Online Analytics:
Think Globally, Act Locally

“Data movement, rather than computational processing, will be the constrained resource at exascale.”

– Dongarra et al. 2011
Services

• Definition of a service
  • A data transformation
• Which services should be onlined?
  • Those that can
    • Be streamed
    • Be automated
  • Those that make sense
    • Reduce data movement
    • Provide immediate information
    • Enable later information

Streamlines in nuclear engineering

FTLE in climate modeling

Morse-Smale complex in combustion

Stream surfaces in meteorology

Phase reconstruction in X-ray microscopy

Voronoi, Delaunay tessellation in cosmology
Simple In Situ Workflow Example
Analysis of Cosmology Simulations

- Just one small part of the complete cosmology workflow
- Converts dark matter particles to an unstructured mesh
- Converts an unstructured mesh to a regular grid
- Computes statistics over the grid and visualizes the results
Intertask Programming Model: Workflow

- A directed graph of tasks and communication between them
- Graph nodes are the tasks
- Graph links are the communication

Footnotes
- Notice the graph does not have to be acyclic (digraph, not DAG)
- Think of “large tasks” (programs), not “small tasks” (threads)
- Nodes and links are parallel (parallel programs and parallel communication)
Intratask Programming Model: Block-Parallelism

1. Separate analysis ops from data ops
2. Group data items into blocks
3. Assign blocks to processes
4. Group blocks into neighborhoods
5. Handle time
6. Communicate between blocks in reusable design patterns
7. Read data and write results

Two examples of 3 out of a total of 25 neighborhoods
Software: Exascale Data Analytics Software Stack

**Applications**
- Exascale simulations, experiments, observations, ensembles

**Automation and Coordination**
- Data and Workflow Management Systems

**User Libraries and Tools**
- Analysis libraries, standard visualization/analysis packages

**Data Movement**
- **DIY** (block parallelism)
- **Decaf** (decoupled dataflows)
- Data movement within one task (DIY) and between tasks (Decaf)

**System Libraries**
- Programming model and runtime

**System Services**
- Storage systems, resource managers, schedulers
Usability

• Q: Why don’t domain scientists use online analytics?
  • Well, they do, actually. They often embed analytics as function calls directly in codes.

• Q: Why don’t domain scientists use generic middleware for online analytics?
  • Resource cost
  • Reliability
  • Learning curve and usability even later
  • Perceived value
  • Support

• Q: What can we, computer scientists, do to change that?
  • (Why) should we?
  • How?
Acknowledgments

Facilities
Argonne Leadership Computing Facility (ALCF)
Oak Ridge National Center for Computational Sciences (NCCS)
National Energy Research Scientific Computing Center (NERSC)

Funding
DOE SDMAV Exascale Initiative
DOE SciDAC SDAV Institute

People
Franck Cappello (ANL), Matthieu Dreher (ANL), Jay Lofstead (SNL),
Patrick Widener (SNL), Dmitriy Morozov (LBNL)