

# I/O-500 Status

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# The Virtual Institute for I/O

## Goals of the Virtual Institute for I/O

- Provide a platform for I/O researchers and enthusiasts for exchanging information
  - Offers info pages for each group
  - Lists information about existing I/O benchmarks together with samples
- Foster training and international collaboration in the field of high-performance I/O
  - Support the community to establish conventions and standards
- Track and encourage the deployment of large storage systems by hosting information about high-performance storage systems



<https://www.vi4io.org>

# Goals of the IO-500 Benchmarking Effort

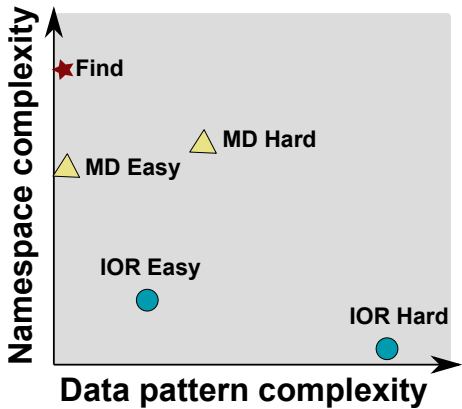
- Foster paradigm shift from compute centric perspective to I/O
- Bound performance expectations for realistic workloads
- Track storage system characteristics behavior over the years
  - Foster understanding of storage performance development
  - Support to identify potent architectures for certain workloads
- Document and share best practices
  - Tuning of the system is encouraged
  - Submitters must submit detailed run parameters
- Support procurements, administrators and users

# IO-500 Requirements

## Requirements of the benchmarking

- **Representative:** for optimized or naive workloads
  - Describe the natural requirements for users
  - IO-easy: upper bound for optimized IO-heavy workloads
  - IO-hard: expected performance for non-optimized applications
  - MD-easy, MD-hard: likewise but cover small-objects/metadata
- **Inclusive:** cover various storage technology and non-POSIX APIs
  - At best: useful for HPC and Big Data workloads
- **Trustworthy:** representative results and prevent cheating
- **Cheap:** easy to run and short benchmarking time (in the order of minutes)

# Covered Access Patterns



- IOR-easy: optimal (large sequential) performance on POSIX files
- IOR-hard: small random performance on a shared POSIX file
- MD-easy: mdtest, per rank directory, with empty files
- MD-hard: more complex metadata operations on 3900 byte files
- find: query and filter files based on name and creation time
- Executing different patterns currently not covered (another dimension)

# Benchmarking Phases

## 1 Create

- 1 IOR-easy write
- 2 IOR-hard write
- 3 MD-easy create
- 4 MD-hard create

## 2 Access

- 5 IOR-easy read (ranks shifted!)
- 6 MD-easy stat
- 7 IOR-hard read (ranks shifted!)
- 8 MD-hard stat
- 9 find files

## 3 Cleanup

- 10 MD-easy remove
- 11 MD-hard remove

### Fixed parameters used:

```
ior_easy="-C -Q 1 -g -G 27 -k -vv -e -F $ior_easy_params \\
-o $workdir/ior_easy/ior_file_easy"
# -W (validation) NOT for testing runtime
```

```
ior_hard="-C -Q 1 -g -G 27 -k -vv -e -t 47000 -b 47000 \\
-s $ior_hard_writes_per_proc -o ${workdir}/ior_hard/IOR_file"
# -W (validation) NOT for testing runtime
```

```
md_easy="-v -u -L -F -u -n $mdtest_easy_files_per_proc \\
-d ${workdir}/mdt_easy"
```

```
md_hard="-t -F -w 3900 -e 3900 -n $mdtest_hard_files_per_proc \\
-d ${workdir}/mdt_hard"
```

# Benchmarking Rules

## Parameterization

- Users may change / provide additional parameters to tune the easy cases
- Runtime for write/create phase at least 5 minutes
  - An autotuning script to determine parameters is provided
- All tests must use the same number of ranks/nodes
- No other changes to IO-500 script allowed
- Proposed usage:
  - Create a batch script that sets tunable parameters
  - It may precreate directory options to optimize (e.g., striping settings)
  - Source the io-500 script to have benchmarks run

# Benchmarking Rules

## Submission

- One submission per configuration allowed !
- Provide the starter (batch) script
- Submit all data describing the supercomputer, storage and run via VI4IO
- Results are immediately visible on the high-performance storage list
  - HPSL: community-managed list tracking many (theoretic) characteristics
  - <http://www.vi4io.org/hpsl/>
- The IO-500 steering committee will periodically curate the results
  - Release them on <https://io500.org>



## Resulting Metrics

- For initial ranking: compute geometric mean for IOR and MD
  - Initial ranking:  $\text{geom\_mean}(\text{IOR}) \cdot \text{geom\_mean}(\text{MD})$
  - Alternative: convert IOR TP to IOOPs, harmonic mean...
- Support flexible ranking on the list, e.g., memory capacity / MD-easy  
See demo: <https://www.vi4io.org/hpsl/sorting>

### Tuning for improving the Geom-Mean value

Description	Input (11 values)	Geom	Arithmetic	Harmonic
Balanced system	... 10 10 <b>10</b>	10	10	10
One slow bench	... 10 10 <b>1</b>	8.1	9.2	5.5
Tuning worst 2x	... 10 10 <b>2</b>	8.6	9.3	7.3
Tuning good 2x	... 10 <b>20 1</b>	8.6	10.1	5.6
Tuning good 100x	... 10 <b>100 1</b>	10	17.4	5.8

Geom mean honors tuning equally, insensitive to “outliers”

# Next Steps

## IO500

- Running IO500 on more systems (currently: DKRZ + KAUST)
- Scripts are available here: <https://github.com/VI4IO/io-500-dev>
- Checking alternative for MD-hard, the md-real-io benchmark
- Enable extension "modules" for IO-500, e.g., concurrent workloads, I/O kernels

VI4IO aims to support dev. of community benchmarks, e.g., via roadmaps

## High-Performance Storage List

- Towards data center list with benchmarking results
- Support subcomponents for compute, e.g., 50 nodes with special equipment
- Support multiple benchmarking reports for cluster/storage

*You are welcome to participate in the VI4IO and the IO-500 efforts, <https://io500.org>*

# History of the IO-500

- Dec. 2015: The High-Performance Storage list has been created
  - Contains a simple approach to store sustained performance
- June 2016: Talks from Lofstead, Kunkel about benchmarking during ISC BoF
- Nov. 2016: joint BoF from Kunkel, Bent, Lofstead during SC
- Nov. 2016: Creation of a mailing list for subsequent discussion
  - There have been discussions about the approach, benchmarks
- June 2017: BoF during ISC presenting approach, benchmarks, rules

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- Mid 2017: Selected runs on Top500 sites
- Nov. 2017: Show results during SC in a BoF

# Collected Information on the HPSL for Performance

## Peak Performance

- Theoretical value based on hardware limits
  - e.g. network (server) throughput, SATA limits
- Best performance of one server x number of servers.
- Describe in the text how the peak is computed

## Sustained Performance

- Actually observed performance with an application or benchmark
- You can use any benchmark and measurement protocol
- Just make sure you are not measuring cache effects
- Describe in the text how the value has been measured