LANL SciDAC Petascale Data Storage Institute Operational Data Releases

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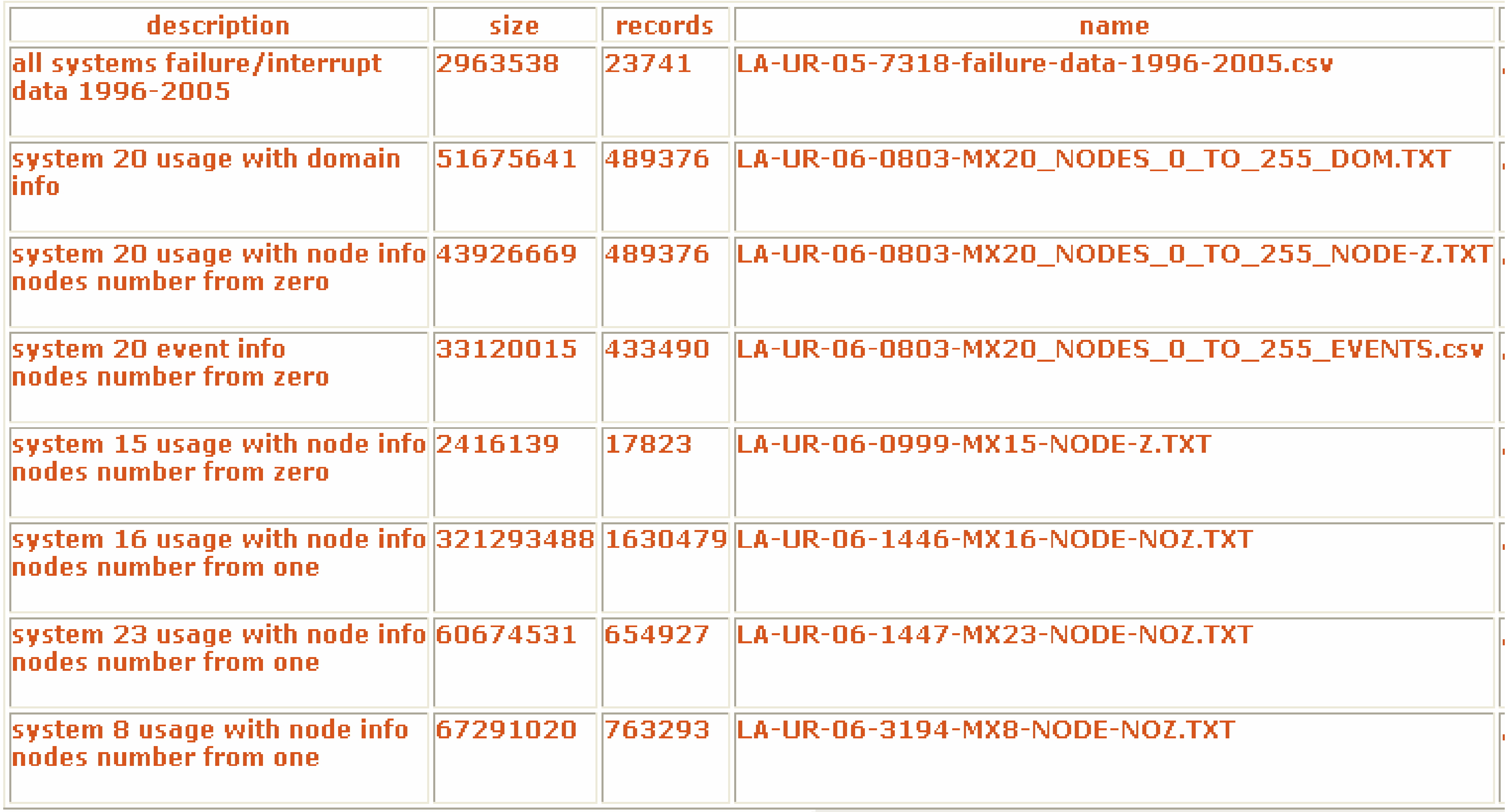
Publicly Available Data from LANL Supercomputers

