ParaTools

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2 February 2017
Northrop Grumman
Woodlawn, MD

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Outline

- Introduction to ParaTools Inc.
- The TAU Performance System®
- ParaTools ThreadSpotter
- Success Stories
- Q&A

ParaTools


Allen Malony (CEO)


Sameer Shende (President)

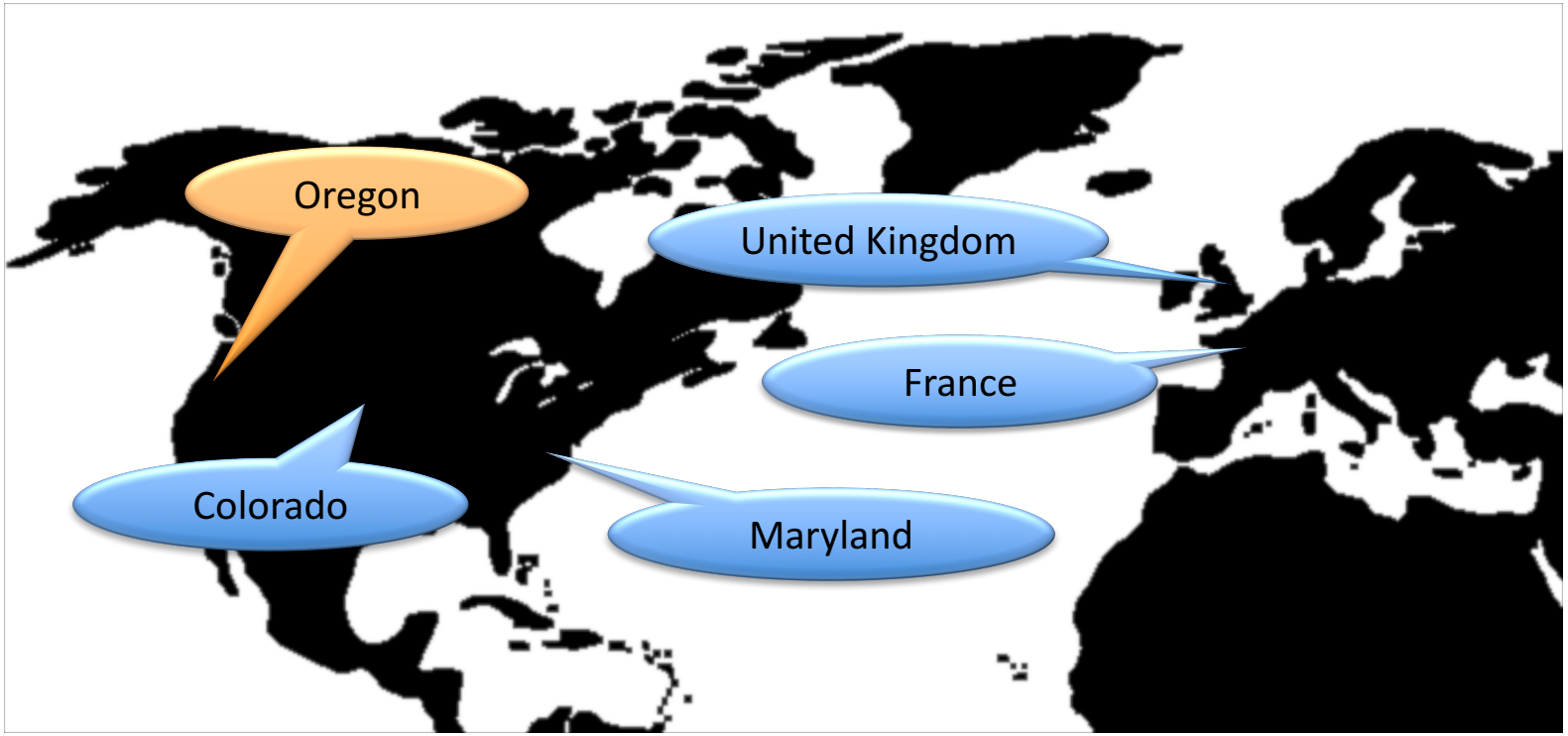

John Linford


Srinath Vadlamani


Kevin Huck


Wyatt Spear


Jean-Baptiste Besnard

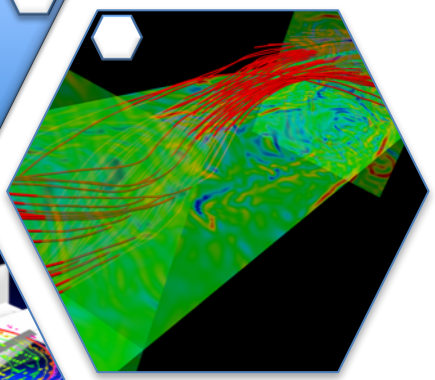


ParaTools Accelerates Software

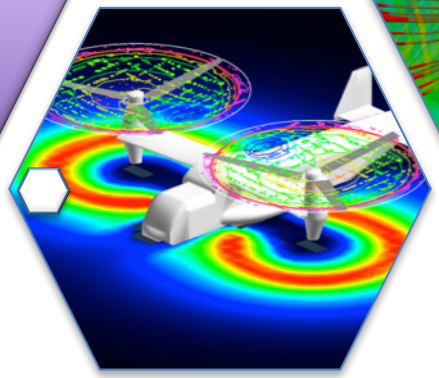
National Security
- Cyber security
- Weapons research
- Intelligence
- Contingency

Research
- Simulation
- Analysis
- Testing

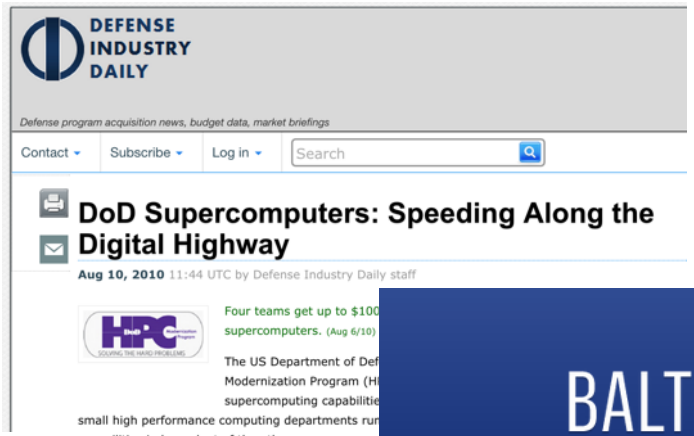
Engineering & Manufacturing
- Time-to-market
- Quality

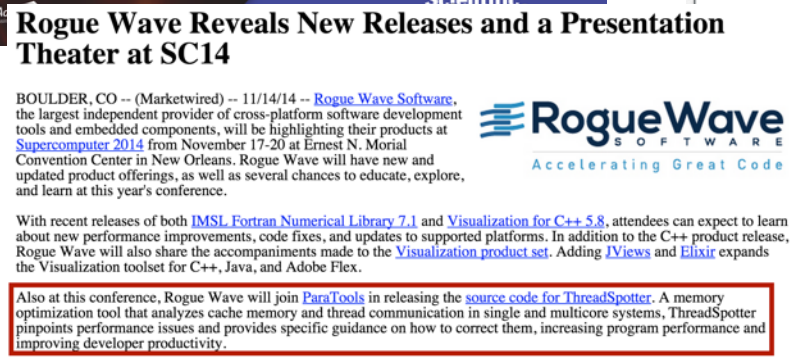


Policy
- Energy
- Environment
- Emergency



In the Press





Rogue Wave Reveals New Releases and a Presentation Theater at SC14

BOULDER, CO -- (Marketwired) -- 11/14/14 -- Rogue Wave Software, the largest independent provider of cross-platform software development tools and embedded components, will be highlighting their products at Supercomputer 2014 from November 17-20 at Ernest N. Morial Convention Center in New Orleans. Rogue Wave will have new and updated product offerings, as well as several chances to educate, explore, and learn at this year's conference.

RogueWave SOFTWARE
Accelerating Great Code

With recent releases of both IMSL Fortran Numerical Library 7.1 and Visualization for C++ 5.8, attendees can expect to learn about new performance improvements, code fixes, and updates to supported platforms. In addition to the C++ product release, Rogue Wave will also share the accompaniments made to the Visualization product set. Adding JViews and Elixir expands the Visualization toolset for C++, Java, and Adobe Flex.

Also at this conference, Rogue Wave will join ParaTools in releasing the source code for ThreadSpotter. A memory optimization tool that analyzes cache memory and thread communication in single and multicore systems, ThreadSpotter pinpoints performance issues and provides specific guidance on how to correct them, increasing program performance and improving developer productivity.

BALTIMORE BUSINESS JOURNAL

UMBC tech park lures Oregon software company

Feb 28, 2014, 1:33pm EST | **UPDATED:** Jun 9, 2014, 9:12am EDT

Sarah Gantz
Reporter- *Baltimore Business Journal*
Email | Twitter

A West Coast software company is expanding to Baltimore to tap into the area's growing cyber security industry.

ParaTools, based in Eugene, Ore., has opened a Baltimore office at the **University of Maryland**, Baltimore County's bwtech@UMBC research and technology park. The company's software was designed to make complex supercomputers run more efficiently. Now, ParaTools wants to use the same efficiency software to improve cyber operations.

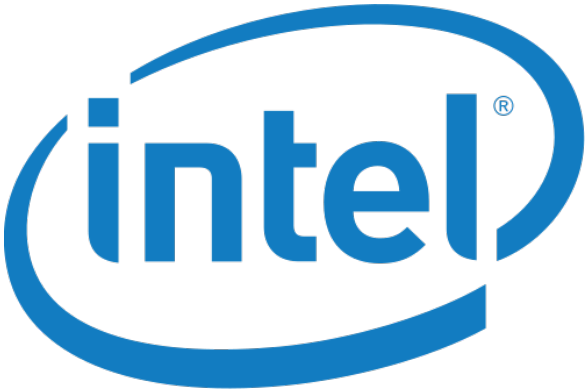
"With our skills in optimizing software and computer performance we think there's a lot of opportunity in the cyber," said John Linford, who is heading up the company's Baltimore office.

ParaTools' software attaches itself to a system and creates a profile that shows how and where time is being spent. The information can be used to rewrite code in trouble spot and make the system run more smoothly.

A possible cyber use for the company's technology is improving efficiency of drone aircraft that scans for suspicious vehicles Previously, the drones collected data and brought it home to be analyzed. With ParaTools' technology, could send data real-time, so they can more quickly address any problems identified.

- http://tau.uoregon.edu/success/irmhd.pdf
- http://www.defenseindustrydaily.com/Up-to-1471M-to-HPTi-for-DoD-High-Performance-Computing-Work-05688/
- http://java.sys-con.com/node/3228954
- http://www.bizjournals.com/baltimore/blog/cyberbizblog/2014/02/umbc-tech-park-lures-oregon-software.html

Partnerships



UNIVERSITY OF OREGON

Products and Services


The TAU Performance System®


TAU Commander / TAU Enterprise


Kppa


RotCFD


ParaTools ThreadSpotter


HPC Linux


PToolsRTE


PToolsWin


IQB


Vampir

Performance Engineering

Software Development

Algorithm Development

Software Porting

Hosting

Data Analytics

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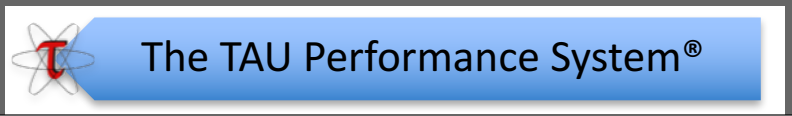
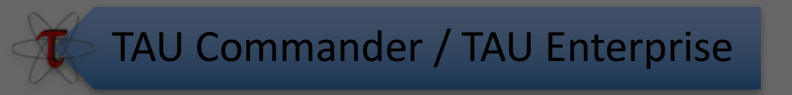
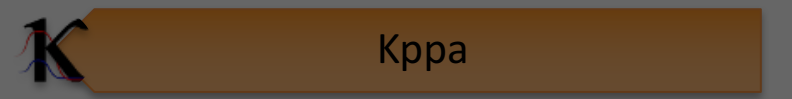
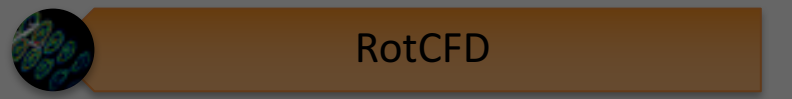
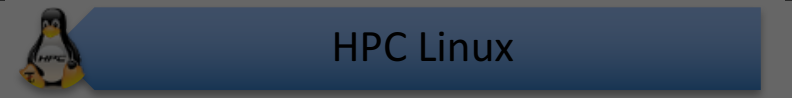
Products and Services

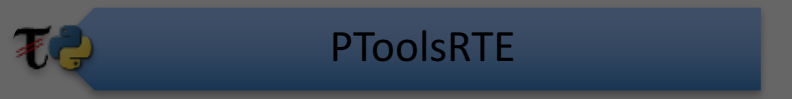


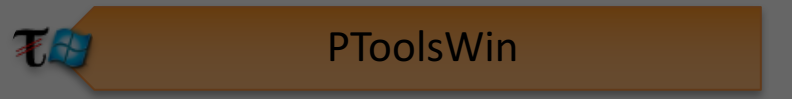


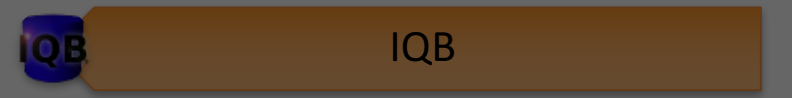


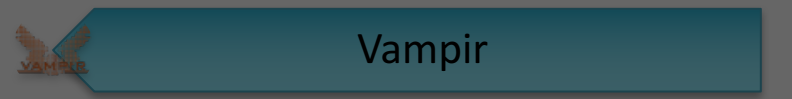












Performance Engineering

Software Development

Algorithm Development

Software Porting

Hosting

Data Analytics

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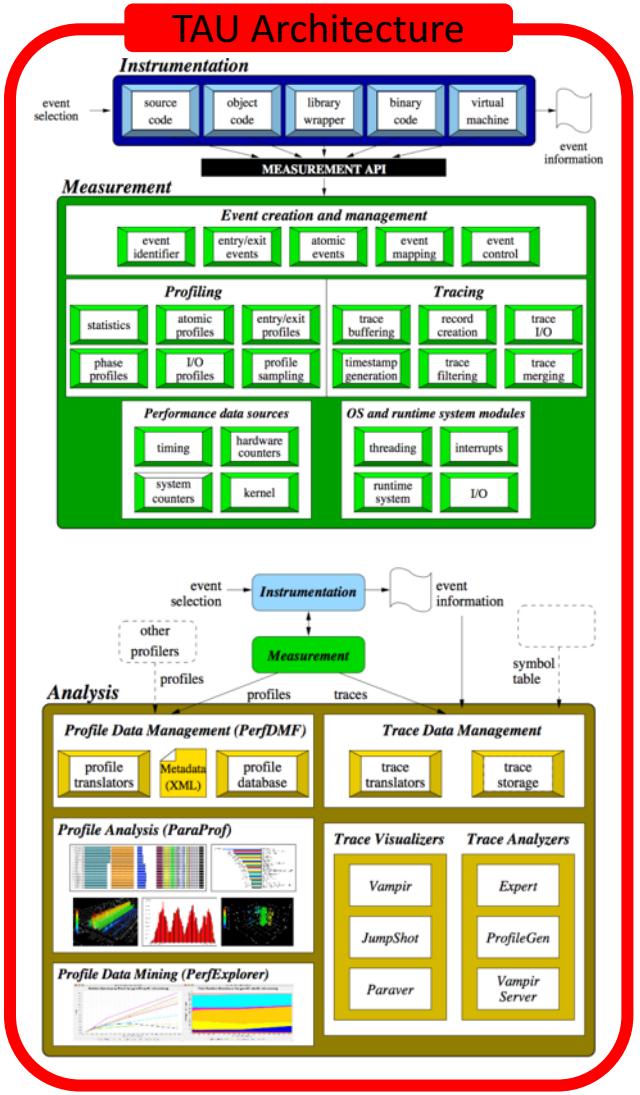
Keeping Up With Technology

