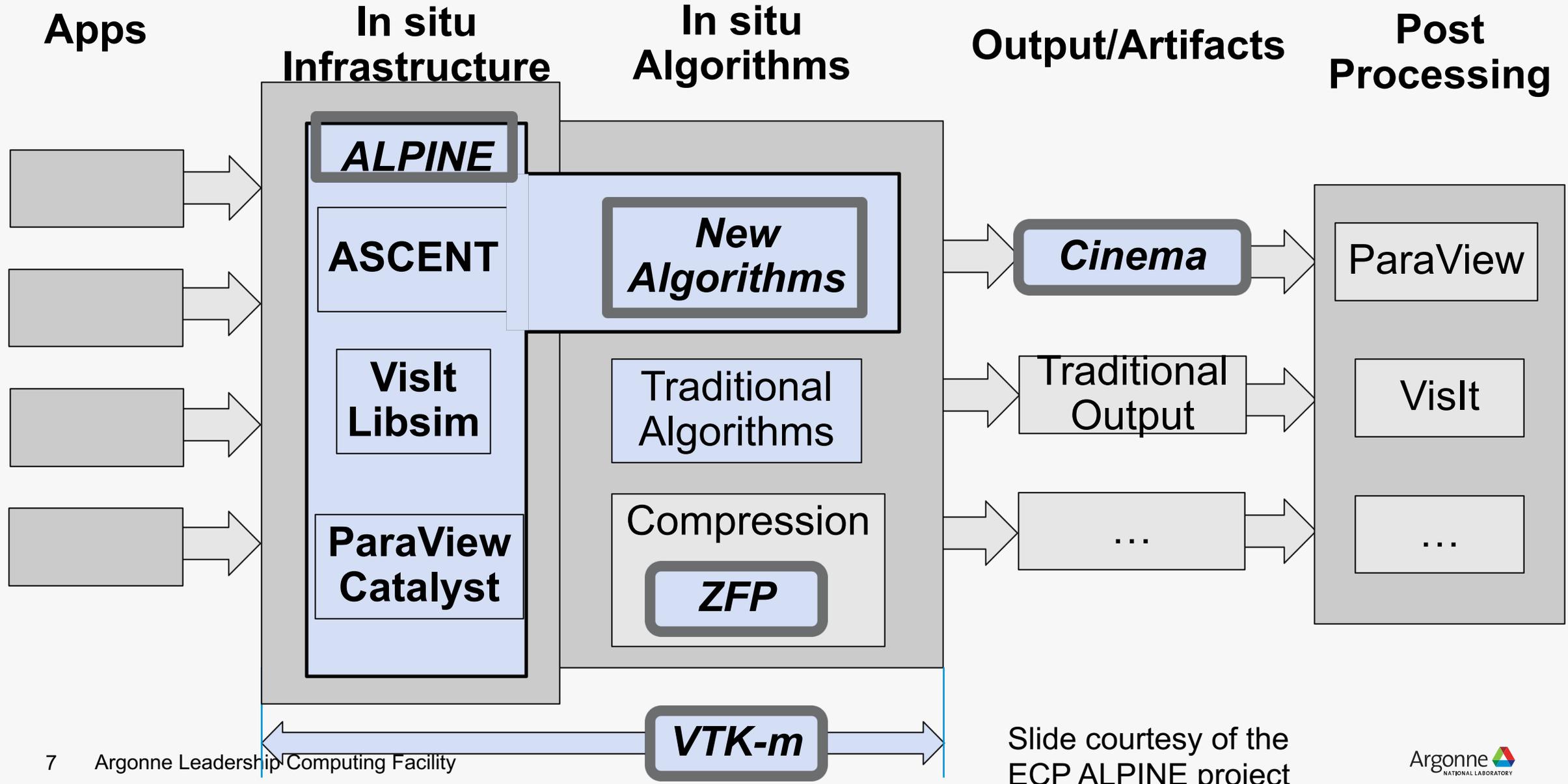
VTK-m's main thrust: a write-once-run-everywhere framework

Contour Streams Clip Render

Surface Normals Ghost Cells Warp ...