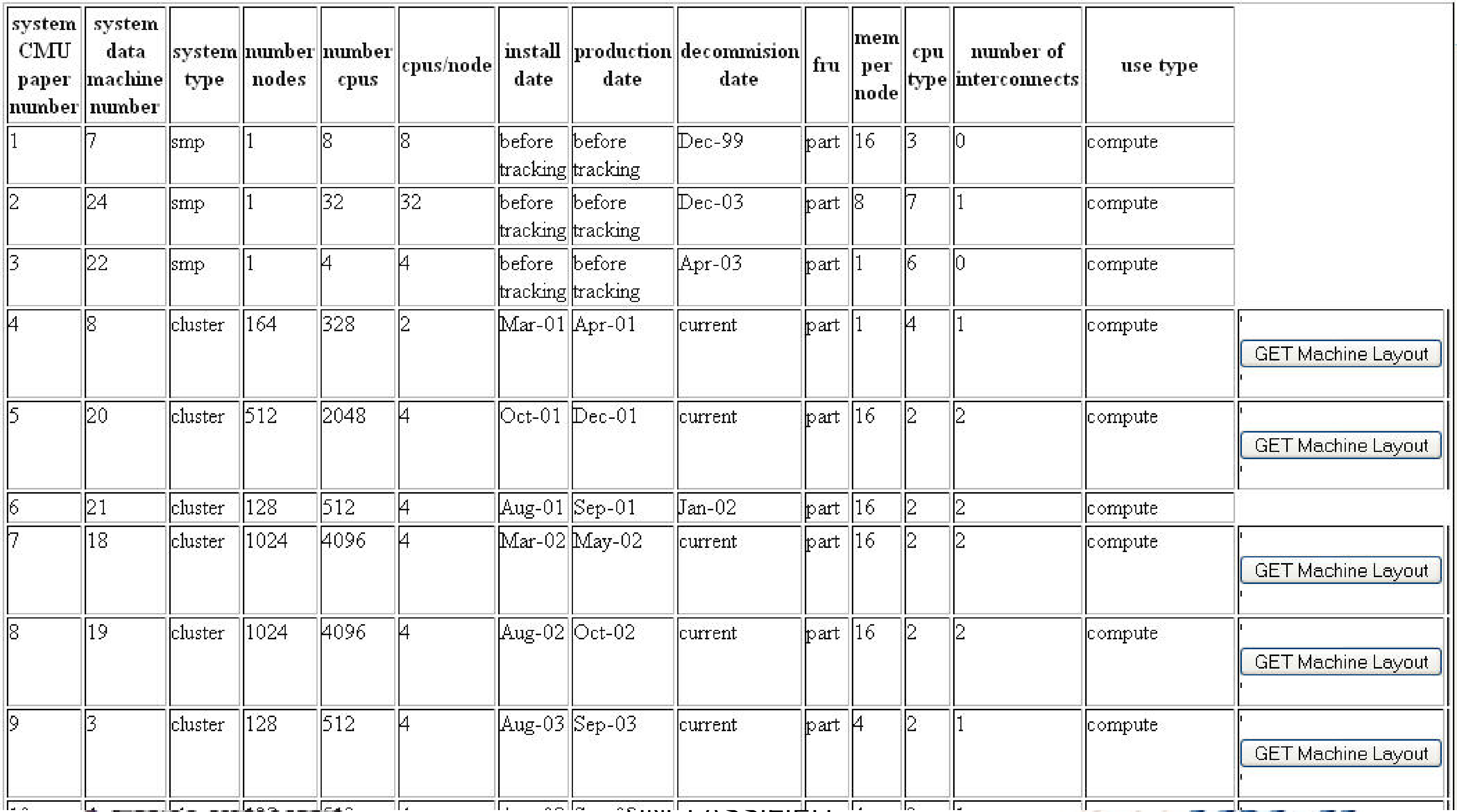
- **Available Data**
  - Nine years of computer operational failure data, over 23,000 records for several thousand machines
  - Several million usage records (job size, processors/machines used, duration, time, etc.)
  - Disk failure data for a single Supercomputer
  - Machine Layout Information (Building, room, Rack location in room, node location in rack, hot/cold rows, etc.)
- **Recently Released Data**
  - I/O Traces of MPI-IO Based Synthetic Application
- **In-Progress**
  - Disk failure, node and scratch file system, data for several Supercomputer
  - Hundreds of workstation File Systems Statistics Information
- **Soon to be Released Data**
  - Physics Application I/O Traces

