esiwace
CENTRE OF EXCELLENCE IN SIMULATION OF WEATHER AND CLIMATE IN EUROPE

Outline

9:00am

- Infrastructure hardware: - 30 minutes -KC
  - Storage devices characteristics
  - Storage devices evolution
  - Importance of software in infrastructure
  - Resulting stack and standardization aspects
  - New applications
- Infrastructure software - 30 minutes - Sai
  - posix
  - mpi-io
  - netcdf
  - object
- Storage trend and possible futures
  - Deep and multi-tier storage hierarchy
  - Technical challenges
    - metadata, data policies, fault tolerance
    - perspective - Storage Class Memory

10:00am KC

- Introduction to Darshan - 30 minutes -
  - Why, Install, HOWTO
  - Darshan DXT

10:30am virtual break

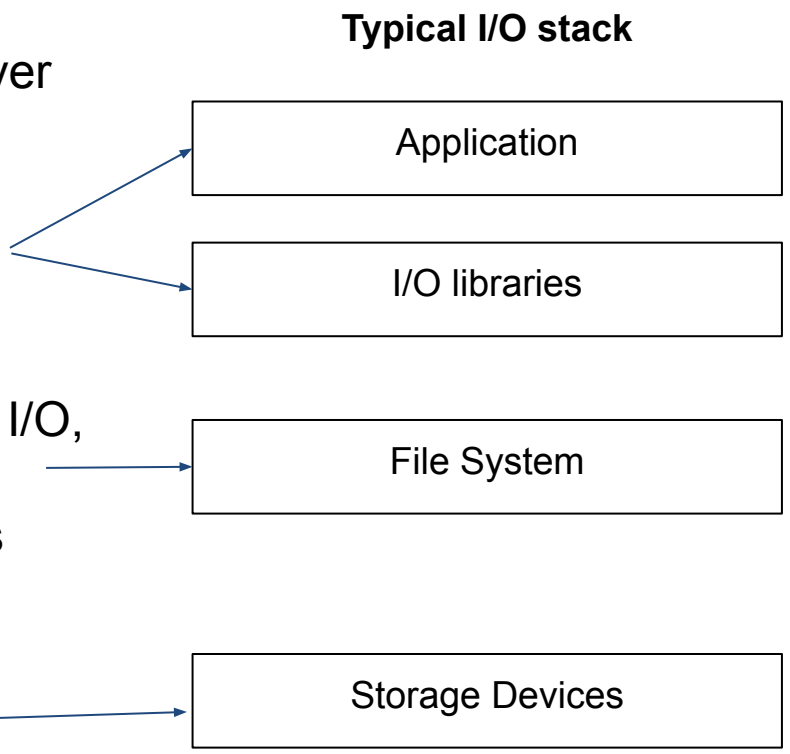
10:45am - KC

- Hands-on session - 1H -
  - 4 differents code to analyse

12:00 wrap-up

I/O tracing and monitor possibilities

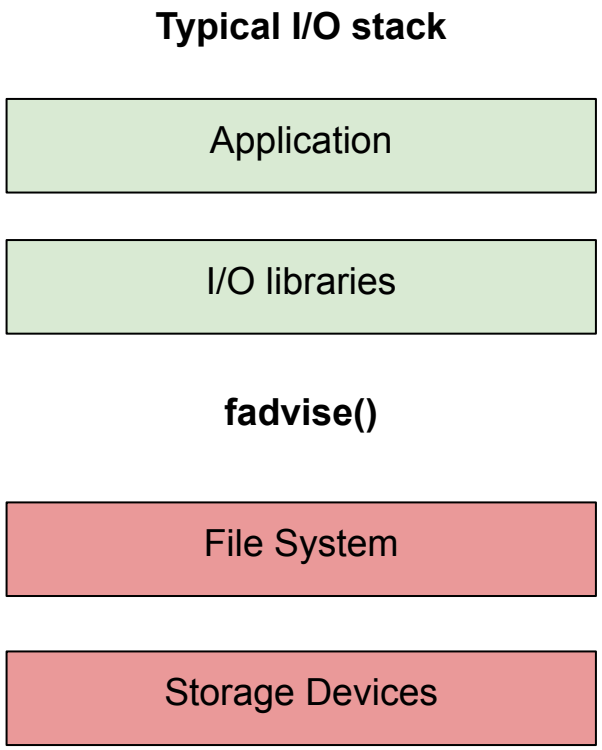
- I/O path consist of several layers
  - Different options to monitor each layer
- Applications level tracing
  - Tools: Darshan, Scalatrace etc.
- File System instrumentation
  - Not always the same as application I/O, libraries may modify the I/O pattern
  - Tools: Lustre and GPFS diagnostics
- Block device instrumentation
  - I/O requests to the actual devices
  - Tools: Linux block tracing, etc.