THE TAU PERFORMANCE SYSTEM

The TAU Performance System®

- Toolkit for performance problem solving and software situational awareness
  - Instrumentation, measurement, analysis, visualization
  - Portable profiling and tracing
  - Performance data management and data mining
- Free, open source, BSD license
- http://tau.uoregon.edu/



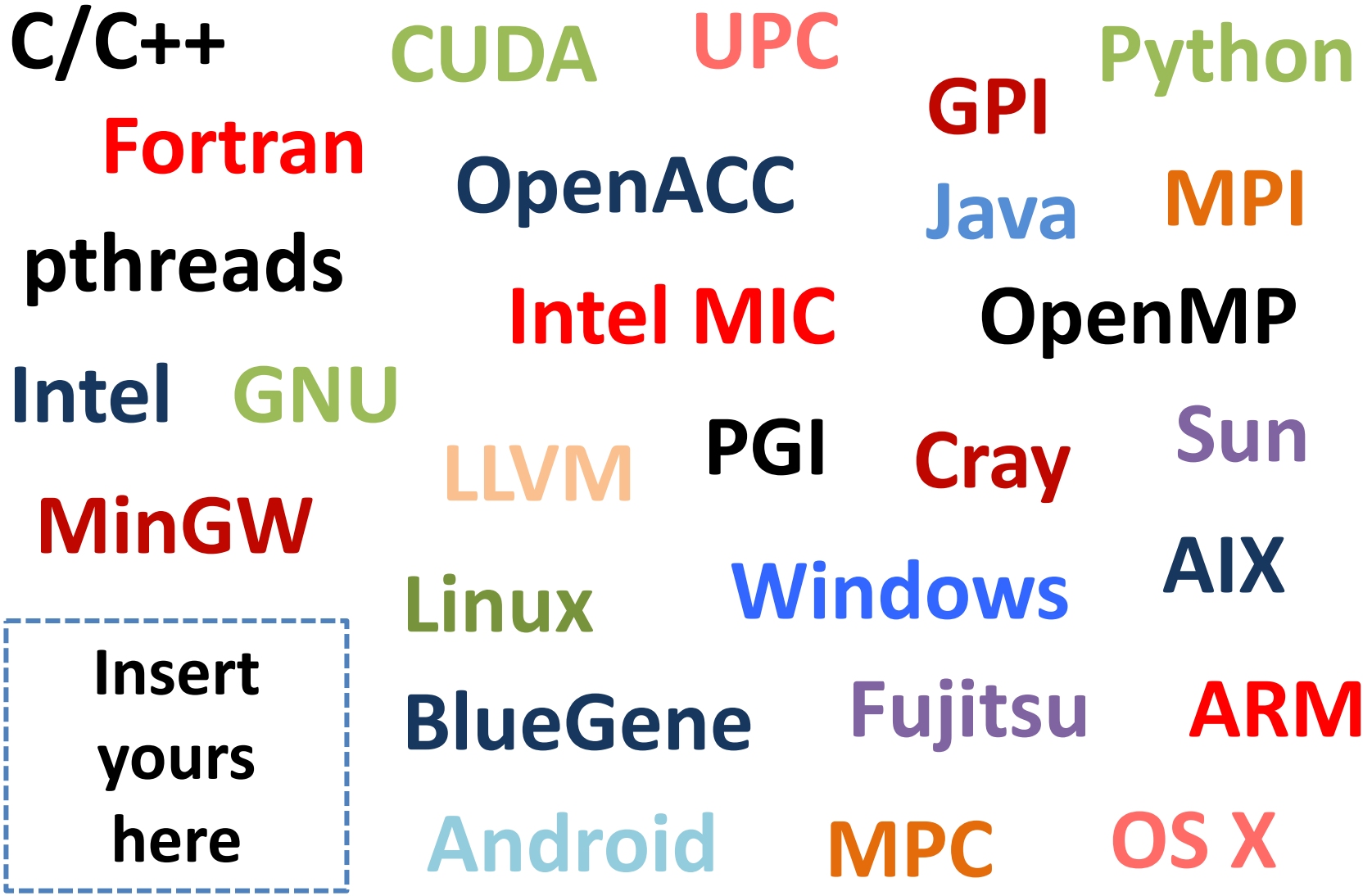
Questions TAU Can Answer

- **How much time** is spent in each application routine and outer *loops*? Within loops, what is the contribution of each *statement*?
- **How many instructions** are executed in these code regions? Floating point, Level 1 and 2 *data cache misses*, hits, branches taken, *vector instructions*?
- What is the **memory usage** of the code? When and where is memory allocated/de-allocated? Are there any *memory leaks*?
- What are the **I/O characteristics** of the code? What is the peak read and write *bandwidth* of individual calls, total volume?
- What is the **time spent waiting for collectives** (e.g. reduce)?
- How does the application **scale**?

Use Cases

- Code Modernization and Hardening
  - CREATE-AV HELIOS / KESTREL
    - Army, Navy, Air Force, NASA, Boeing…
  - FraPPE: Framework for Parallel Program Engineering
    - Army, NASA
- Performance Provenance
  - Protection (like ClearCase for performance)
- Performance Optimization
  - Load balancing
  - “Hot spot” identification
  - Improvement quantification
- Performance Regression Testing

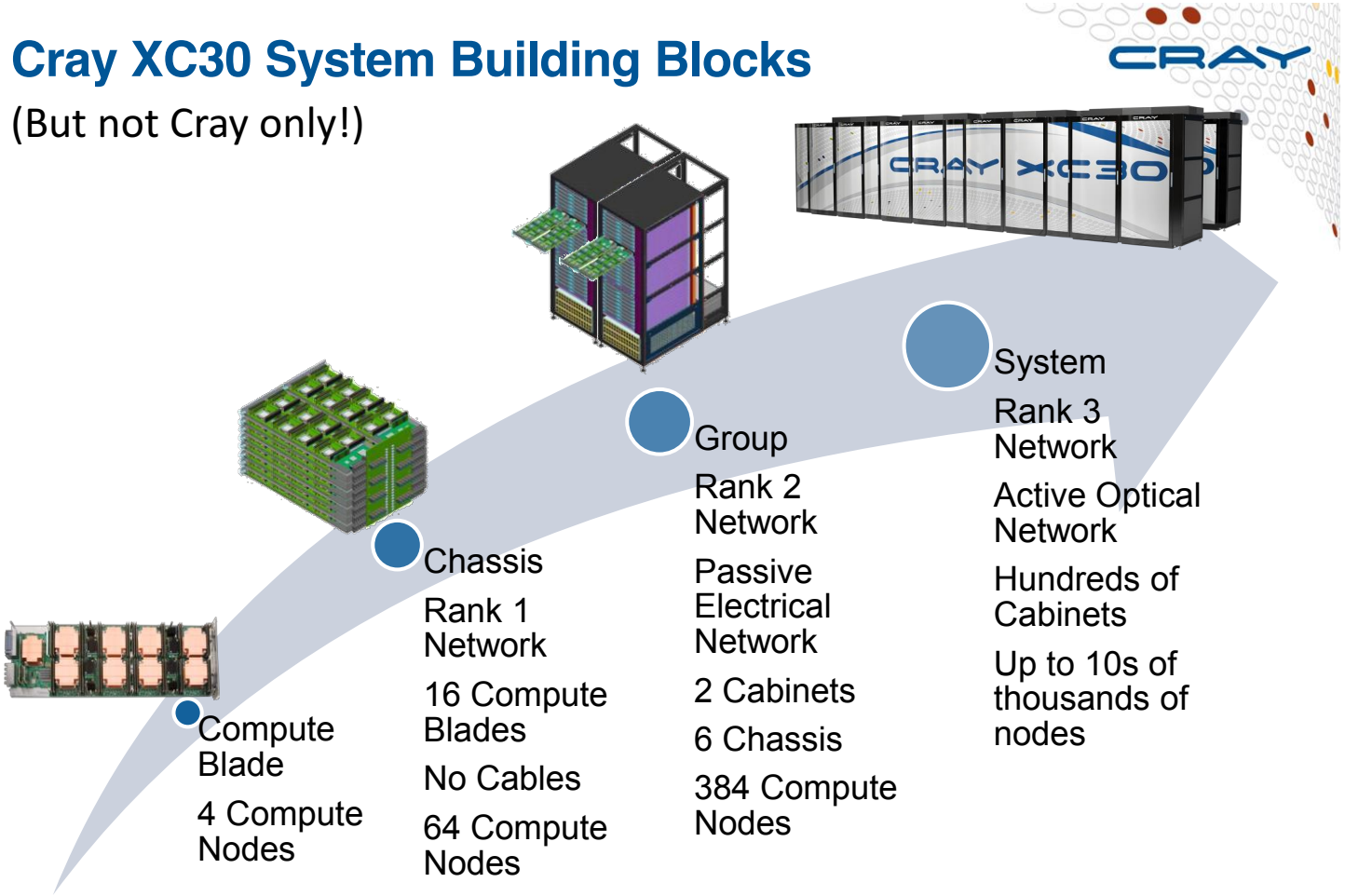
Apples to Apples Across Platforms



Measurement at Every Layer

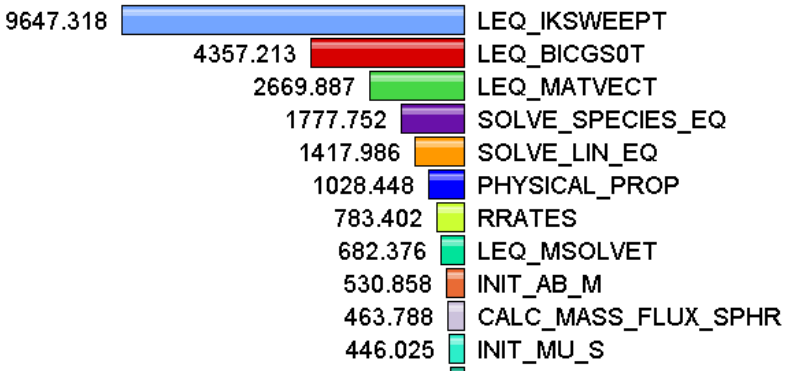
Cray XC30 System Building Blocks

(But not Cray only!)



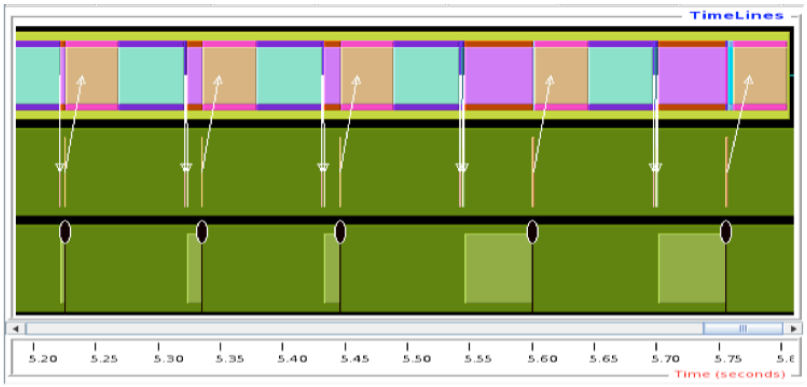
Measurement Approaches

Profiling



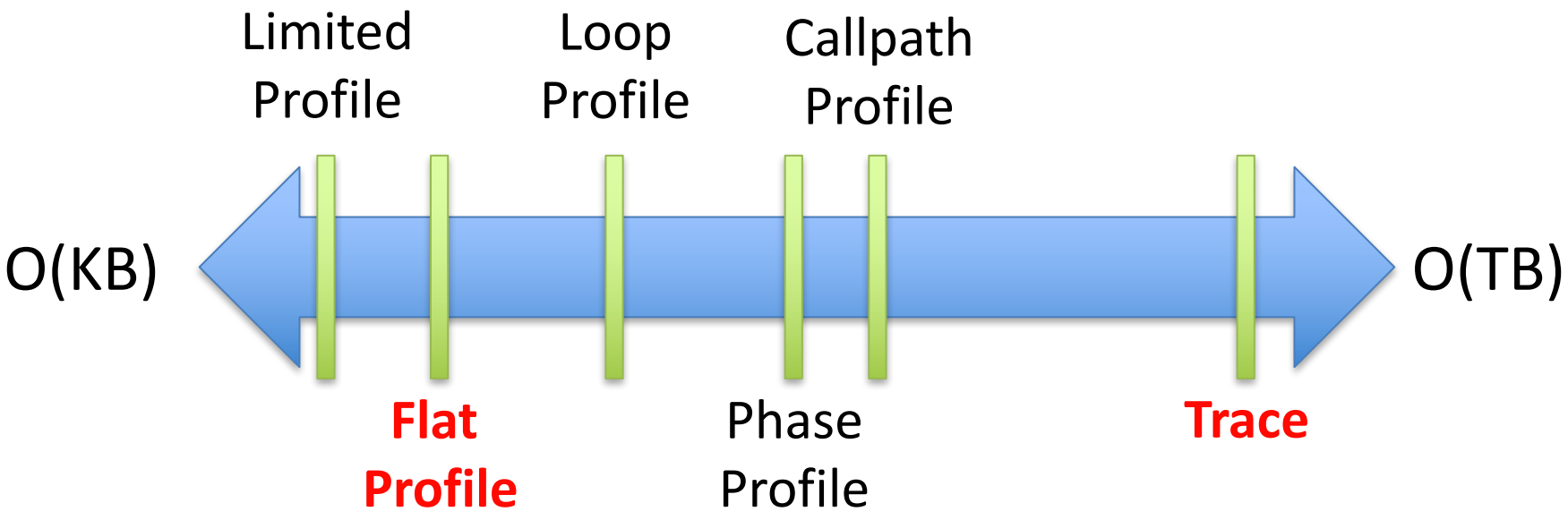
Shows **how much** time was spent in each routine

Tracing



Shows **when** events take place on a timeline

How Much Data do you Want?