Failure/Usage/Event Data Sets From LANL Supercomputers



description	size	records	name
all systems failure/interrupt data 1996-2005	2963538	23741	LA-UR-05-7318-failure-data-1996-2005.csv
system 20 usage with domain info	51675641	489376	LA-UR-06-0803-MX20_NODES_0_TO_255_DOM.TXT
system 20 usage with node info nodes number from zero	43926669	489376	LA-UR-06-0803-MX20_NODES_0_TO_255_NODE-Z.TXT
system 20 event info nodes number from zero	33120015	433490	LA-UR-06-0803-MX20_NODES_0_TO_255_EVENTS.csv
system 15 usage with node info nodes number from zero	2416139	17823	LA-UR-06-0999-MX15-NODE-Z.TXT
system 16 usage with node info nodes number from one	321293488	1630479	LA-UR-06-1446-MX16-NODE-NOZ.TXT
system 23 usage with node info nodes number from one	60674531	654927	LA-UR-06-1447-MX23-NODE-NOZ.TXT
system 8 usage with node info nodes number from one	67291020	763293	LA-UR-06-3194-MX8-NODE-NOZ.TXT

Machine Information:
23 LANL Supercomputers



system CMU paper number	system data machine number	system type	number nodes	number cpus	cpus/node	install date	production date	decommision date	fru	mem per node	cpu type	number of interconnects	use type	
1	7	smp	1	8	8	before tracking	before tracking	Dec-99	part	16	3	0	compute	
2	24	smp	1	32	32	before tracking	before tracking	Dec-03	part	8	7	1	compute	
3	22	smp	1	4	4	before tracking	before tracking	Apr-03	part	1	6	0	compute	
4	8	cluster	164	328	2	Mar-01	Apr-01	current	part	1	4	1	compute	GET Machine Layout
5	20	cluster	512	2048	4	Oct-01	Dec-01	current	part	16	2	2	compute	GET Machine Layout
6	21	cluster	128	512	4	Aug-01	Sep-01	Jan-02	part	16	2	2	compute	
7	18	cluster	1024	4096	4	Mar-02	May-02	current	part	16	2	2	compute	GET Machine Layout
8	19	cluster	1024	4096	4	Aug-02	Oct-02	current	part	16	2	2	compute	GET Machine Layout
9	3	cluster	128	512	4	Aug-03	Sep-03	current	part	4	2	1	compute	GET Machine Layout

Sample Machine Layout Information

```
Machine 8, bldg 1, room 1
,RackPosition,RackPosition,Position in Rack,Row facing
NODE NUM,East/West,North/South,Vertical Position,Single row cluster
N#,1 to 26,28 to 35,"1 to 37, top to bottom",
1,23,28,1,rear to N/Hot
2,23,28,2,rear to N/Hot
3,23,28,3,rear to N/Hot
4,23,28,4,rear to N/Hot
5,23,28,5,rear to N/Hot
6,23,28,6,rear to N/Hot
7,23,28,7,rear to N/Hot
8,23,28,8,rear to N/Hot
…
159,23,34,19,rear to N/Hot
160,23,34,20,rear to N/Hot
161,23,34,21,rear to N/Hot
162,23,34,22,rear to N/Hot
163,23,34,23,rear to N/Hot
164,23,34,24,rear to N/Hot
```