x86 CUDA Xeon Phi Radeon X^e

Demonstrated Upcoming

Slide courtesy of the ECP VTK-m project

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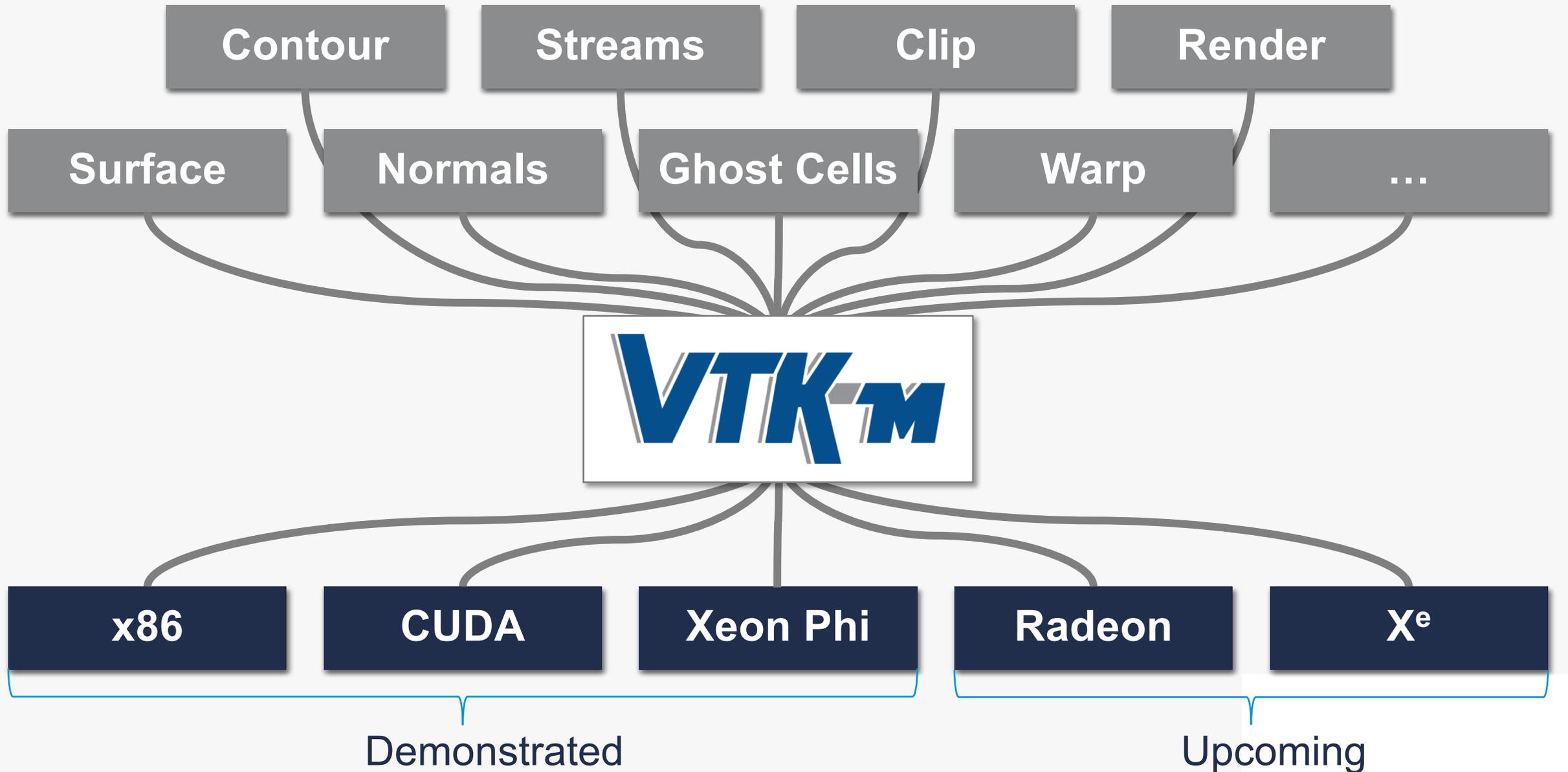
What is Cinema?