All levels support multiple metrics/counters

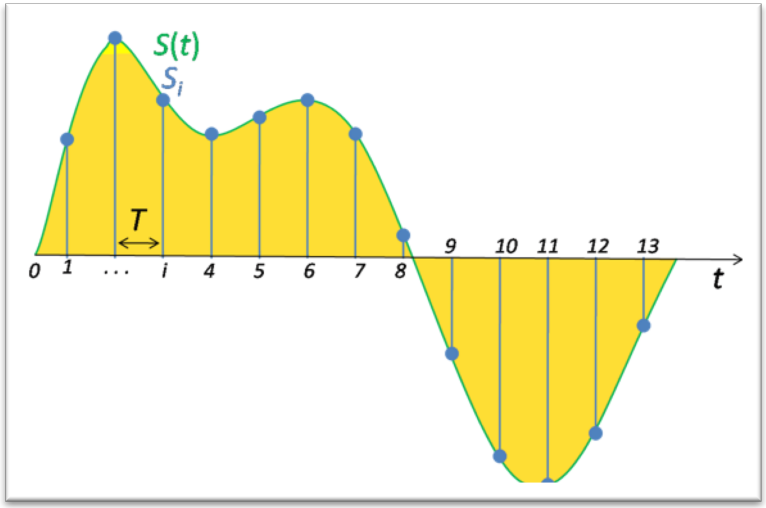
Performance Data Measurement

Direct via Probes

```
call TAU_START('potential')
// code
call TAU_STOP('potential')
```

- Exact measurement
- Fine-grain control
- Code region granularity
- Calls inserted into code

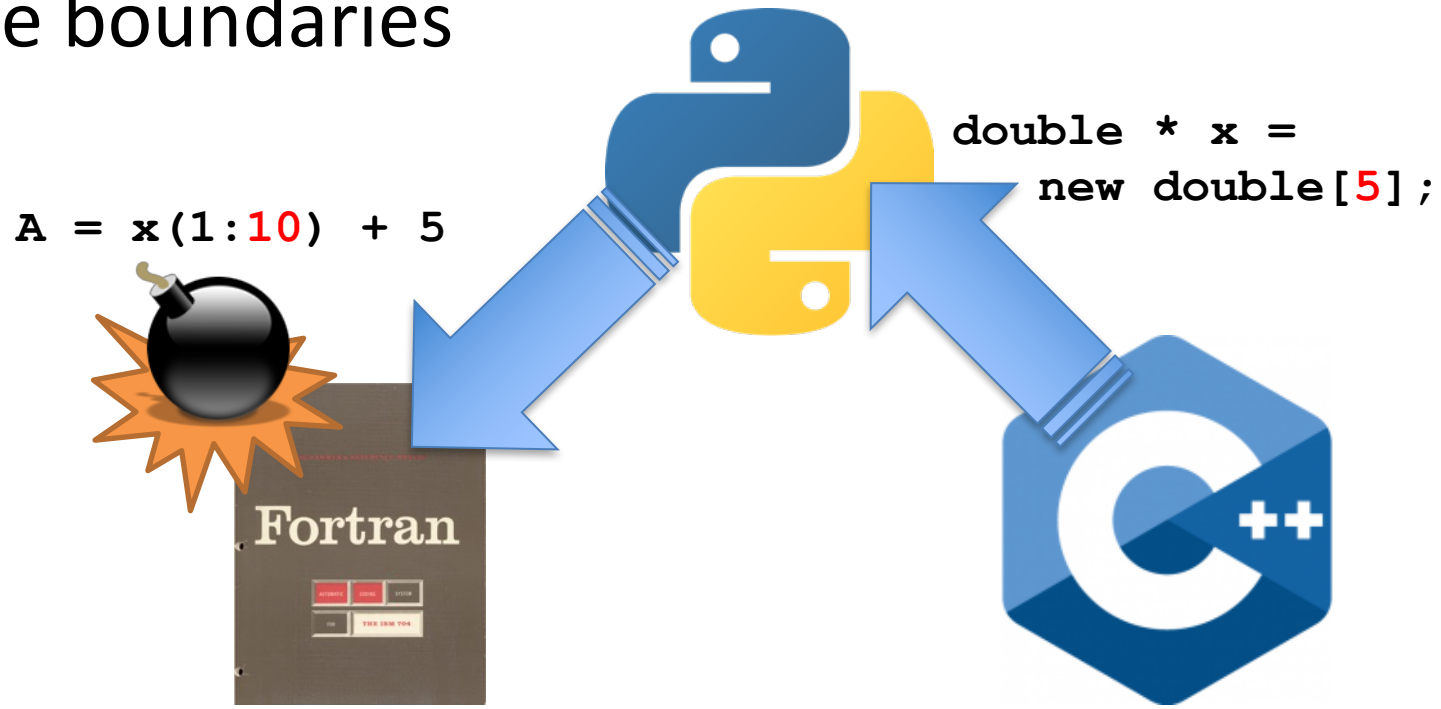
Indirect via Sampling



- No code modification
- Minimal effort
- Code line granularity
- Uses debug symbols

Multi-Language Debugging

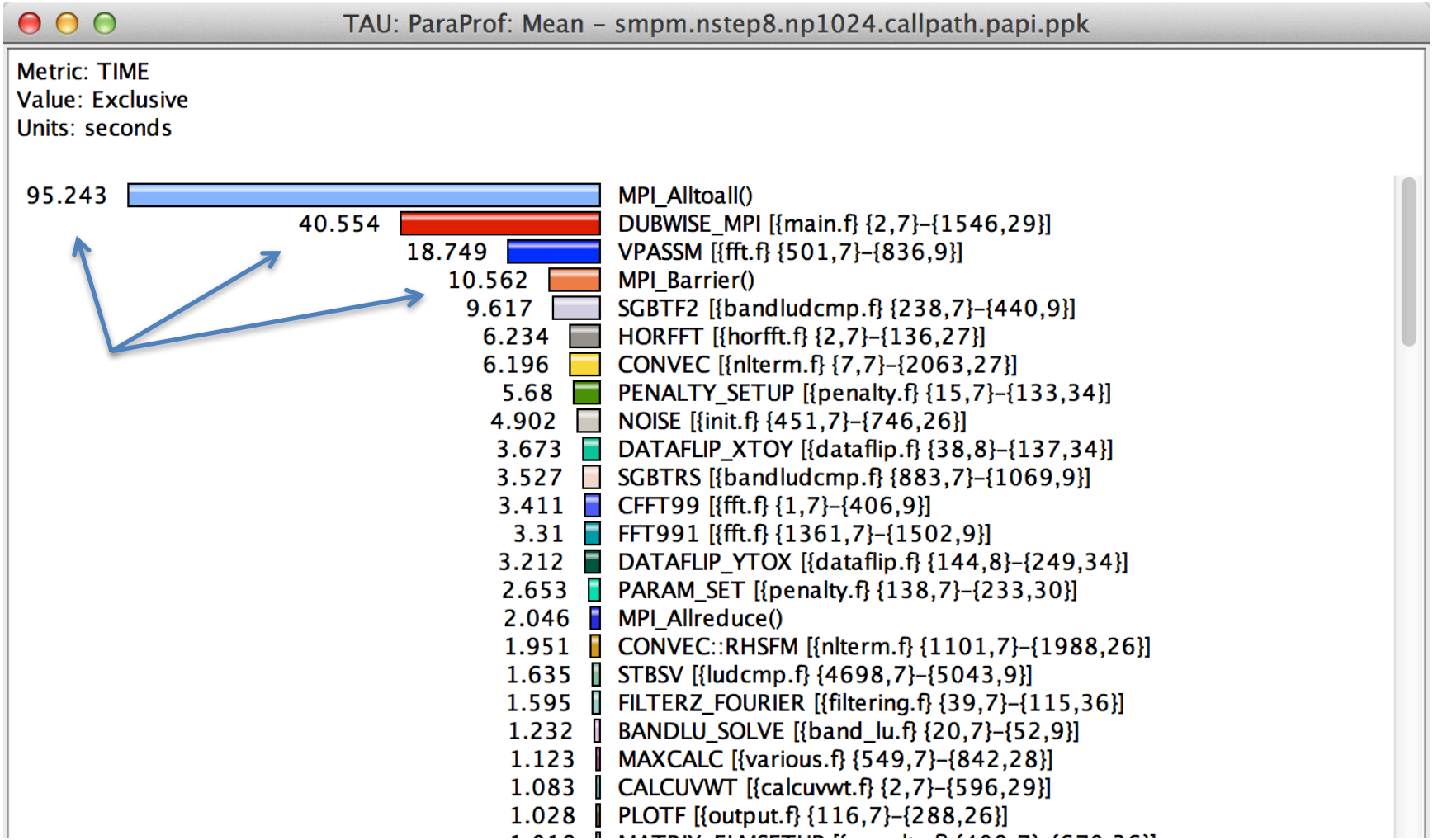
- Identify the source location of a crash by unwinding the system callstack
- Identify memory errors (off-by-one, etc.) across language boundaries



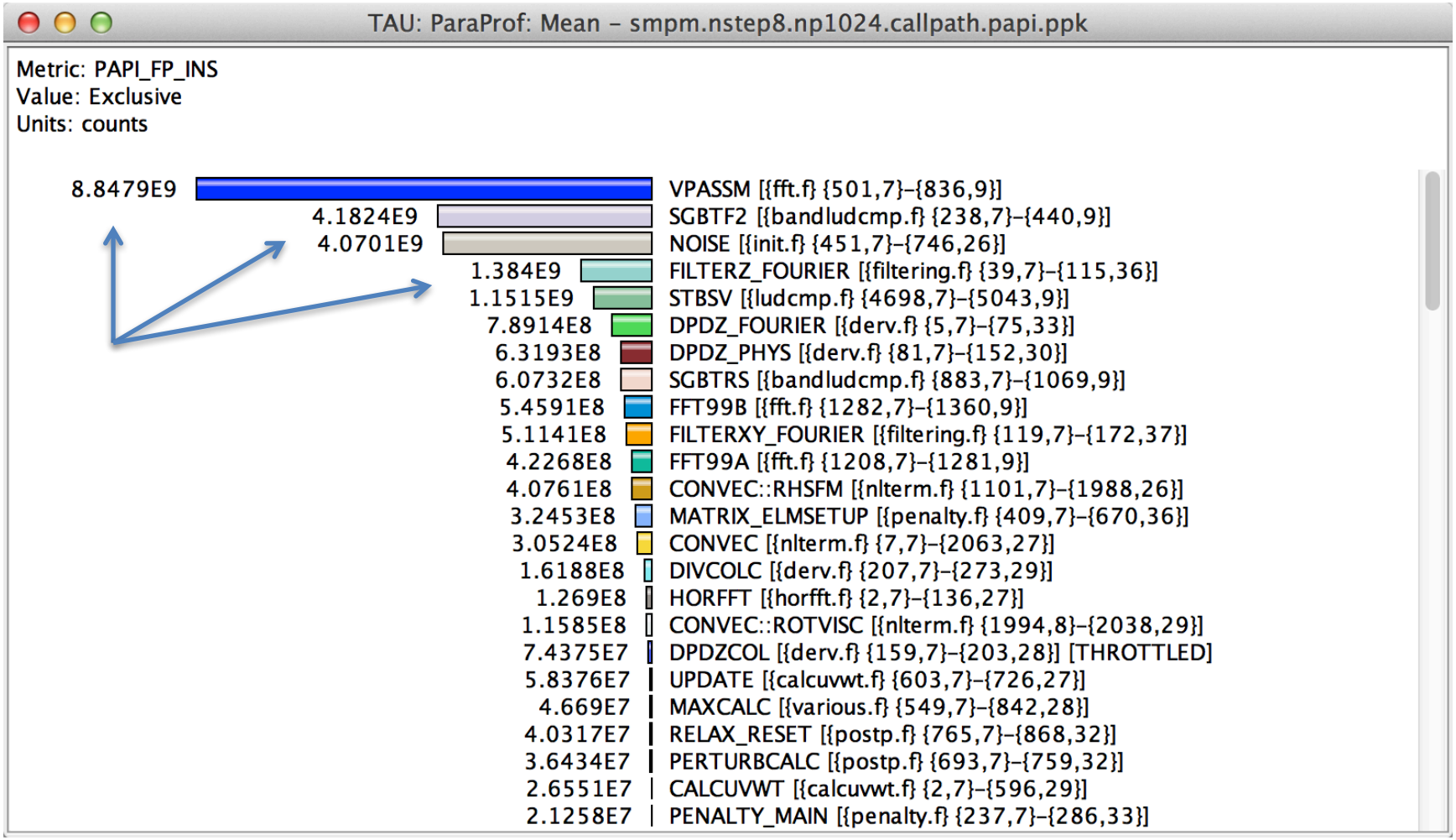
Keeping Up With Technology

DATA ANALYSIS WITH TAU

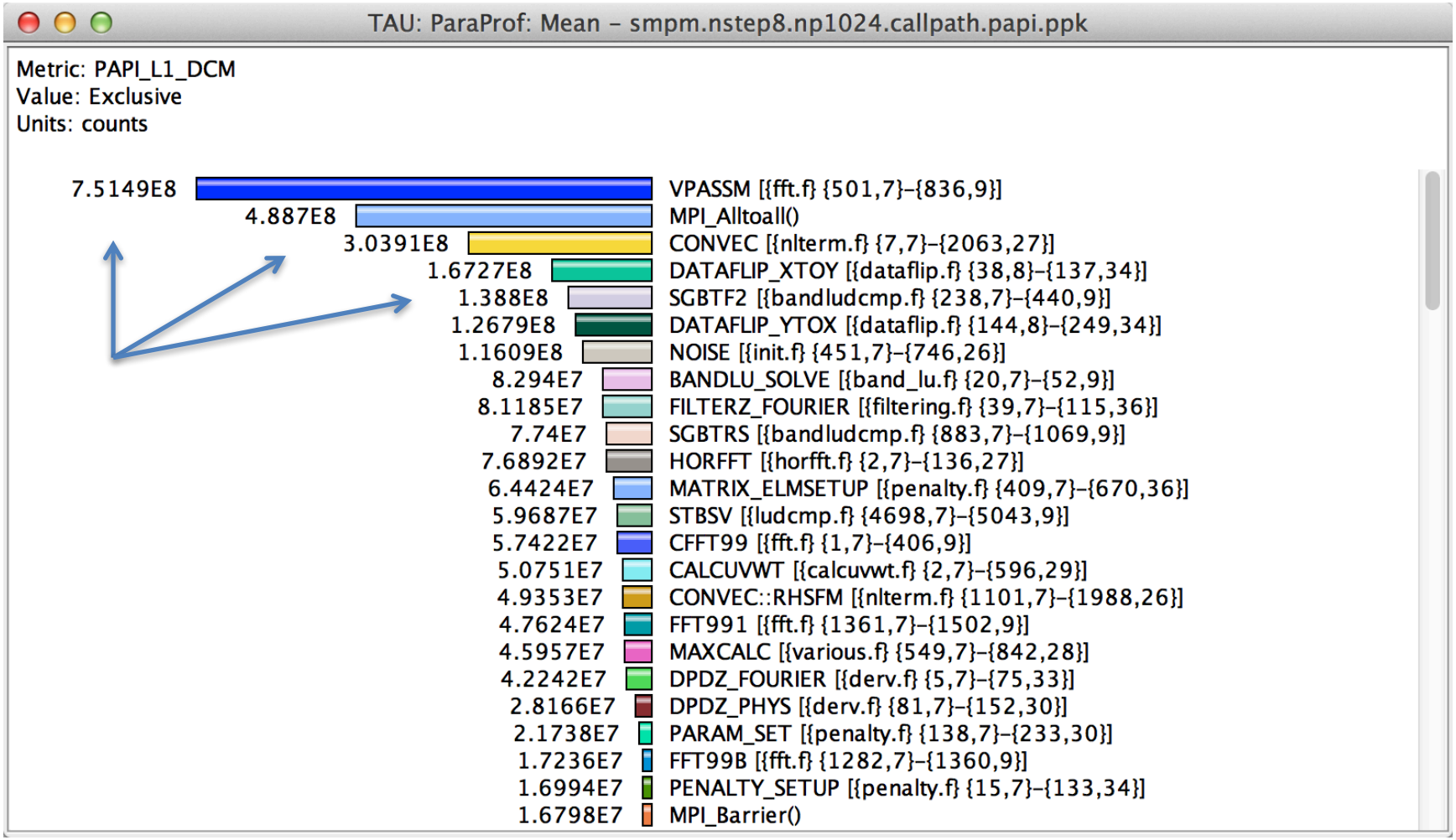
How Much Time per Code Region?