File Systems Statistics Survey

- **Based on CMU/Panasas File System Statistics Survey (fsstats)**
- **Purpose**
  - Develop better understanding of file system components
  - Gather and Build large db of static file tree statistics
- **Usage**
  - Parallel statistics collection with LANL’s MPI-File Tree Walk
  - DB query interface
- **LANL Data**
  - Production file system statistics from LANL Supercomputers & Testbeds
  - Hundreds of statistics from backups of workstations Lab-wide
- **Output: Histogram and statistics on**
  - File Size
  - Capacity Used
  - Directory Size
  - File Name Size

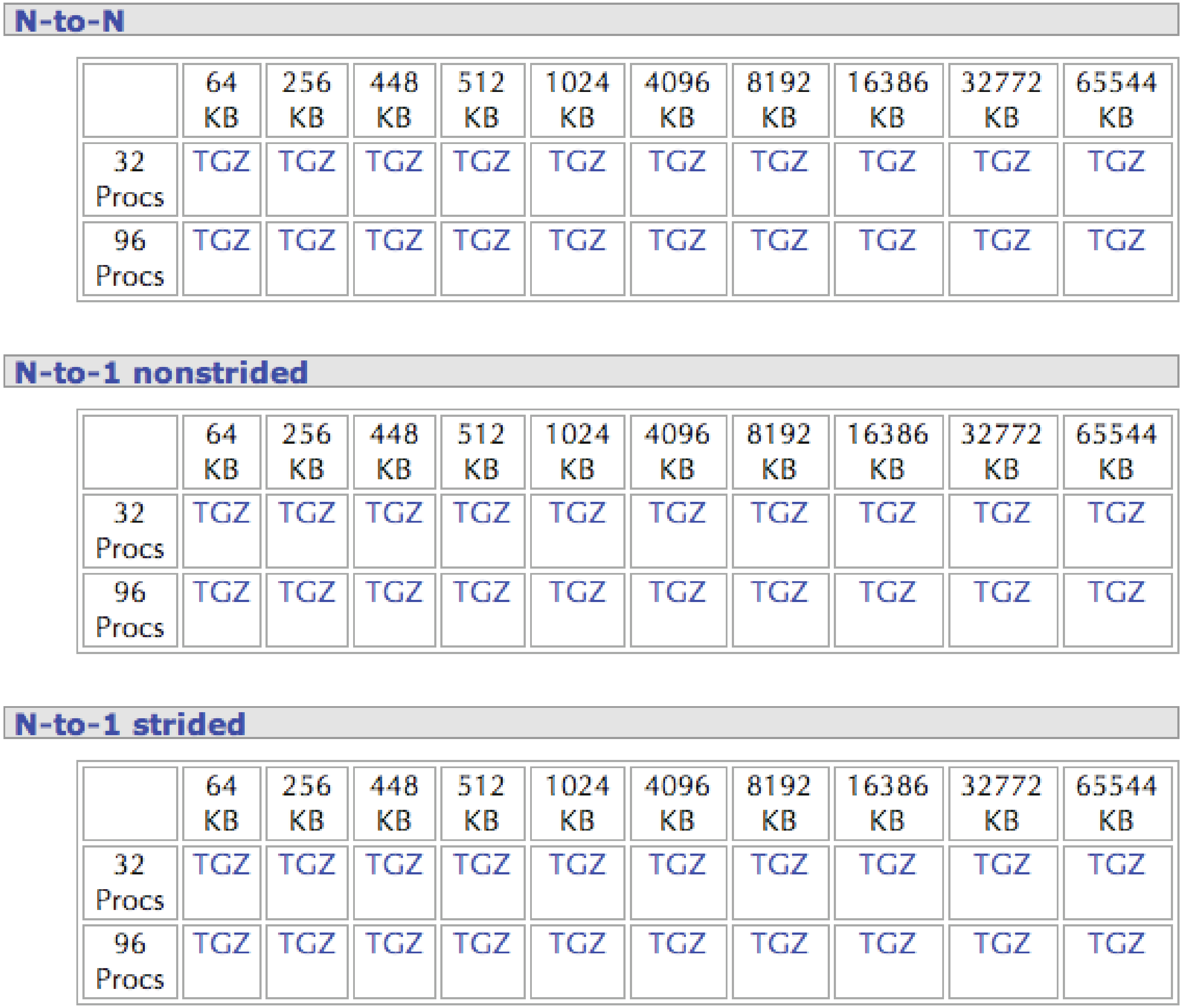
Sample File Systems Statistics Survey

```
histogram,file size
count,2400,items
average,195.763750,KB
min,0,KB
max,18629,KB
bucket min,bucket max,count,percent,cumulative pct
0,2,14,0.005833,0.005833
2,4,20,0.008333,0.014167
…
histogram,filename length
count,48175,items
average,19.143830,chars
min,0,chars
max,164,chars
bucket min,bucket max,count,percent,cumulative pct
0,7,4150,0.086144,0.086144
8,15,24112,0.500509,0.586653
16,23,10512,0.218204,0.804857
…
```