I/O stack tuning

- I/O the access pattern in all layer impacts performance

- Applications developers
  - Control the I/O request from the Application to the I/O libraries and the file system
  - Can **not** control how file system will internally translate their I/O requests
    - However, the **fadvice()** to pass hints for access patterns
- File System developers / System Admins
  - Control file system request to storage devices



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Application level I/O monitoring with Darshan

- What is Darshan
  - Name means “sight” or “vision” in Sanskrit
  - Lightweight, scalable I/O characterization tool
  - Transparently captures application I/O access pattern information
  - Open source library and runtime
    - Developed and maintained at Argonne National Laboratory

Key features

- Captures several I/O interfaces
  - POSIX I/O, MPI-IO, and limited HDF5 and PNetCDF
- Instrumentation on compile time or at run time
- Compatible with popular compilers and MPI implementations
- File system agnostic
  - Can be used with any file system
- Does not impact application performance in measurable way
  - Use it on production runs
- No need for applications code modification

Components

- **darshan-runtime**
  - Used to capture I/O statistics while the application is running
  - Installed on an HPC system to instrument MPI applications
    - Installation steps vary depending on the platform
- **darshan-util**
  - Use to annayle Darshan log files
  - Installed on a workstation to analyze Darshan log files
    - (log files themselves are portable)
  - Installation is generic for almost any unix-like platform

Compilation and Installation process

- System-wide (available to all users)
- User's home directory (no root access required)
  - There is no difference in functionality
- Download source code from
  - https://www.mcs.anl.gov/research/projects/darshan/download/
- `tar -zxvf darshan-$version.tar.gz`
- Compile Darshan runtime, use the same compiler as your application
  - `cd darshan-$version/darshan-runtime`
  - `./configure CC=mpicc --prefix=$installation-dir --with-log-path-by-env=DARSHAN_LOGPATH --with-jobid-env=NONE --with-mem-align=128`
  - `make && make install`
- Compile Darshan util
  - `cd darshan-$version/darshan-util`
  - `./configure --prefix=$installation-dir`
  - `make && make install`

How to use it

- The simplest method to use Darshan is to build a dynamic executable that is dynamically linked with the MPI library
  - To determine if your executable is dynamic or not:
    - `ldd a.out`
    - `libmpi.so.1 => /$inst_path/libmpi.so.1 [ ... ]`
- Set log path directory
  - `export DARSHAN_LOGPATH=./`
- Then prefix the MPI execution command with the Darshan library
  - `LD_PRELOAD=$path/libdarshan.so mpirun -np 4 a.out`
- Each job instrumented with Darshan produces a single log file
  - Application must call MPI_Finalize() to generate the log file
- Darshan command line utilities are used to analyze these log files
- Online doc:
  - https://www.mcs.anl.gov/research/projects/darshan/docs/darshan-runtime.html

Log file analysis tools

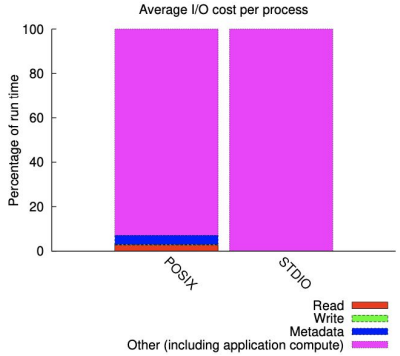
- **darshan-job-summary.pl**
  - creates pdf file with graphs useful for initial analysis
  - packages needed: Perl, pdflatex, epstopdf, and gnuplot
- **darshan-summary-per-file.sh**
  - similar to above, but creates a separate pdf file for each file opened by the application
- **darshan-parser**
  - dumps all information into ascii (text) format

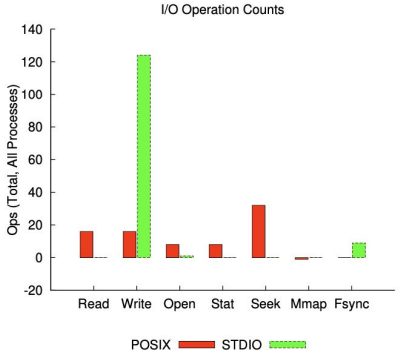
- Online documentation at
  - https://www.mcs.anl.gov/research/projects/darshan/docs/darshan-util.html