How Many Instructions per Code Region?



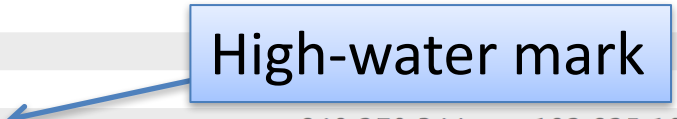
How Many L1/L2/L3 Cache Misses?



How Much Memory Does the Code Use?

TAU: ParaProf: Mean Context Events – sphere_np32_nsteps5_mem.ppk

Name △	Total	NumSamples	MaxValue	MinValue	MeanValue	Std. Dev.
▼ .TAU application						
free size (bytes)	14,236,992.16	27,169.781	49,152	1	524.001	2,013.103
malloc size (bytes)	13,132,932	23,292	262,144	1	563.839	4,492.057
▶ MPI_Finalize()						
▼ OurMain()						
free size (bytes)	1,298,918.679	1,495.125	461,766.25	4	868.769	16,928.073
malloc size (bytes)	48,150	20	36,032	11	2,407.5	7,911.992
▼ OurMain						
free size (bytes)	3,465	9	769	32	385	260.2
malloc size (bytes)	4,314	12	769	32	359.5	240.981
▼ <module>						
free size (bytes)	293,088	449	32,564	32	652.757	1,526.875
malloc size (bytes)	311,966	493	32,564	32	632.791	1,460.941
▶ staticCFD						
▶ __init__						
▶ <module>						
Memory Utilization (heap, in KB)		849,270.344	192,825.168	0.078	147,832.141	62,621.576
Message size for all-gather	4,096	1	4,096	4,096	4,096	0
Message size for all-reduce	23,340	843	320	4	27.687	64.653
Message size for all-to-all	104	26	4	4	4	0
Message size for broadcast	24,923	206	8,788	4	120.985	860.992
Message size for reduce	8,912	8	8,788	4	1,114	2,900.511
free size (bytes)	27,417,881,391.51	413,600.719	24,025,667	1	66,290.701	199,538.234
malloc size (bytes)	27,468,709,355.914	435,669.625	24,025,667	0	63,049.402	195,561.193



How Much Memory Does the Code Use?

TAU: ParaProf: Mean Context Events – sphere_np32_nsteps5_mem.ppk

Name △	Total	NumSamples	MaxValue	MinValue	MeanValue	Std. Dev.
▼ .TAU application						
free size (bytes)	14,236,992.16	27,169.781	49,152	1	524.001	2,013.103
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Message size for reduce	8,912	8	8,788	4	1,114	2,900.511
free size (bytes)	27,417,881,391.51	413,600.719	24,025,667	1	66,290.701	199,538.234
malloc size (bytes)	27,468,709,355.914	435,669.625	24,025,667	0	63,049.402	195,561.193

Total allocated/deallocated

Where is Memory Allocated / Deallocated?

TAU: ParaProf: Mean Context Events – sphere_np32_nsteps5_mem.ppk

Name △	Total	NumSamples	MaxValue	MinValue	MeanValue	Std. Dev.
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free size (bytes)	14,236,992.16	27,169.781	49,152	1	524.001	2,013.103
malloc size (bytes)	13,132,932	23,292	262,144	1	563.839	4,492.057
▶ MPI_Finalize()						
▼ OurMain()						
free size (bytes)	1,298,918.679	1,495.125	461,766.25	4	868.769	16,928.073
malloc size (bytes)	48,150	20	36,032	11	2,407.5	7,911.992
▼ OurMain						
free size (bytes)	3,465	9	769	32	385	260.2
malloc size (bytes)	4,314	12	769	32	359.5	240.981
▼ <module>						
free size (bytes)	293,088	449	32,564	32	652.757	1,526.875
malloc size (bytes)	311,966	493	32,564	32	632.791	1,460.941
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Message size for all-gather	4,096	1	4,096	4,096	4,096	0
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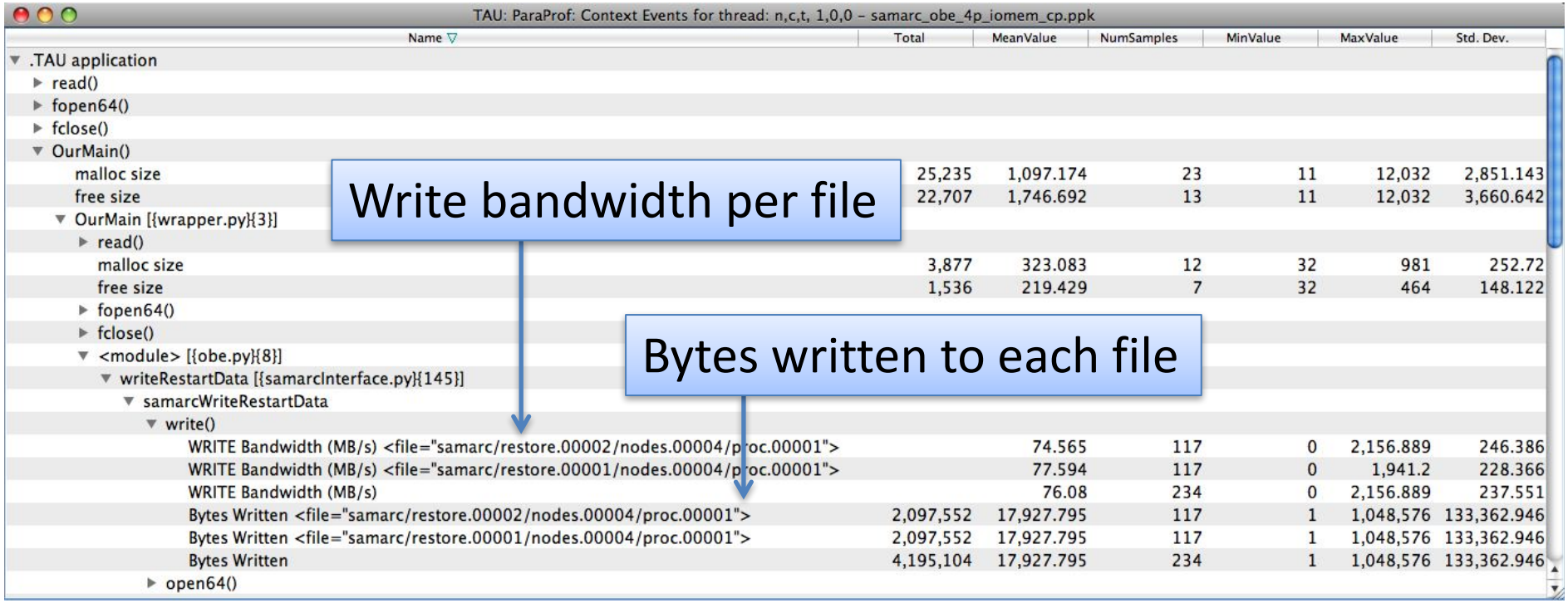
Message size for all-to-all	104	26	4	4	4	0
Message size for broadcast	24,923	206	8,788	4	120.985	860.992
Message size for reduce	8,912	8	8,788	4	1,114	2,900.511
free size (bytes)	27,417,881,391.51	413,600.719	24,025,667	1	66,290.701	199,538.234
malloc size (bytes)	27,468,709,355.914	435,669.625	24,025,667	0	63,049.402	195,561.193

Allocation / Deallocation Events

What are the I/O Characteristics?



Name	Total	MeanValue	NumSamples	MinValue	MaxValue	Std. Dev.
.TAU application						
read()						
fopen64()						
fclose()						
OurMain()						
malloc size	25,235	1,097.174	23	11	12,032	2,851.143
free size	22,707	1,746.692	13	11	12,032	3,660.642
OurMain [{wrapper.py}{3}]						
read()						
malloc size	3,877	323.083	12	32	981	252.72
free size	1,536	219.429	7	32	464	148.122
fopen64()						
fclose()						
<module> [{obe.py}{8}]						
writeRestartData [{samarcInterface.py}{145}]						
samarcWriteRestartData						
write()						
WRITE Bandwidth (MB/s) <file="samarc/restore.00002/nodes.00004/proc.00001">		74.565	117	0	2,156.889	246.386
WRITE Bandwidth (MB/s) <file="samarc/restore.00001/nodes.00004/proc.00001">		77.594	117	0	1,941.2	228.366
WRITE Bandwidth (MB/s)		76.08	234	0	2,156.889	237.551
Bytes Written <file="samarc/restore.00002/nodes.00004/proc.00001">	2,097,552	17,927.795	117	1	1,048,576	133,362.946
Bytes Written <file="samarc/restore.00001/nodes.00004/proc.00001">	2,097,552	17,927.795	117	1	1,048,576	133,362.946
Bytes Written	4,195,104	17,927.795	234	1	1,048,576	133,362.946
open64()						

What are the I/O Characteristics?

Name △	Total	NumSamples	MaxValue	MinValue	MeanValue	Std. Dev.
▶ Incl						
▶ Initialize						
▶ LoadBodyEuler						
▶ LoadMesh						
MPI-IO Bytes Written	4,328,712	144	893,152	0	30,060.5	128,042.696
MPI-IO Write Bandwidth (MB/s)		144	196.86	0	3.421	16.87
▶ MPI_Allgatherv()						
▶ MPI_Bcast()						
▶ MPI_Comm_create()						
▶ MPI_File_close()						
▶ MPI_File_open()						
▶ MPI_File_write_all()						
▶ MPI_File_write_at()						
▶ MPI_Finalize()						
▶ MPI_Gather()						
▶ MPI_Gatherv()						

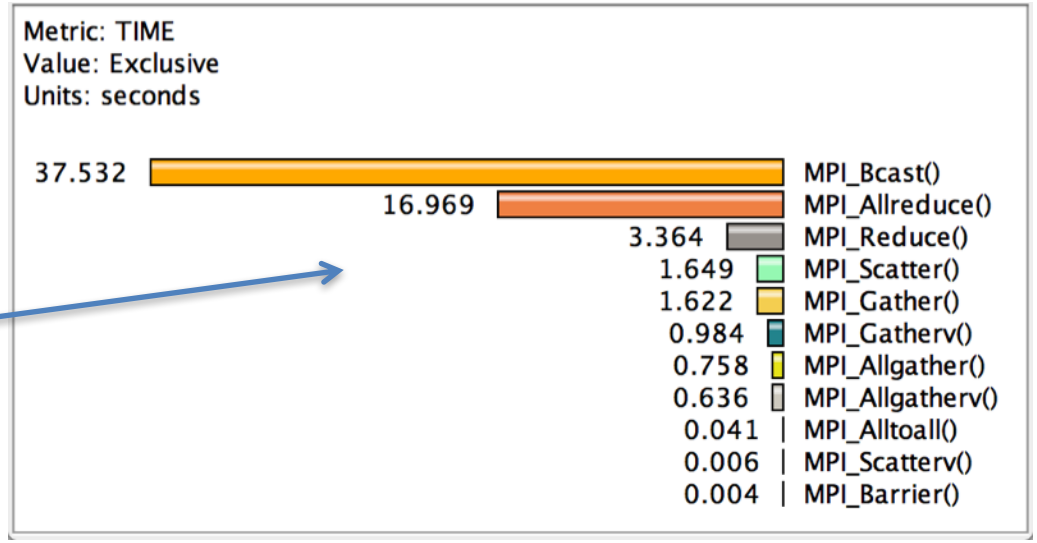
Peak Parallel I/O Write Bandwidth

How Much Time is Spent in Collectives?

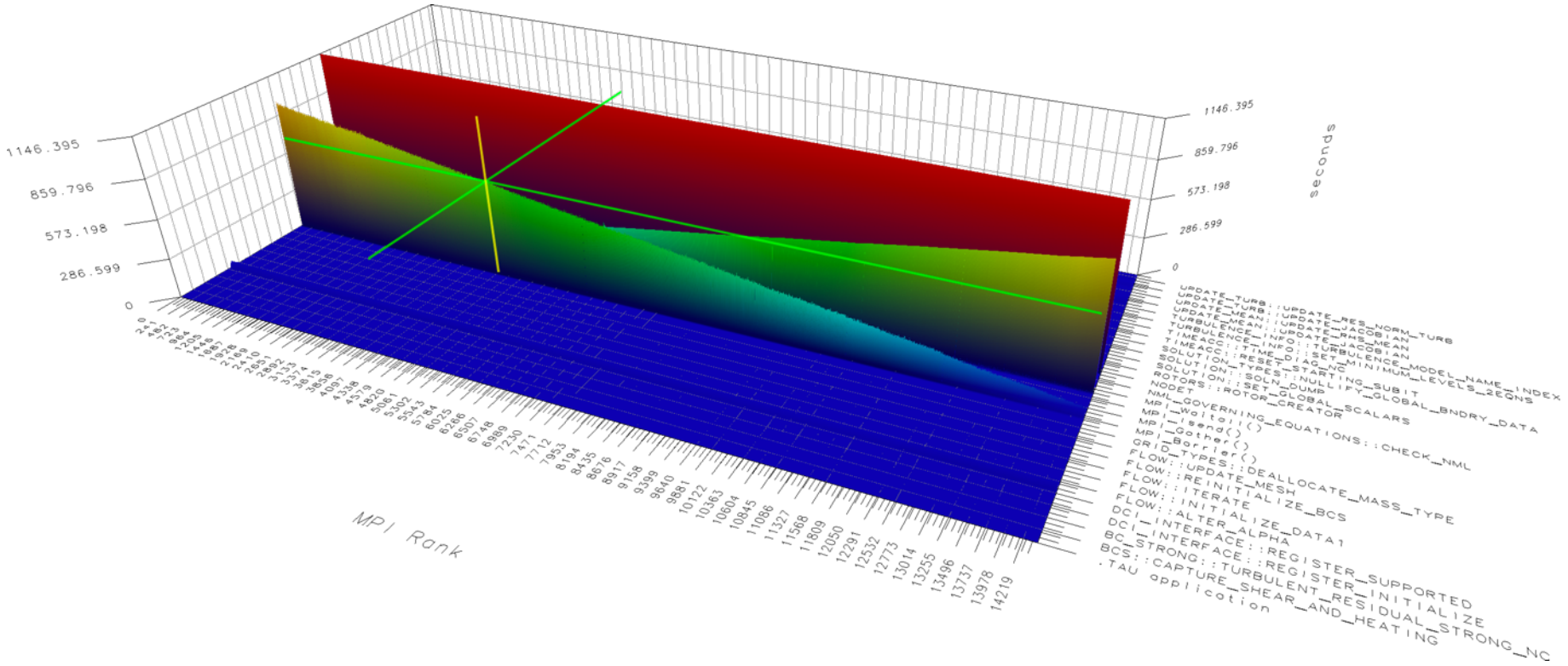
Name △	Total	Num...	MaxValue	MinValue	MeanValue	Std. Dev.
▶ MPI_Wait()						
▶ MPI_Waitall()						
Message size for all-gather	305,753,268	72	172,215,296	4	4,246,573.167	22,551,605.859
Message size for all-reduce	163,308	632	21,908	4	258.399	897.725
Message size for all-to-all	112	14	8	8	8	0
Message size for broadcast	692,208,045.5	3,346	18,117,620	0	206,876.284	1,284,673.036
Message size for gather	6,901,452.378	15.312	1,387,306.625	4	450,707.094	483,216.499
Message size for reduce	66,812	1,520	56	4	43.955	21.598
Message size for scatter	63,147.906	146	62,567.906	4	432.52	5,160.063