Tracing Mechanisms and Trace Data

- **Desired Attributes in a Trace Mechanism**
  - Minimum overhead
  - Bandwidth preserving
- **Methods being Reviewed**
  - Linux ltrace/strace
  - Tracefs from SUNY Stony Brook
- **Information Collected**
  - Time Stamps to detect node clock skew and drift
  - Library and system calls and summery information
  - Listing of directories
- **Traces Availability**
  - Available Now - Traces of Open Source Benchmark: MPI-IO based synthetic
  - Real Physics Application I/O Traces

Tracing Mechanisms and Trace Data



N-to-N

	64 KB	256 KB	448 KB	512 KB	1024 KB	4096 KB	8192 KB	16386 KB	32772 KB	65544 KB
32 Procs	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ
96 Procs	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ

N-to-1 nonstrided

	64 KB	256 KB	448 KB	512 KB	1024 KB	4096 KB	8192 KB	16386 KB	32772 KB	65544 KB
32 Procs	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ
96 Procs	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ

N-to-1 strided

	64 KB	256 KB	448 KB	512 KB	1024 KB	4096 KB	8192 KB	16386 KB	32772 KB	65544 KB
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96 Procs	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ	TGZ

Sample MPI-Based Synthetic I/O Trace

- **Timing Information**

```
#Barrier before benchmark_call
7: testbedX_node113 (10378) Entered barrier at 1159808385.170918
7: testbedX_node113 (10378) Exited barrier at 1159808385.173167
3: testbedX_node117 (11335) Entered barrier at 1159808385.166396
3: testbedX_node117 (11335) Exited barrier at 1159808385.168893
5: testbedX_node115 (10373) Entered barrier at 1159808385.168842
5: testbedX_node115 (10373) Exited barrier at 1159808385.171370
```

- **Traced Application Data**

```
10:59:47.092996 MPI_File_open(92, 0x80675c0, 37, 0x80675a8, 0xbfdfe5e4 <unfinished ...>
10:59:47.093718 SYS_statfs64(0x80675c0, 84, 0xbfdfe410, 0xbfdfe410, 0xbd3ff4) = 0
    <0.011131>
10:59:47.108352 SYS_open("/FS/scratch/usr1/O"..., 32832, 0600) = 3 <0.000745>
10:59:47.109189 SYS_close(3) = 0 <0.000063>
10:59:47.109310 SYS_open("/FS/scratch/usr1/O"..., -2147450814, 0600) = 3 <0.000564>
10:59:47.110912 <... MPI_File_open resumed> ) = 0 <0.017855>
10:59:47.110955 MPI_Wtime(0x8063830, 0xb7fee8dc, 0xbfdfe568, 0xb7f66ad7, 0x8059020
    <unfinished ...>
```