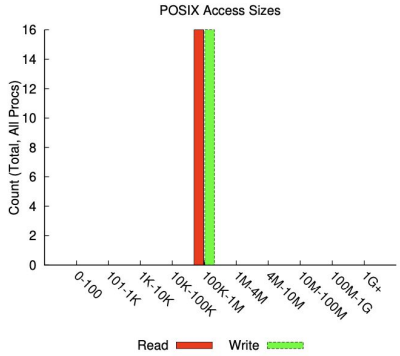
Darshan job summary example

jobid: 202545	uid: 1008	nprocs: 4	runtime: 1 seconds

I/O performance *estimate* (at the POSIX layer): transferred 8.0 MiB at 101.99 MiB/s
I/O performance *estimate* (at the STDIO layer): transferred 0.0 MiB at 2.71 MiB/s







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Darshan job parser example

#<module>	<rank>	<record id>	<counter>	<value>	<file name>	<mount pt>	<fs type>
POSIX	-1	22..36	POSIX_OPENS	8	file	/home	nfs4
POSIX	-1	22..36	POSIX_FILENOS	0	file	/home	nfs4
POSIX	-1	22..36	POSIX_DUPS	0	file	/home	nfs4
POSIX	-1	22..36	POSIX_READS	16	file	/home	nfs4
POSIX	-1	22..36	POSIX_WRITES	16	file	/home	nfs4
POSIX	-1	22..36	POSIX_SEEKS	32	file	/home	nfs4
POSIX	-1	22..36	POSIX_STATS	8	file	/home	nfs4
POSIX	-1	22..36	POSIX_MMAPS	-1	file	/home	nfs4
POSIX	-1	22..36	POSIX_FSYNCS	0	file	/home	nfs4
POSIX	-1	22..36	POSIX_MODE	436	file	/home	nfs4
POSIX	-1	22..36	POSIX_BYTES_READ	4194304	file	/home	nfs4

Darshan eXtended Tracing (DXT) module

- “Advanced” Darshan to report every intercepted call
- Not on by default, to enable
  - export DXT_ENABLE_IO_TRACE=1
- I/O Traces appear as a time series
- Special tool for post process analysis
  - darshan-dxt-parser
- Provide tools for applying different types of analyses to the logs.
- Provides different levels of granularity
  - DXT_TRIGGER_CONF_PATH environment variable to notify DXT of the path of the configuration file
    - file triggers: trace files based on regex matching of file paths
    - rank triggers: trace files based on regex matching of ranks
    - dynamic triggers: trace files based on runtime analysis of I/O characteristics (e.g., frequent small or unaligned I/O accesses

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darshan-dxt-parser example output

```
# ************************************************
# DXT_POSIX module data
# ************************************************

# DXT, file_id: 16457598720760448348, file_name: /tmp/test/testFile
# DXT, rank: 0, hostname: shane-thinkpad
# DXT, write_count: 4, read_count: 4
# DXT, mnt_pt: /, fs_type: ext4
# Module    Rank  Wt/Rd  Segment        Offset       Length    Start(s)      End(s)
 X_POSIX      0  write       0             0       262144      0.0029      0.0032
 X_POSIX      0  write       1        262144       262144      0.0032      0.0035
 X_POSIX      0  write       2        524288       262144      0.0035      0.0038
 X_POSIX      0  write       3        786432       262144      0.0038      0.0040
 X_POSIX      0   read       0             0       262144      0.0048      0.0048
 X_POSIX      0   read       1        262144       262144      0.0049      0.0049
 X_POSIX      0   read       2        524288       262144      0.0049      0.0050
 X_POSIX      0   read       3        786432       262144      0.0050      0.005
```

Other darshan tools

- **darshan-convert:**
  - converts an existing log file to the newest log format
- **darshan-diff:**
  - provides a text diff of two Darshan log files, comparing both job-level metadata and module data records between the files
- **darshan-analyzer:**
  - walks an entire directory tree of Darshan log files and produces a summary of the types of access methods used in those log files
- **dxt_analyzer**:
  - plots the read or write activity of a job using data obtained from Darshan's DXT modules (if DXT is enabled)

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Hands on tutorial

- Download virtual machine
  - https://rb.gy/n82oex
- Download sample applications
  - https://github.com/kchasapis/esiwace_demo_darshan

Guidelines for optimizing I/O

- Large request size
- Avoid single shared file for parallel file systems
- Sequential I/O performs always better
- For MPI-I/O Collective I/O results in better performance

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