Message sizes

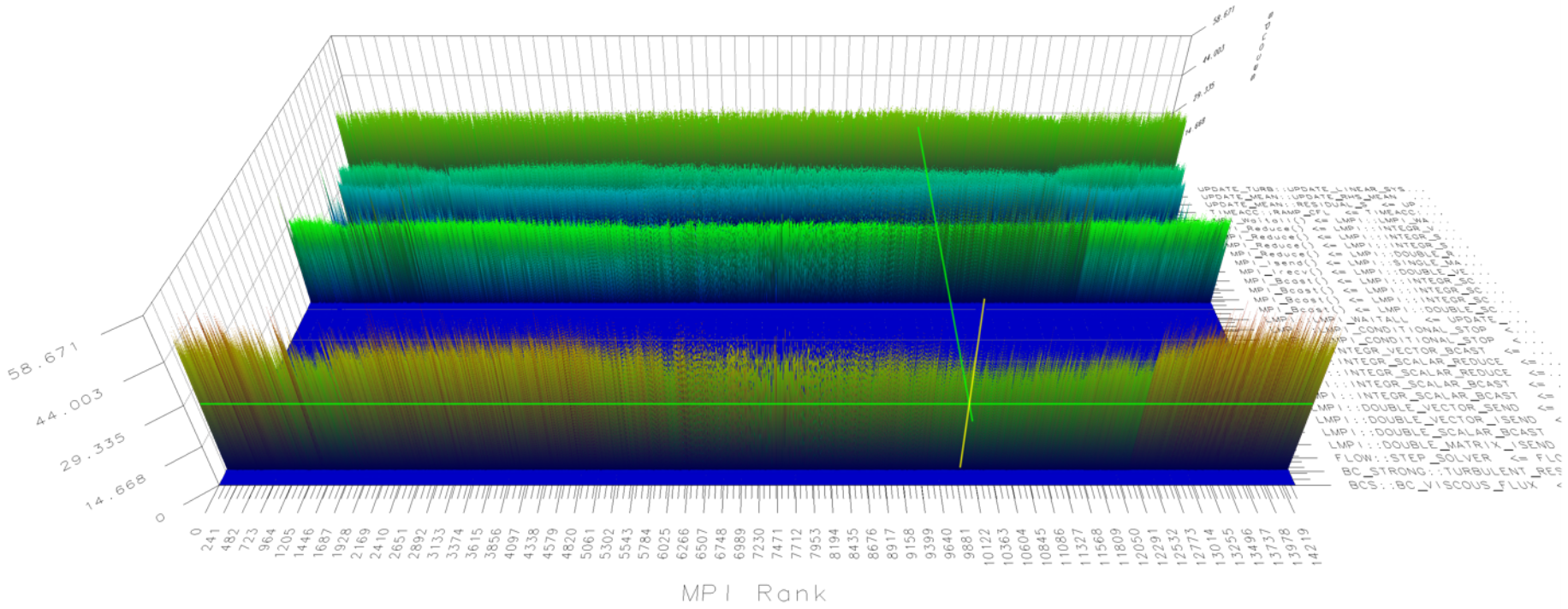
Time spent in collectives



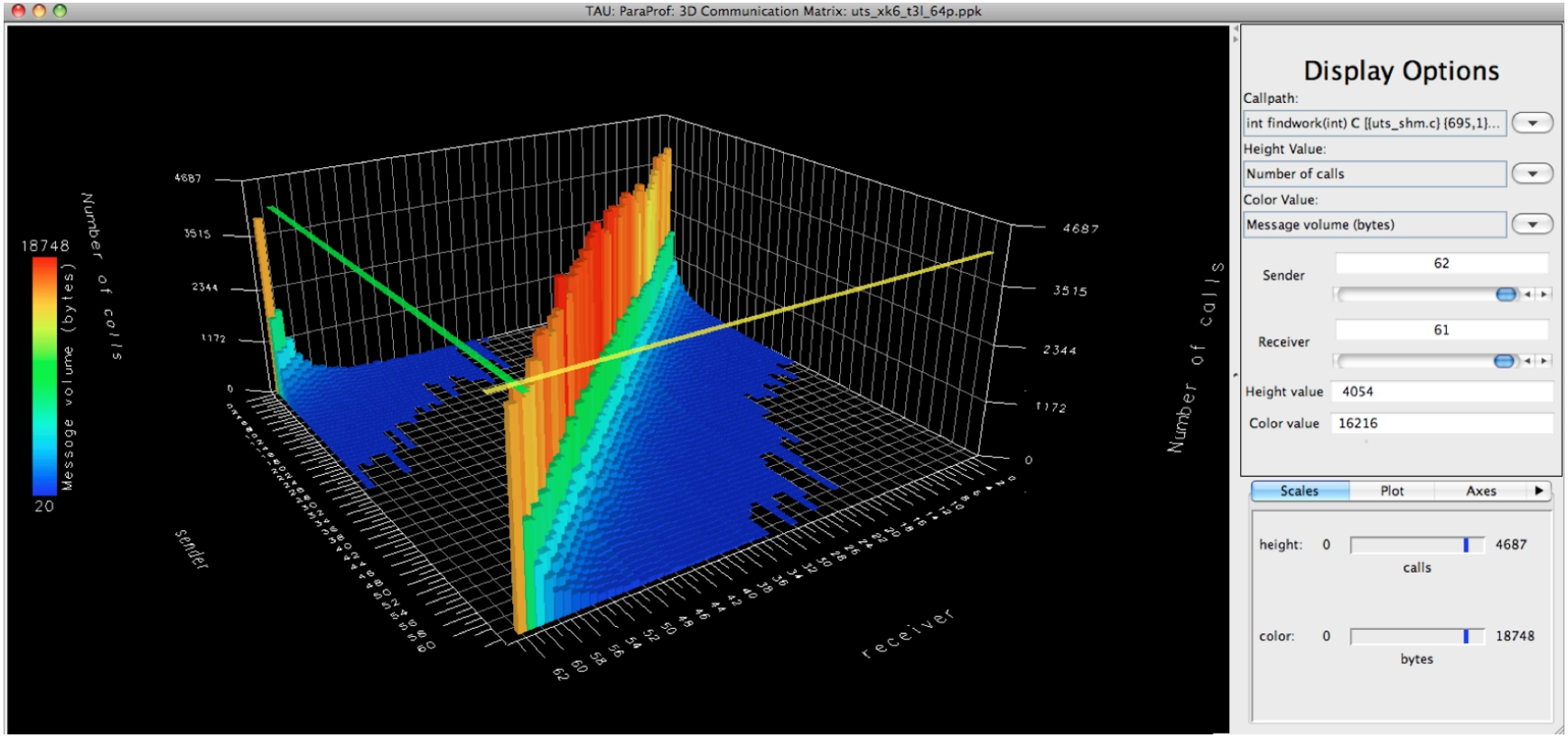
Are there relationships or patterns?



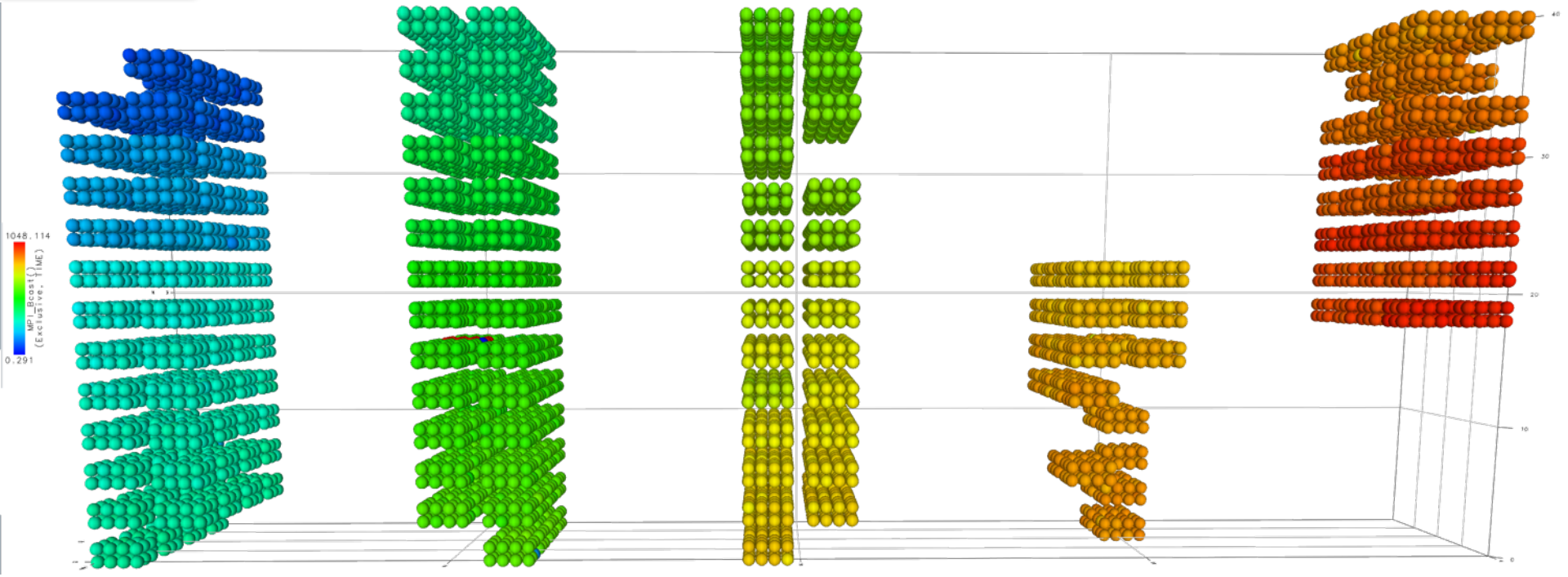
Are there load imbalances?



What is the communication profile?

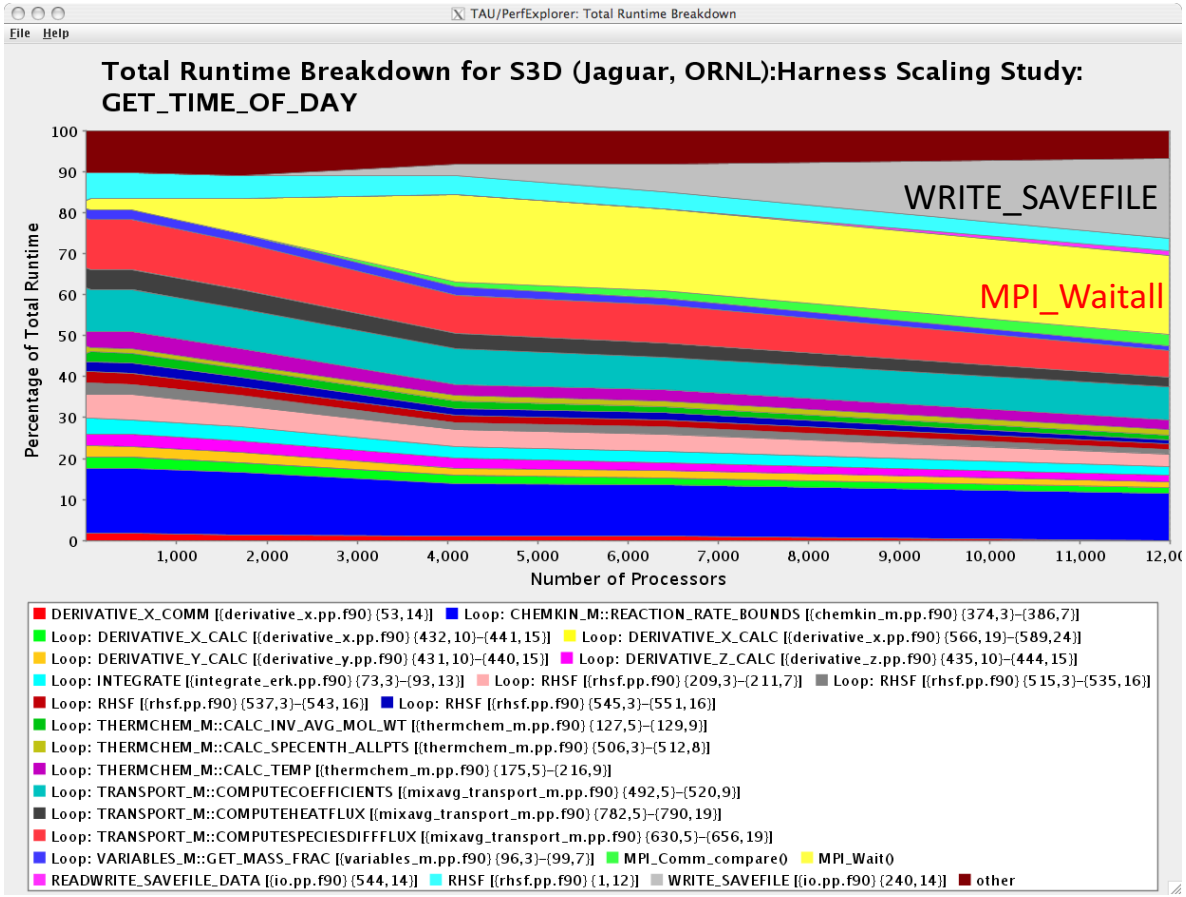


Where is the computation performed?