- **Cinema** is part of an integrated workflow, providing a method of extracting, saving, analyzing or modifying and viewing complex data artifacts from large scale simulations.
  - If you're having difficulty exploring the complex results from your simulation, Cinema can help.
- **The Cinema 'Ecosystem'** is an integrated set of writers, viewers, and algorithms that allow scientists to export, analyze/modify and view Cinema databases.
  - This ecosystem is embodied in widely used tools (**ParaView, VisIt, Ascent**) and the database specification.
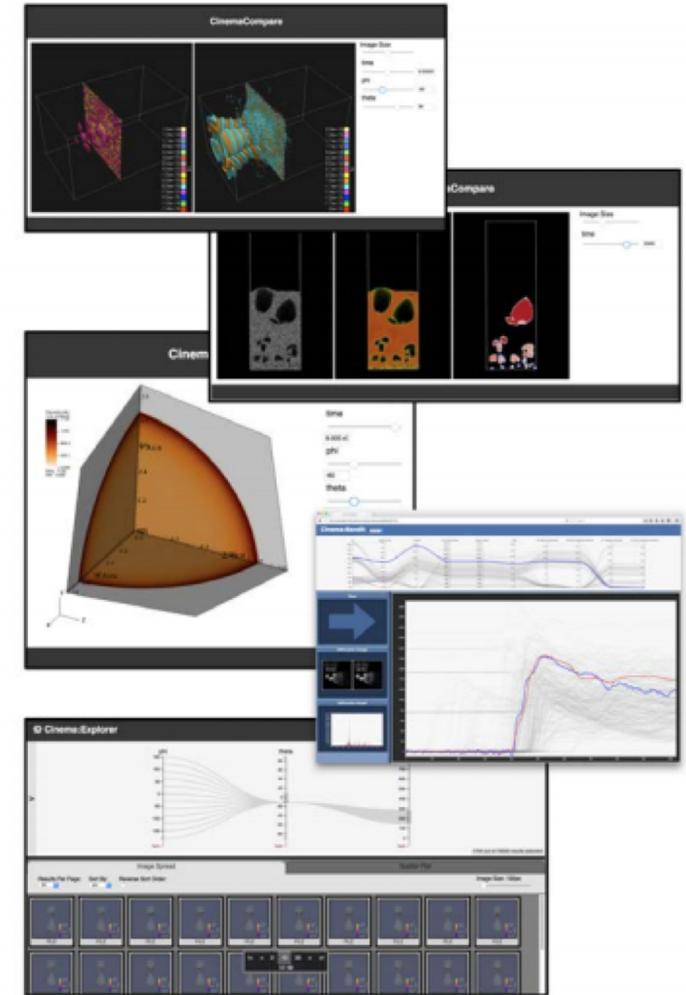
Slide courtesy of Los Alamos National Lab and the CINEMA project

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Catalyst Revised: Rethinking the ParaView In Situ Analysis and Visualization API

simulation

Catalyst Adaptor
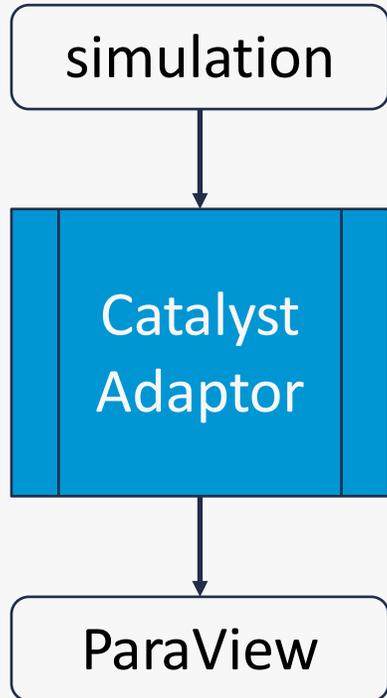
ParaView

Development challenges:
- Requires good understanding of VTK data model and APIs

Build/development challenges:
- Requires a CMake-based build system
- Requires ParaView SDK (cannot use distributed ParaView binaries)
- Simulation build tightly coupled with ParaView version used

Maintenance challenges:
- Changing APIs and data model
- Changing build system

Extracts from slide set courtesy Utkarsh Ayachit, Kitware Inc.

