Visualization and Analysis of Massive Data with VisIt

Argonne Training Program on Extreme-Scale Computing

Hank Childs, *University of Oregon and Lawrence Berkeley National Laboratory*

Cyrus Harrison, *Lawrence Livermore National Laboratory*
Outline

- VisIt Project Introduction (25 min)
  - Connecting to ALCF resources
- VisIt Demo (25 min)
- Questions (10 min)
VisIt is an open source, turnkey application for data analysis and visualization of mesh-based data.

- Production end-user tool supporting scientific and engineering applications.
- Provides an infrastructure for parallel post-processing that scales from desktops to massive HPC clusters.
- Source released under a BSD style license.
VisIt supports a wide range of use cases.

Data Exploration

Comparative Analysis

Quantitative Analysis

Visual Debugging

Presentation Graphics
Examples of VisIt’s visualization capabilities.
VisIt uses MPI for distributed-memory parallelism on HPC clusters.

Full Dataset
(27 billion total cells)

3072 sub-grids
(each 192x129x256 cells)

We are enhancing VisIt’s pipeline infrastructure to also support threaded processing.
VisIt is a vibrant project with many participants.

- The VisIt project started in 2000 to support LLNL’s large scale ASC physics codes.
- The project grew beyond LLNL and ASC with research and development from DOE SciDAC and other efforts.
- VisIt is now supported by multiple organizations:
  - LLNL, LBNL, ORNL, UC Davis, Univ of Utah, …
- Over 75 person years effort, 1.5+ million lines of code.
Analysis Example: Evolution of Vorticity

- **Goal:** Identify and track coherent vortical structures in turbulent flow as time evolves.

Collaboration with Kelly Gaither, TACC et al (IEEE CG&A July/August 2012)

*VisIt was used to calculate isosurfaces, identify connected components, and extract component features.*
**Goal:** Provide a one set of turbulence tools that can be used across multiple codes.

**Application:** Validate RANS model parameters from high fidelity DNS simulations.

Joint work with Oleg Schilling, LLNL

We are developing scripted building blocks for flow analysis, including field means and fluctuations.
## VisIt scales well on current HPC platforms.

<table>
<thead>
<tr>
<th>Machine</th>
<th>Architecture</th>
<th>Problem Size</th>
<th># of Cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graph</td>
<td>X86_64</td>
<td>$20,001^3$ (8 T cells)</td>
<td>12K</td>
</tr>
<tr>
<td>Dawn</td>
<td>BG/P</td>
<td>$15,871^3$ (4 T cells)</td>
<td>64K</td>
</tr>
<tr>
<td>Franklin</td>
<td>Cray XT4</td>
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<td>32K</td>
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<tr>
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<td>32K</td>
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<tr>
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<tr>
<td>Purple</td>
<td>IBM P5</td>
<td>$8,000^3$ (0.5 T cells)</td>
<td>8K</td>
</tr>
</tbody>
</table>

*Scaling Studies of Isosurface Extraction and Volume Rendering (2009)*

VisIt is also used daily by domain scientists.
The VisIt team focuses on making a robust, usable product for end users.

- **Regular releases (~ 6 / year)**
  - Executables for all major platforms
  - End-to-end build process script `build_visit`

- **Customer Support and Training**
  - visitusers.org, wiki for users and developers
  - Email lists: visit-users, visit-developers
  - Beginner and advanced tutorials
  - VisIt class with detailed exercises

- **Documentation**
  - “Getting data into VisIt” manual
  - Python interface manual
  - Users reference manual

*Slides from the VisIt class*
VisIt provides a flexible data model, suitable for many application domains.

- **Mesh Types:**
  - Point, Curve, 2D/3D Rectilinear, Curvilinear, Unstructured
  - Domain Decomposed, AMR
  - Time Varying

- **Fields:**
  - Scalar, Vector, Tensor, Material volume fractions, Species

VisIt currently supports over 110 file formats.
VisIt employs a parallelized client-server architecture.

Local Components

Parallel Cluster

Data Flow Network

Filter

VisIt Viewer

VisIt GUI

VisIt CLI

Python Clients

Java Clients
VisIt automatically switches to a scalable rendering mode for large data sets.

- Rendering Modes:
  - Local (hardware)
  - Remote (software or hardware)

- Beyond surfaces:
  - VisIt also provides scalable volume rendering.
VisIt’s infrastructure provides a flexible platform for custom workflows.

- **C++ Plugin Architecture**
  - Custom File formats, Plots, Operators
  - Interface for custom GUIs in Python, C++ and Java

- **Python Interfaces**
  - Python scripting and batch processing
  - Data analysis via Python Expressions and Queries.

- **Libsim library**
  - Enables coupling of simulation codes to VisIt for in situ visualization.
VisIt is used as a platform to deploy visualization research.

- Research Collaborations:
  - Algorithms research: How to efficiently calculate particle paths in parallel.
  - Scaling research: Scaling to 10Ks of cores and trillions of cells.
  - Methods research: How to incorporate statistics into visualization.

UT/TACC Subcontract

- Research Focus:
  - Next Generation Architectures
  - Parallel Algorithms

2006 – 2011

2012 – 2017

Scalable Data Management, Analysis, and Visualization
Using VisIt on Argonne ALCF Tukey

Argonne Leadership Computing Facility
an Office of Science user facility

User Guides
- How to Get an Allocation
- New User Guide
  - Accounts & Access
  - Allocations
  - Blue Gene/Q Versus Blue Gene/P
  - Mira/Cetus/Vesta
  - Intrepid/Challenger/Surveyor
  - Tukey
    - Compiling and Linking
    - ParaView on Tukey
    - Using Cobalt on Tukey

VisIt on Tukey

Getting Started
On your local machine:
- Download (https://wci.llnl.gov/codes/visit/download.html) and install VisIt (The version installed on Tukey is 2.6.2)
- Download the Tukey host profile for VisIt (you may need to right-click and choose "Save link as..." or "Save target as...")
- Copy this file to a file called "/.visit/host/profile_ani_tukey.xml (NOTE: The file extension should be changed to .xml, not .txt).

On the Tukey login host:
- Edit your .soft.tukey file to include the "@visit" key before the "@default" line

https://www.alcf.anl.gov/user-guides/visit-tukey
Using VisIt on Argonne ALCF Tukey

- Host profiles
  - Hosts
    - 0-25-0-4c-3f-aa.ceph.lbnl.us
    - ANL Cosmea
    - ANL Eureke
    - ANL Gadzooks
    - ANL TeraGrid
  - ANL Tukey:
    - MCS Login
    - NERSC Carver
    - NERSC Euclid
    - NERSC Hopper
    - ORNL Ewok
    - ORNL Jaguar
    - ORNL JaguarPF
    - ORNL Lens
    - ORNL Photon
    - ORNL Stih
    - RSMAS Enterprise
    - localhost

- Host Settings
  - Host Settings
    - parallel
    - serial

- Launch Profiles
  - New Profile
  - Delete Profile
  - Copy Profile
  - Make Default

- Settings
  - Parallel
  - GPU Acceleration

- Launch parallel engine
  - Launch
  - Advanced
  - Parallel launch method: qsub/mpirun
  - Default number of processors: 80
  - Default number of nodes: 10
  - Default Bank / Account: 60
  - Default Machine File: $COBALT_NODEFILE
VisIt Demo