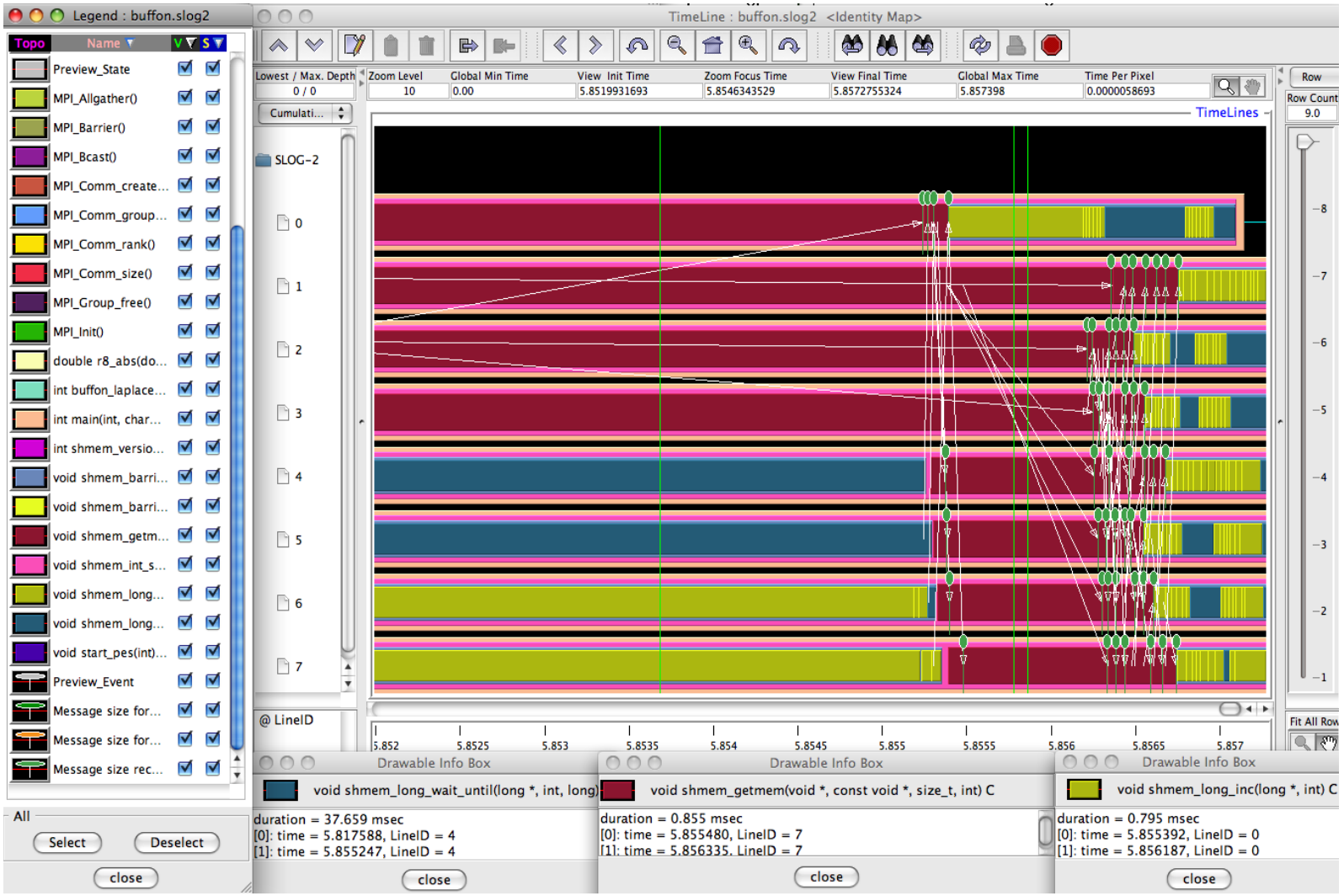
Note: Virtual, physical, and user-defined topologies are supported.

How does the application scale?

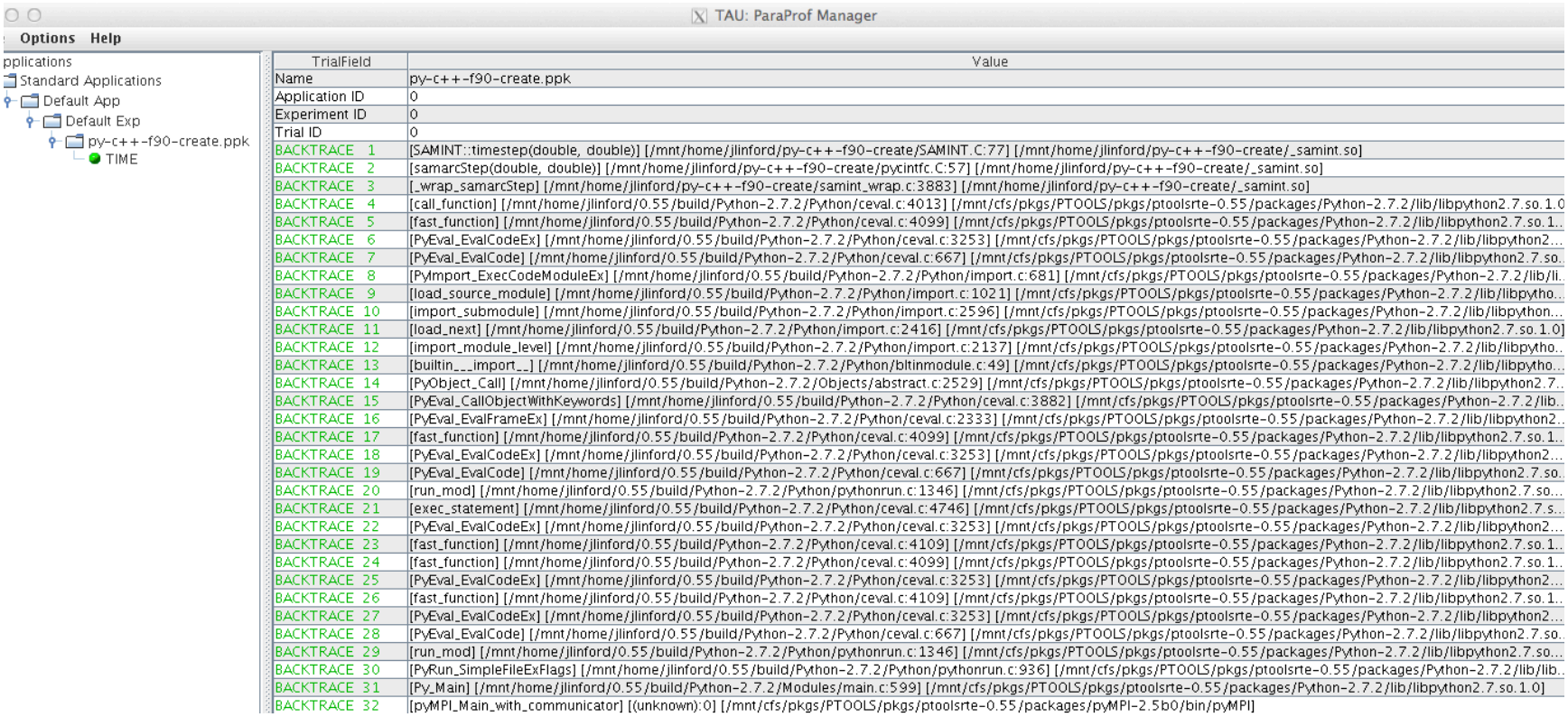


`% perfexplorer` **(Charts → Runtime Breakdown)**

When do Events Occur?



What Caused My Application to Crash?



TrialField	Value
Name	py-c++-f90-create.ppk
Application ID	0
Experiment ID	0
Trial ID	0
BACKTRACE 1	[SAMINT::timestep(double, double)] [/mnt/home/jlinford/py-c++-f90-create/SAMINT.C:77] [/mnt/home/jlinford/py-c++-f90-create/_samint.so]
BACKTRACE 2	[samarcStep(double, double)] [/mnt/home/jlinford/py-c++-f90-create/pycintfc.C:57] [/mnt/home/jlinford/py-c++-f90-create/_samint.so]
BACKTRACE 3	[_wrap_samarcStep] [/mnt/home/jlinford/py-c++-f90-create/samint_wrap.c:3883] [/mnt/home/jlinford/py-c++-f90-create/_samint.so]
BACKTRACE 4	[call_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4013] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0
BACKTRACE 5	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4099] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1..
BACKTRACE 6	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2...
BACKTRACE 7	[PyEval_EvalCode] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:667] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so..
BACKTRACE 8	[PyImport_ExecCodeModuleEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:681] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/li..
BACKTRACE 9	[load_source_module] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:1021] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpytho...
BACKTRACE 10	[import_submodule] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:2596] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython...
BACKTRACE 11	[load_next] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:2416] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 12	[import_module_level] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:2137] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpytho...
BACKTRACE 13	[builtin___import__] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/bltinmodule.c:49] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpytho...
BACKTRACE 14	[PyObject_Call] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Objects/abstract.c:2529] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7..
BACKTRACE 15	[PyEval_CallObjectWithKeywords] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3882] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib..
BACKTRACE 16	[PyEval_EvalFrameEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:2333] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2..
BACKTRACE 17	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4099] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1..
BACKTRACE 18	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2...
BACKTRACE 19	[PyEval_EvalCode] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:667] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so..
BACKTRACE 20	[run_mod] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/pythonrun.c:1346] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so...
BACKTRACE 21	[exec_statement] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4746] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.s...
BACKTRACE 22	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2...
BACKTRACE 23	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4109] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1..
BACKTRACE 24	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4099] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1..
BACKTRACE 25	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2...
BACKTRACE 26	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4109] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1..
BACKTRACE 27	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2...
BACKTRACE 28	[PyEval_EvalCode] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:667] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so..
BACKTRACE 29	[run_mod] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/pythonrun.c:1346] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so...
BACKTRACE 30	[PyRun_SimpleFileExFlags] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/pythonrun.c:936] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/lib..
BACKTRACE 31	[Py_Main] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Modules/main.c:599] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 32	[pyMPI_Main_with_communicator] [(unknown):0] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/pyMPI-2.5b0/bin/pyMPI]

```
% qsub –env TAU_TRACK_SIGNALS=1 …
% paraprof
```

What Caused My Application to Crash?

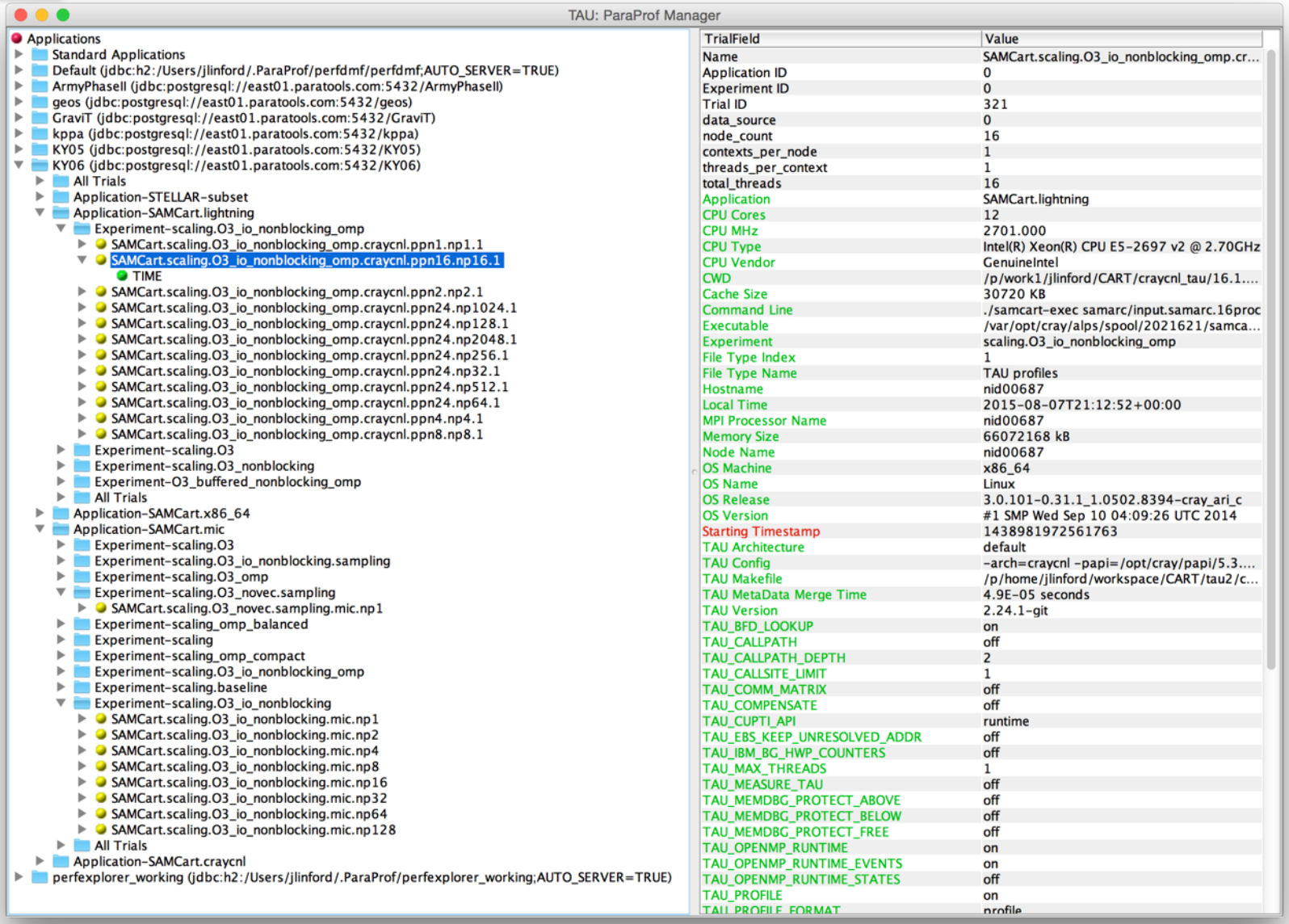
Right-click to see source code

Metadata fo...0,0

Name	Value
BACKTRACE 1	[SAMINT::timestep(double, double)] [/mnt/home/jlinford/py-c++-f90-create/SAMI...linford/py-c++-f90-create/_samint.so]
BACKTRACE 2	[samarcStep(double, double)] [/mnt/home/jlinford/py-c++-f90-create/pycintfc.C:5...py-c++-f90-create/_samint.so]
BACKTRACE 3	[_wrap_samarcStep] [/mnt/home/jlinford/py-c++-f90-create/samint_wrap.c:3883] [/mnt/home/jlinford/py-c++-f90-create/_samint.so]
BACKTRACE 4	[call_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4013] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 5	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4099] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 6	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2....
BACKTRACE 7	[PyEval_EvalCode] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:667] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so...
BACKTRACE 8	[PyImport_ExecCodeModuleEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:681] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/li...
BACKTRACE 9	[load_source_module] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:1021] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython...
BACKTRACE 10	[import_submodule] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:2596] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2...
BACKTRACE 11	[load_next] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:2416] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 12	[import_module_level] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/import.c:2137] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpytho...
BACKTRACE 13	[builtin___import__] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/bltinmodule.c:49] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython...
BACKTRACE 14	[PyObject_Call] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Objects/abstract.c:2529] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7....
BACKTRACE 15	[PyEval_CallObjectWithKeywords] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3882] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib...
BACKTRACE 16	[PyEval_EvalFrameEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:2333] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2....
BACKTRACE 17	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4099] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 18	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2....
BACKTRACE 19	[PyEval_EvalCode] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:667] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so...
BACKTRACE 20	[run_mod] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/pythonrun.c:1346] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so....
BACKTRACE 21	[exec_statement] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4746] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so...
BACKTRACE 22	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2....
BACKTRACE 23	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4109] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 24	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4099] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 25	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2....
BACKTRACE 26	[fast_function] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:4109] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 27	[PyEval_EvalCodeEx] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:3253] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2....
BACKTRACE 28	[PyEval_EvalCode] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/ceval.c:667] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so...
BACKTRACE 29	[run_mod] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/pythonrun.c:1346] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so....
BACKTRACE 30	[PyRun_SimpleFileExFlags] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Python/pythonrun.c:936] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/lib...
BACKTRACE 31	[Py_Main] [/mnt/home/jlinford/0.55/build/Python-2.7.2/Modules/main.c:599] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/Python-2.7.2/lib/libpython2.7.so.1.0]
BACKTRACE 32	[pyMPI_Main_with_communicator] [(unknown):0] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/pyMPI-2.5b0/bin/pyMPI]
BACKTRACE 33	[main] [(unknown):0] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/pyMPI-2.5b0/bin/pyMPI]
BACKTRACE 34	[__libc_start_main] [(unknown):0] [/lib64/libc-2.5.so]
BACKTRACE 35	[_start] [(unknown):0] [/mnt/cfs/pkgs/PTOOLS/pkgs/ptoolsrte-0.55/packages/pyMPI-2.5b0/bin/pyMPI]