Sample MPI-Based Synthetic I/O Trace

- **Summary Information**

```
# SUMMARY COUNT OF TRACED CALL(S)
# Function Name Number of Calls Total time (s)
#======================================================================
MPIO_Wait 2 0.000118
MPI_Barrier 29 2.156431
MPI_File_close 2 0.108482
MPI_File_delete 1 0.102532 …
# SUMMARY COUNT OF CALLS WITHIN 1 MPI_File_delete CALL(S)
# Function Name Number of Calls Total time (s)
#========================================================================
   =
SYS_ipc 8 0.000140
SYS_statfs64 1 0.009227
SYS_unlink 1 0.092411
```

Additional Sources of Data

- NERSC I/O Trace Data and Workload Profiles
  - http://pdsi.nersc.gov/benchmarks.htm
- USENIX Computer Failure Data Repository
  - The USENIX, the Advanced Computing Systems Association has begun a project to index all of these large scale operational data releases on the internet, at cfdr.usenix.org. LANL and the PDSI are helping to organize and lead this effort.

Publications Based on LANL Data or Software

- Eric Lalonde. "A Characterization of LANL HPC Systems", Masters Thesis, University of California, Santa Cruz. 2007
- Olen Davis, Kari Macklin, BailyKelly "Parallel Search using multiple Google Desktops in Parallel", Colorado School of Mines, Technical report, 2007.
- Clay Baenziger, Bruce Bugbee, Ryan Ford, Charlie, Grammon. "LANL Supercomputing Data Analysis", Colorado School of Mines Technical Report, 2007.
- Bianca Schroeder, Garth Gibson. "The computer failure data repository." Invited contribution to the Workshop on Reliability Analysis of System Failure Data (RAF'07)to be held at MSR Cambridge, UK.
- Bianca Schroeder, Garth Gibson. "Disk failures in the real world: What does an MTTF of 1,000,000 hours mean too you?" 5th UsenixConference on File and Storage Technologies (FAST 2007). Winner of best paper award. This paper has also been featured in an article on slashdot, which so far has received more than 75,000 hits!
- Bianca Schroeder, Garth Gibson. "A large scale study of failures in high-performance-computing systems." International Symposium on Dependable Systems and Networks (DSN 2006). As one of the best DSN'06 papers invited to IEEE Transactions on Dependable and Secure Computing (TDSC).
- Michael Mesnier, Matthew Wachs, Raja R. Sambasivan, Alice Zheng, Gregory R. Ganger. Modeling the relative fitness of storage. International Conference on Measurement and Modeling of Computer Systems (SIGMETRICS 2007). San Diego, CA. June 12-14, 2007. ACM. Awarded Best Paper. Michael Mesnier, Matthew Wachs, Raja R. Sambasivan, Julio Lopez, James Hendricks, Gregory R. Ganger, David O'Hallaron. //TRACE: Parallel Trace Replay with Approximate Causal Events.Fifth Conference on File and Storage Technologies (FAST'07). San Jose,CA. February 12-13, 2007. USENIX

Links to Data & Codes

- **Machine Failure/Usage/Event/Location & Disk Failure Data Sets**
  - http://institutes.lanl.gov/data/fdata
- **Traces of MPI-IO Based Synthetic**
  - http://institutes.lanl.gov/data/tdata/
- **MPI-IO based synthetic, MPI-File Tree Walk, LANL Trace**
  - http://institutes.lanl.gov/data/software/
- **File Systems Statistics Survey (fsstats) Code**
  - http://www.pdsi-scidac.org/fsstats/
- **USENIX Computer Failure Data Repository**
  - http://cdfr.usenix.org
- **Contact E-mail:** jnunez@lanl.gov