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Catalyst Revised: the design

Simplifying the adaptor

----> switch to Conduit

- Avoid need to understand VTK data model
- Provide mechanism to provide data with zero-copy & meta-data to interpret it

Simplifying build and deployment

- Inspired by MPICH ABI compatibility initiative
- Simulations to link against a tiny stub and allow switching of implementation at runtime

Utkarsh Ayachit, Andrew Bauer, Ben Boeckel, Berk Geveci, Ken Moreland, Patrick O'Leary, and Tom Osika: *Catalyst Revised: Rethinking the ParaView In Situ Analysis and Visualization API*, WOIV 2021

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Additional Resources

Argonne Leadership Computing Facility

Visualization Help

support@alcf.anl.gov

Publication Images & Covers

Animations

- SC Visualization Showcase [Best Vis Finalist 2014-2020]
- APS Division of Fluid Dynamics Gallery of Fluid Motion
- SC Gordon Bell Submissions
- Press Releases

InSitu Vis and Analysis
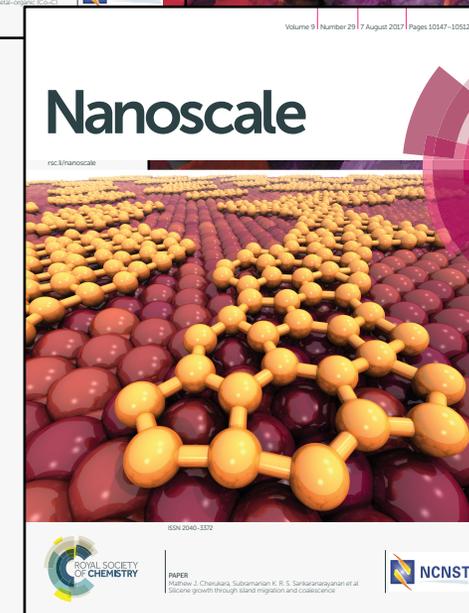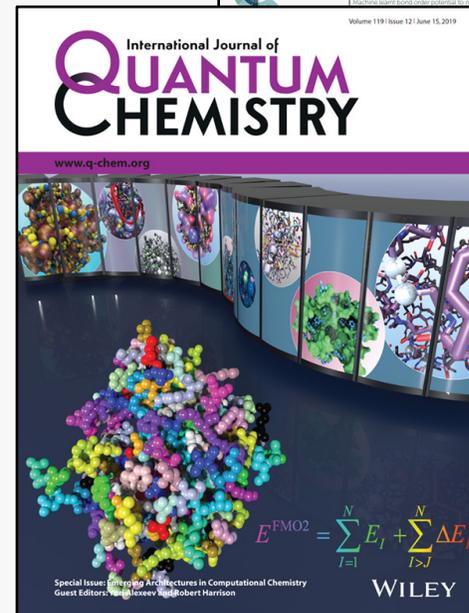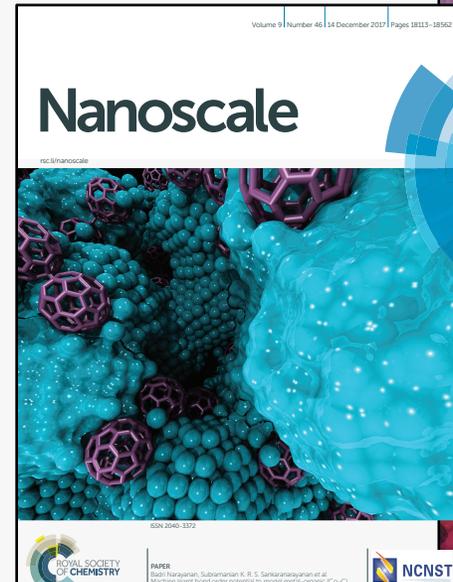
QUESTIONS?

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