Show Source Code

Performance Provenance



Keeping Up With Technology

PARATOOLS THREADSPOTTER

ParaTools ThreadSpotter

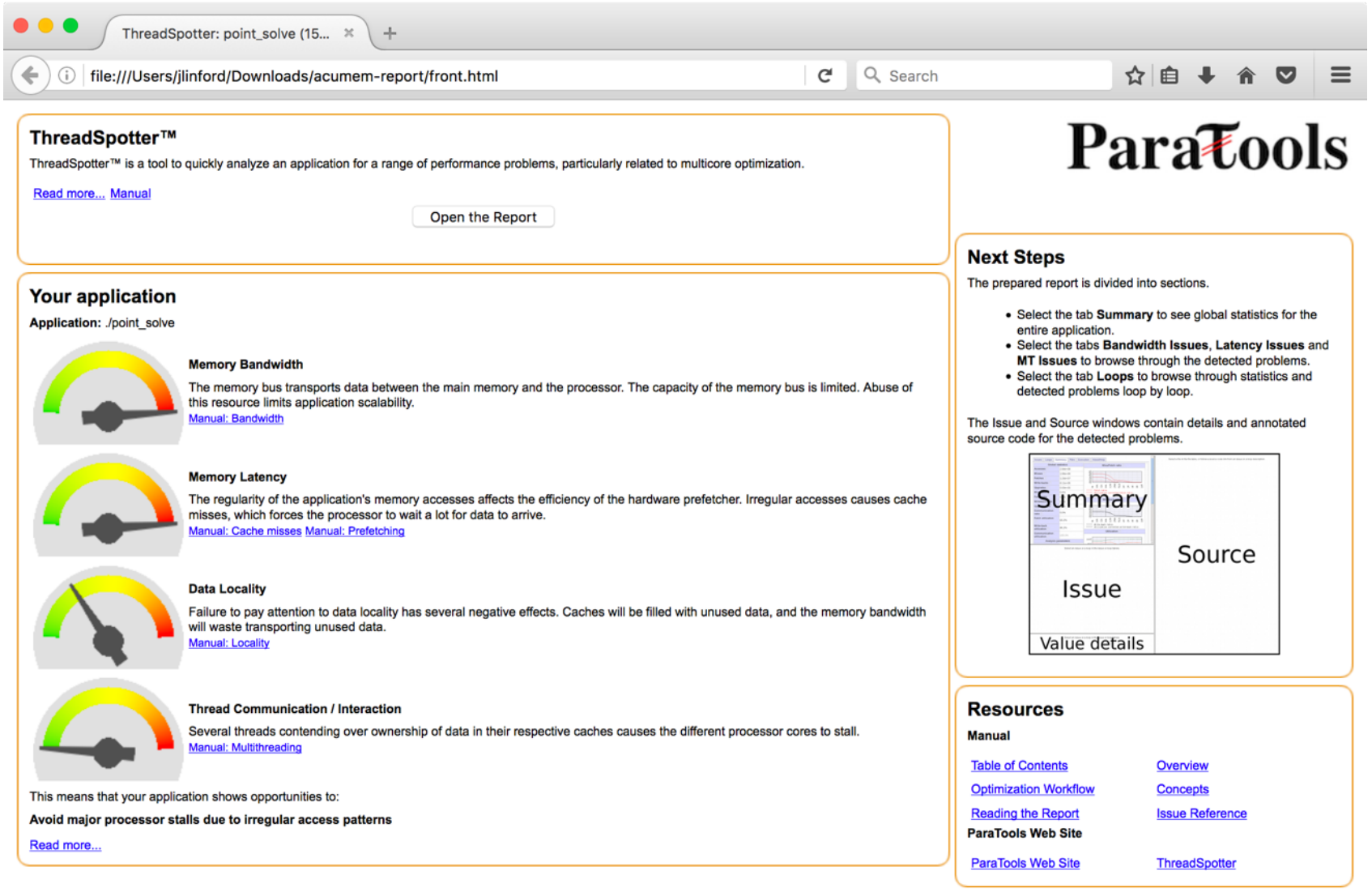
- A cache and memory optimization tool integrated with TAU
  - Analyzes **memory bandwidth** and latency, data locality and **thread communication**
  - Identifies specific issues and pinpoints troublesome areas in source code
  - Provides guidance towards a resolution
- Provides **qualitative** measurement:
  - Data is not dependent on the hardware
  - Can predict performance for other memory systems
    - E.g. Intel Xeon Phi “Knights Landing” MCDRAM vs. DDR

Questions ThreadSpotter can Answer

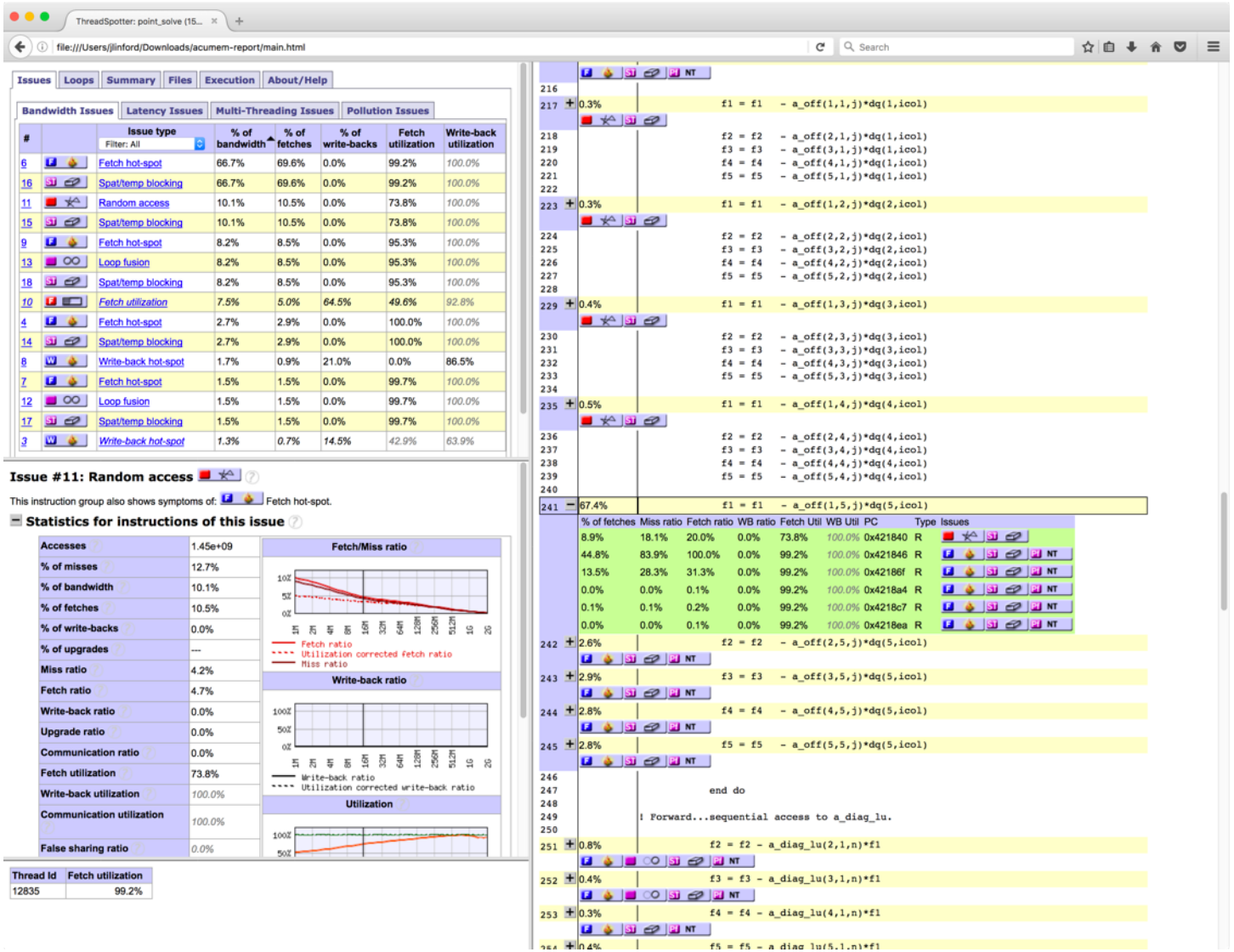
- **Miss ratio**: What is the likelihood that a memory access will miss in a cache?
- **Miss rate**: D:o per time unit, e.g. per-second, per-1000-instructions
- **Fetch ratio/rate***: What is the likelihood that a memory access will cause a fetch to the cache [including HW prefetching]
- **Fetch utilization***: What fraction of a cacheline was used before it got evicted
- **Writeback utilization***: What fraction of a cacheline written back to memory contains dirty data
- **Communication utilization***: What fraction of a communicated cacheline is ever used?

*Terms used in ParaTools ThreadSpotter reports.

ThreadSpotter Report Front Page



ThreadSpotter Report

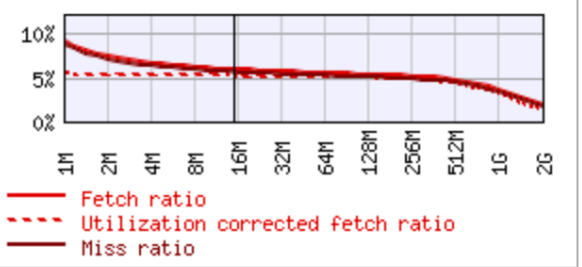


Application Performance Summary

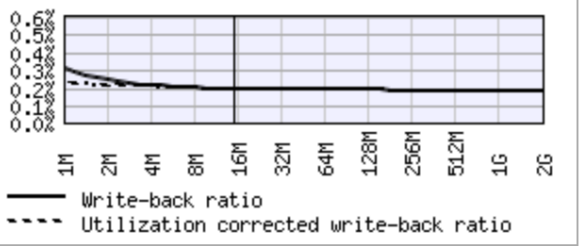
Issues | Loops | Summary | Files | Execution | About/Help

Global statistics	
Accesses	1.16e+10
Misses	6.55e+08
Fetches	6.92e+08
Write-backs	2.26e+07
Upgrades	0.00e+00
Miss ratio	5.7%
Fetch ratio	6.0%
Write-back ratio	0.2%
Upgrade ratio	0.0%
Communication ratio	0.0%
Fetch utilization	88.1%
Write-back utilization	*100.0%*
Communication utilization	6.5%
Analysis parameters	
Processor model	Intel(R) Xeon(R) CPU E5-2620 v3 @ 2.40GHz (auto)
Number of CPUs	2
Number of caches	2
Cache level	3
Cache size	15M
Line size	64
Replacement policy	random
Software prefetches active	Yes

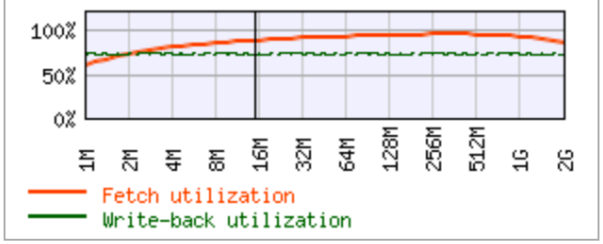
Miss/Fetch ratio



Write-back ratio



Utilization



Performance Issues

Bandwidth Issues | Latency Issues | Multi-Threading Issues | Pollution Issues

#		Issue type Filter: All	% of bandwidth ▲	% of fetches	% of write-backs	Fetch utilization	Write-back utilization
13		Inefficient loop nesting	63.7%	65.8%	0.0%	96.2%	*100.0%*
23		Spat/temp blocking	63.7%	65.8%	0.0%	96.2%	*100.0%*
18		Random access	15.6%	16.1%	0.0%	60.4%	*100.0%*
22		Spat/temp blocking	15.6%	16.1%	0.0%	60.4%	*100.0%*
16		Inefficient loop nesting	6.6%	6.9%	0.0%	100.0%	*100.0%*
20		Loop fusion	6.6%	6.9%	0.0%	100.0%	*100.0%*
25		Spat/temp blocking	6.6%	6.9%	0.0%	100.0%	*100.0%*
10		*Fetch utilization*	*6.3%*	*4.5%*	*62.1%*	*51.5%*	*100.0%*
12		Inefficient loop nesting	2.6%	2.7%	0.0%	88.3%	*100.0%*
21		Spat/temp blocking	2.6%	2.7%	0.0%	88.3%	*100.0%*
14		Inefficient loop nesting	1.6%	1.7%	0.0%	86.8%	*100.0%*
19		Loop fusion	1.6%	1.7%	0.0%	86.8%	*100.0%*
24		Spat/temp blocking	1.6%	1.7%	0.0%	86.8%	*100.0%*
15		Inefficient loop nesting	1.2%	0.6%	19.6%	0.0%	100.0%
3		*Write-back hot-spot*	*1.1%*	*0.7%*	*12.8%*	*43.5%*	*86.1%*
17		Inefficient loop nesting	0.3%	0.3%	2.1%	*57.4%*	*30.5%*
26		Spat/temp blocking	0.3%	0.3%	2.1%	*57.4%*	*30.5%*

Random Access Issue Detail

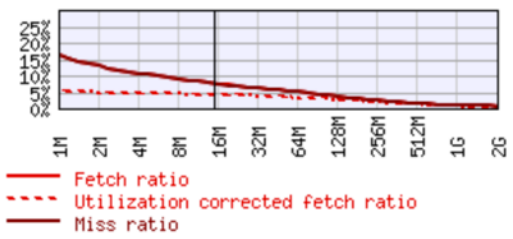
Issue #18: Random access

This instruction group also shows symptoms of: Fetch utilization, Fetch hot-spot.

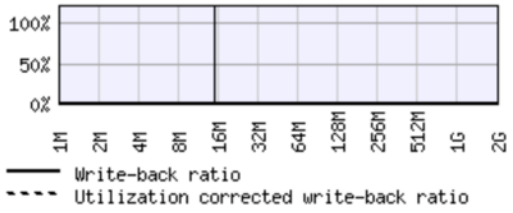
Statistics for instructions of this issue

Accesses	1.42e+09
% of misses	17.0%
% of bandwidth	15.6%
% of fetches	16.1%
% of write-backs	0.0%
% of upgrades	---
Miss ratio	7.8%
Fetch ratio	7.8%
Write-back ratio	0.0%
Upgrade ratio	0.0%
Communication ratio	0.0%
Fetch utilization	60.4%
Write-back utilization	*100.0%*
Communication utilization	15.0%
False sharing ratio	*0.0%*
HW prefetch probability	0.0%
Access randomness	Very high
Worst instruction	"point_solve"!

