Scalability of Paraview’s Coprocessing Capability

Nathan Fabian
Sandia National Laboratories, Dept. 1461
ndfabia@sandia.gov

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.
What is ParaView

CUG 2011
Golden Nuggets of Discovery
Current ParaView Usage

- Used by academic, government, and commercial institutions worldwide.
  - Downloaded ~3K times/month.

- Landmarks of SNL usage:
  - 6 billion structured cells (2005).
  - 250 million unstructured cells (2005).
  - Billions of AMR cells with 100’s of thousands of blocks (2008).
  - Scaling test over 1 Trillion structured cells (2010).
ParaView Application Architecture

ParaView Client
Qt Controls

pvpython
Python Wrappings

ParaView Server
Parallel Abstractions and Controls

VTK
Core Visualization Algorithms

CUG 2011
Golden Nuggets of Discovery
Traditional Visualization Workflow is Breaking Down

Image from Rob Ross, Argonne National Laboratory

The rate of performance improvement in supercomputing systems, as measured by Linpack, since 1993 [Meuer, 2008].
Cielo Tips, updated February 22, 2011

“...remember that the sweet-spot for I/O process count is maximal at 16 K, but it drops off substantially with larger numbers of procs issuing parallel I/O transfer requests.”
What is the ParaView Coprocessing Library?
What is the ParaView Coprocessing Library?
What is the ParaView Coprocessing Library?

Simulation

ParaView Coprocessing

Output Processed Data

Polygonal Output with Field Data

Rendered Images

CUG 2011
Golden Nuggets of Discovery
What is the ParaView Coprocessing Library?
# What is the ParaView Coprocessing Library?

## Simulation

### Augmented script in input deck.

```python
# Create the reader and set the filename.
reader = servermanager.sources.Reader(FileNames=path)
view = servermanager.CreateRenderView()
repr = servermanager.CreateRepresentation(reader, view)
reader.UpdatePipeline()
dataInfo = reader.GetDataInformation()
pDinfo = dataInfo.GetPointDataInformation()
arrayInfo = pDInfo.GetArrayInformation("displacement9")
if arrayInfo:
    # get the range for the magnitude of displacement9
    range = arrayInfo.GetComponentRange(-1)
lut = servermanager.rendering.PVLookupTable()
lut.RGBPoints = 
    range[0], 0.0, 0.0, 1.0,
    range[1], 1.0, 0.0, 0.0
lut.VectorMode = "Magnitude"
repr.LookupTable = lut
repr.ColorArrayName = "displacement9"
repr.ColorAttributeType = "POINT_DATA"
```

## Script Export

### Statistics

### Series Data

### Polygonal Output with Field Data

### Rendered Images
What is the ParaView Coprocessing Library?
Solid Scaling Performance

CUG 2011
Golden Nuggets of Discovery
Coprocessing Library

**Solver**

**ParaView Server**

**Adaptor**

**Coprocessing API**

- `initialize()`
- `addPipeline(in pipeline)`
- `requestDataDescription(in time, out fields)`
- `coProcess(in vtkDataSet)`
- `finalize()`

---

CUG 2011
Golden Nuggets of Discovery
CTH

Example of 2D AMR image courtesy Wikimedia commons

Fragment detection in a simulation of an exploding pipe

CUG 2011
Golden Nuggets of Discovery
Water tight surfaces
• CTH often runs using most available memory
• Very little room for ParaView
• Solution:
  • Wrap existing VTK array
  • Maps VTK index to CTH index
  • Shallow copy the data
ParaView Streaming

http://www.kitware.com/products/html/MultiResolutionStreamingInVTKAndParaView.html

CUG 2011
Golden Nuggets of Discovery
Semi-Strong Scaling

![Diagram showing semi-strong scaling with refinement depths 4, 5, and 6. The x-axis represents cores, and the y-axis represents blocks per core. The graph shows a decrease in blocks per core as the number of cores increases for each refinement depth.]

CUG 2011
Golden Nuggets of Discovery
Low end Scaling

Refinement Depth 4
Refinement Depth 5
Refinement Depth 6

Blocks per Core vs. Cores

Seconds vs. Cores

Redsky

CUG 2011
Golden Nuggets of Discovery
High end Scaling

Cielo

CUG 2011
Golden Nuggets of Discovery
Live Data to Vis nodes

CUG 2011
Golden Nuggets of Discovery