DXT: Darshan Extended Tracing

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Outline

• Motivation

• Darshan eXtended Tracing (DXT)

• Overhead Measurement

• Case Studies

• Future Work
Motivation

- Optimizing I/O is difficult
  - Supercomputers evolve to exascale
  - Increasingly complex I/O subsystems
- The Challenge: Profiling Tools
  - Facilitate characterization of I/O activities
  - Existing tools: Darshan, ScalaIOTrace, Breeze HPC, LIOProf, LMT, etc.
- Need for a comprehensive solution.
  - More control over the resolution.
  - Minimal runtime performance impact.
  - Correlate data from multiple sources for complete picture
Darshan eXtended Tracing (DXT)

• What is Darshan?
  • I/O profiling tool from ANL deployed on many large systems.
  • Intercepts Application I/O and reports aggregate statistics

• What is “extended tracing”?
  • Enhance Darshan to (optionally) report every intercepted call.
  • Traces appear as a time series and can be post-processed offline.
  • Provide tools for applying different types of analyses to the logs.
  • Aggregate statistics and/or drill down to any level of granularity.
DXT Components

• Logging
  • Records each intercepted I/O call.
  • Request offset, length, start time, end time, MPI rank and the hostname.
  • Can be switched on or off at runtime using an environment variable.
  • Log buffer starts small and expands gradually as needed.
  • Uses compression to limit the size of the output log file.

• Analysis
  • Python script; basic analysis and visualization, but can be enhanced.
  • Correlates traces with Lustre striping information.
  • Group/filter requests by rank, host or Lustre OST.
  • Detects outliers.
DXT Overhead: IOR on Cori

- **Evaluation Environment**
  - Range from 1024 to 4096 processes
  - Interleaved I/O on a single shared file

![Graph showing execution time vs number of processes]

- Execution Time (Sec)
- Number of Processes
DXT Overhead: Varying Transfer Size

- **IOR Transfer Size**
  - Tunes the data transferred per I/O operation.
  - For constant file size, smaller transfers result in more I/O operations.
  - Larger DXT log file size due to more log entries.
Case Study: GCRM-IO

- I/O kernel of a climate code that models global atmospheric circulation.
- 256 processes write the pressure variable
  - Grid: 10, Subdomain: 4, Timesteps: 64
Case Study: GCRM-IO

- Lock contention due to false sharing.
- Due to optimistic extent-based locks granted by LDLM.

### Outliers in POSIX Write Operations

[Mean(GB/s): 1.28, Median(GB/s): 1.40]

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Case Study: HACC-IO

- I/O kernel of Hardware Accelerated Cosmology Code.
- 256 Processes write 8 billion particles to single shared file
  - ~300GB
- MPI Collective I/O performs much worse than POSIX

![Bandwidth Comparison Chart]

[Image of bandwidth comparison chart showing POSIX and Collective operations]

I/O Operations: Write, Read

Bandwidth (MB/Sec):
- POSIX
- Collective
Aliasing

• Serialization of requests during communication phase.

Contiguous (Worst Case)

Interleaved (Ideal Case)
Future Work

• DXT has landed and is available at: http://www.mcs.anl.gov/research/projects/darshan/
• First step to a comprehensive solution.
• Add more features to the analysis tool.
• Correlate data from multiple sources more effectively.
• Analysis over multiple jobs / system-wide.
• ML based adaptive caching/pre-fetching for reads.