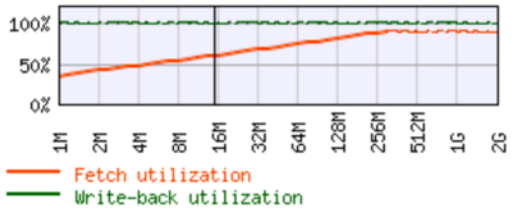
Fetch/Miss ratio



Write-back ratio



Utilization



If the program was changed as to reach 100% fetch utilization, fetches in this instruction group would be reduced with 42.4%, and total number of fetches would be reduced with 6.8%.

Inefficient Loop Nesting Issue Detail

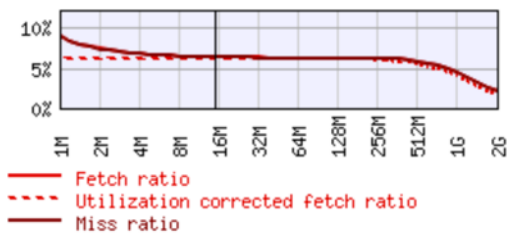
Issue #13: Inefficient loop nesting

This instruction group also shows symptoms of: Fetch hot-spot.

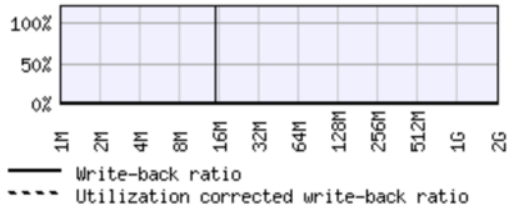
Statistics for instructions of this issue

Accesses	7.13e+09
% of misses	69.4%
% of bandwidth	63.7%
% of fetches	65.8%
% of write-backs	0.0%
% of upgrades	---
Miss ratio	6.4%
Fetch ratio	6.4%
Write-back ratio	0.0%
Upgrade ratio	0.0%
Communication ratio	0.0%
Fetch utilization	96.2%
Write-back utilization	*100.0%*
Communication utilization	*100.0%*
False sharing ratio	*0.0%*
HW prefetch probability	0.0%
Access randomness	Low
Worst instruction	"point_solve"!

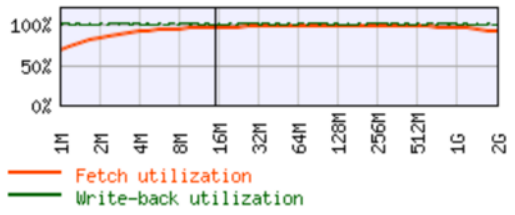
Fetch/Miss ratio



Write-back ratio

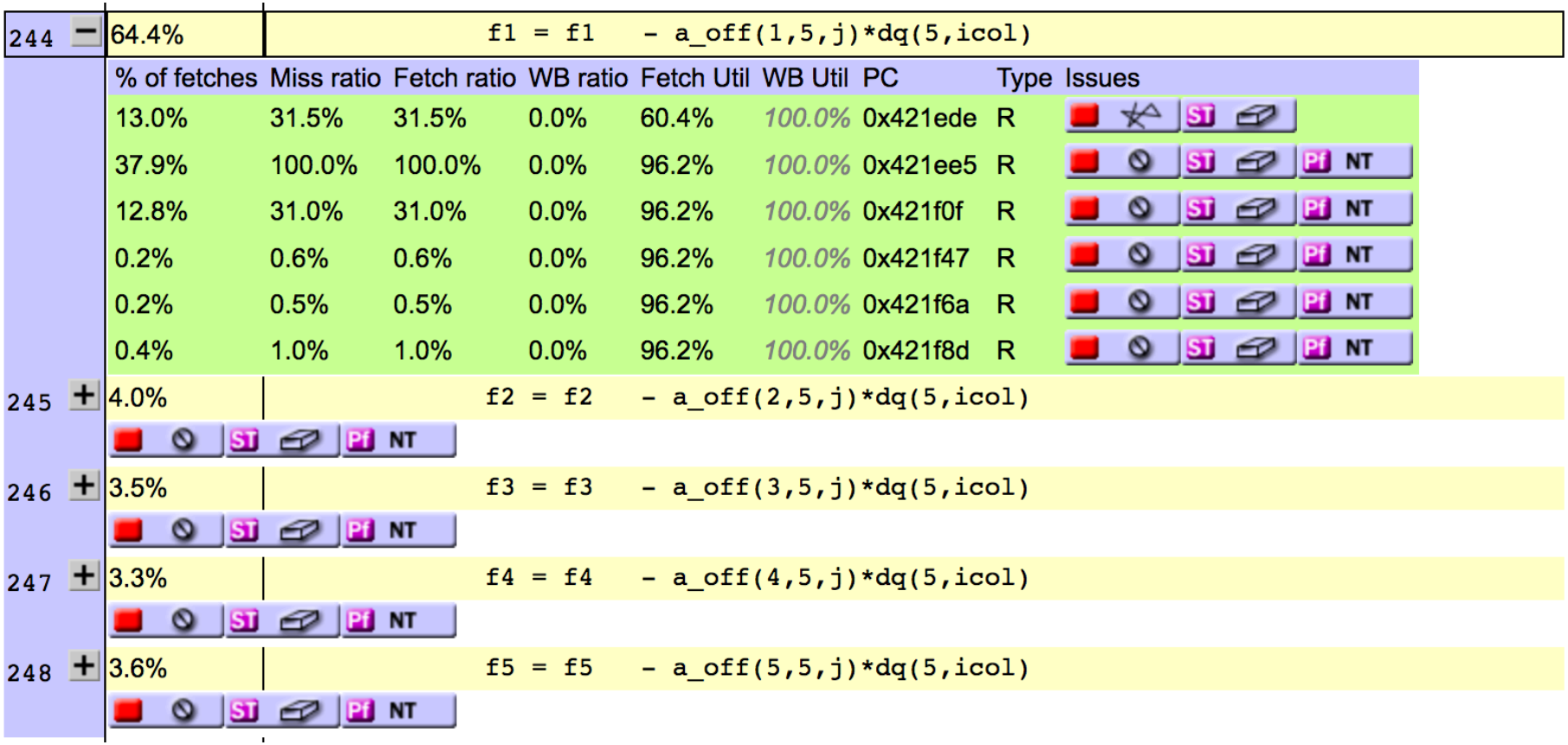


Utilization

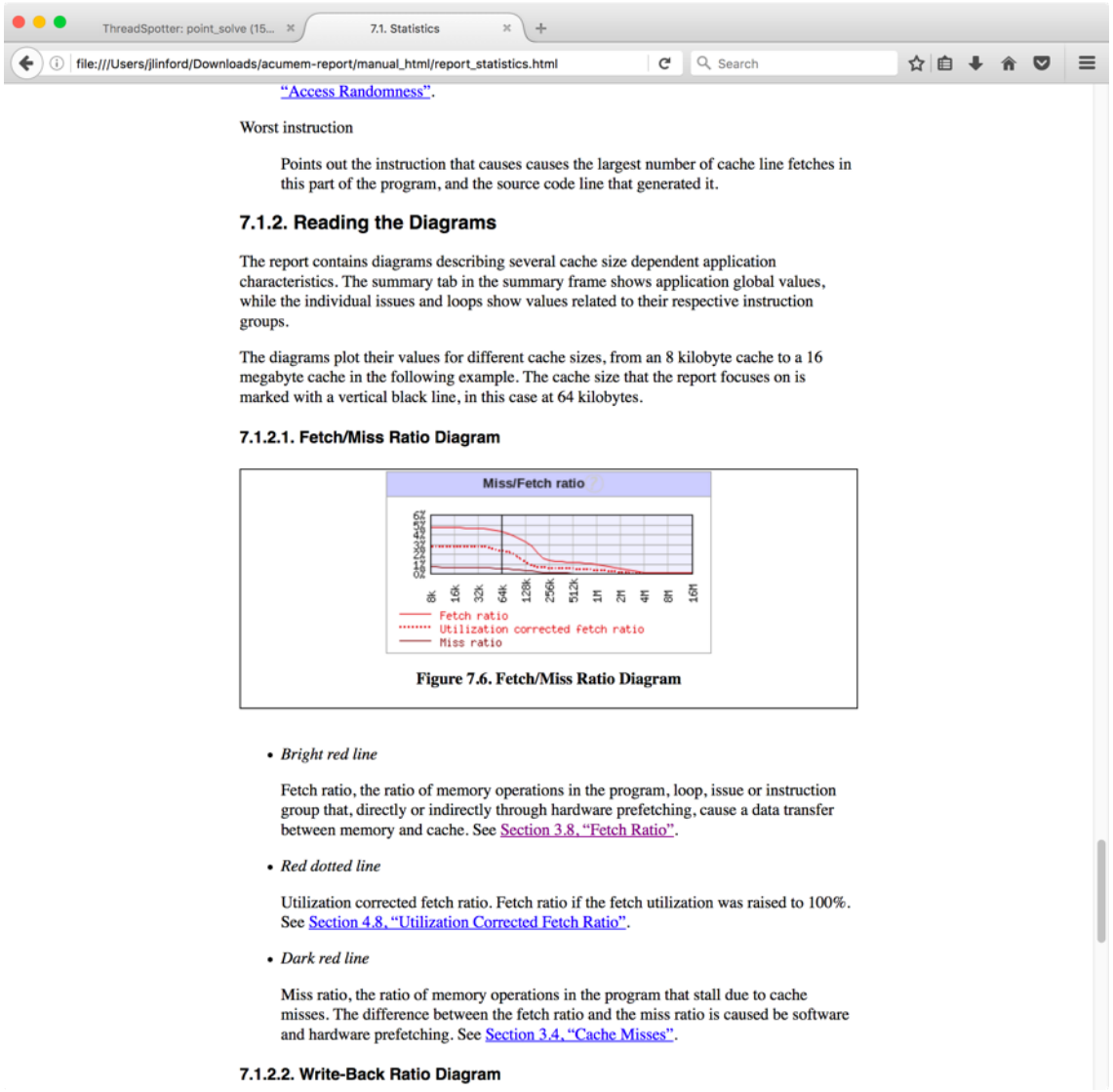


If the program was changed as to reach 100% fetch utilization, fetches in this instruction group would be reduced with 3.8%, and total number of fetches would be reduced with 2.5%.

Source Code / Issue Mapping



ThreadSpotter Online Help



Keeping Up With Technology

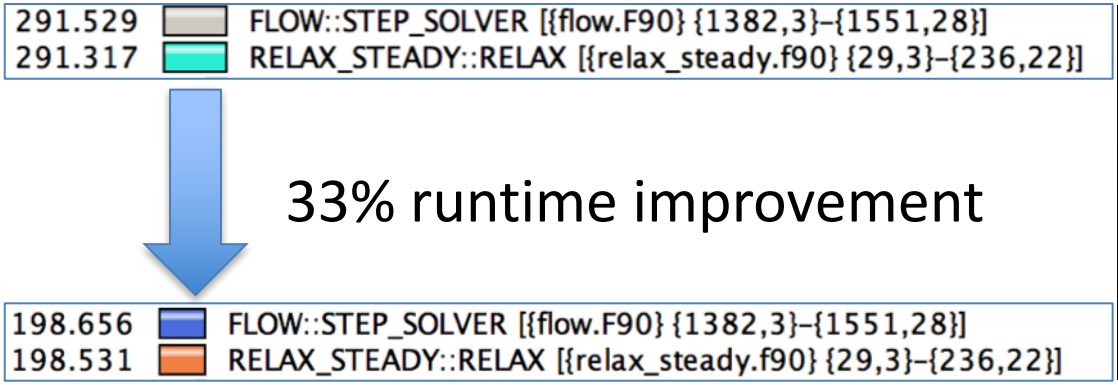
SUCCESS STORIES

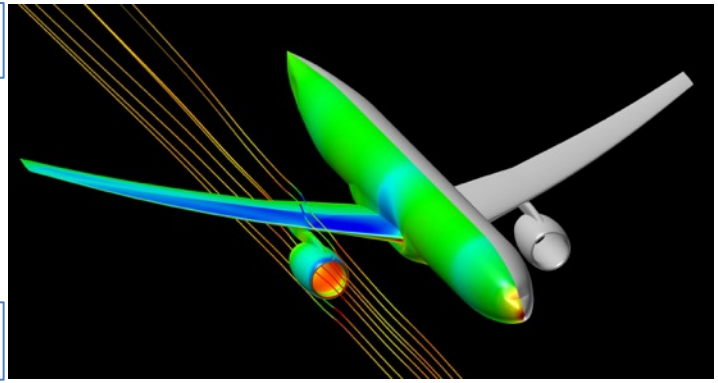
NASA FUN3D

"These days I get excited about 1-2% speedups that I find....quite unusual to find something of this magnitude these days, especially with just a 2-line fix in the code! :)"

One of the largest and most accurate wing-body-nacelle simulations of 2016.

- 1,651,089,924 grid points
- 5,902,801,476 tetrahedral elements
- 1,310,290,264 prismatic elements
- 14,400 Ivy Bridge cores





DOD CREATE-AV

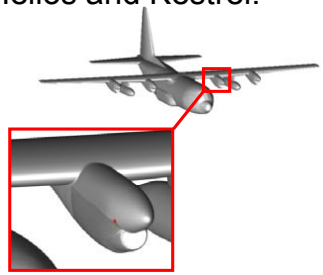
Strand Technology

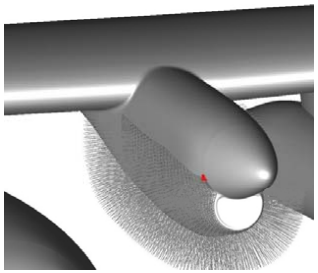
Technology Drivers

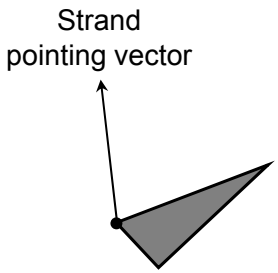
- Timeliness (automation of mesh generation)
- Timeliness (automation and scalability of domain connectivity)
- Timeliness/Physical accuracy (computational efficiency and scalability of aerodynamic solvers)
- Processor architecture (small memory footprint maps well to hierarchical memory architectures, e.g., multi-core, GPU)

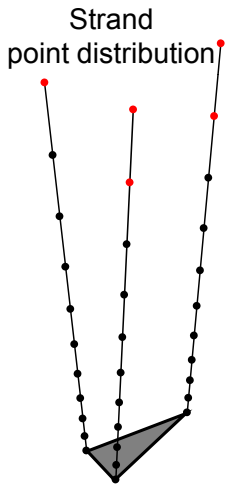
CREATE-AV Example

This is a new meshing paradigm introduced in 2007 by current members of the CREATE-AV technical staff. The technology is being matured in the Helios product and will be deployed through both Helios and Kestrel.

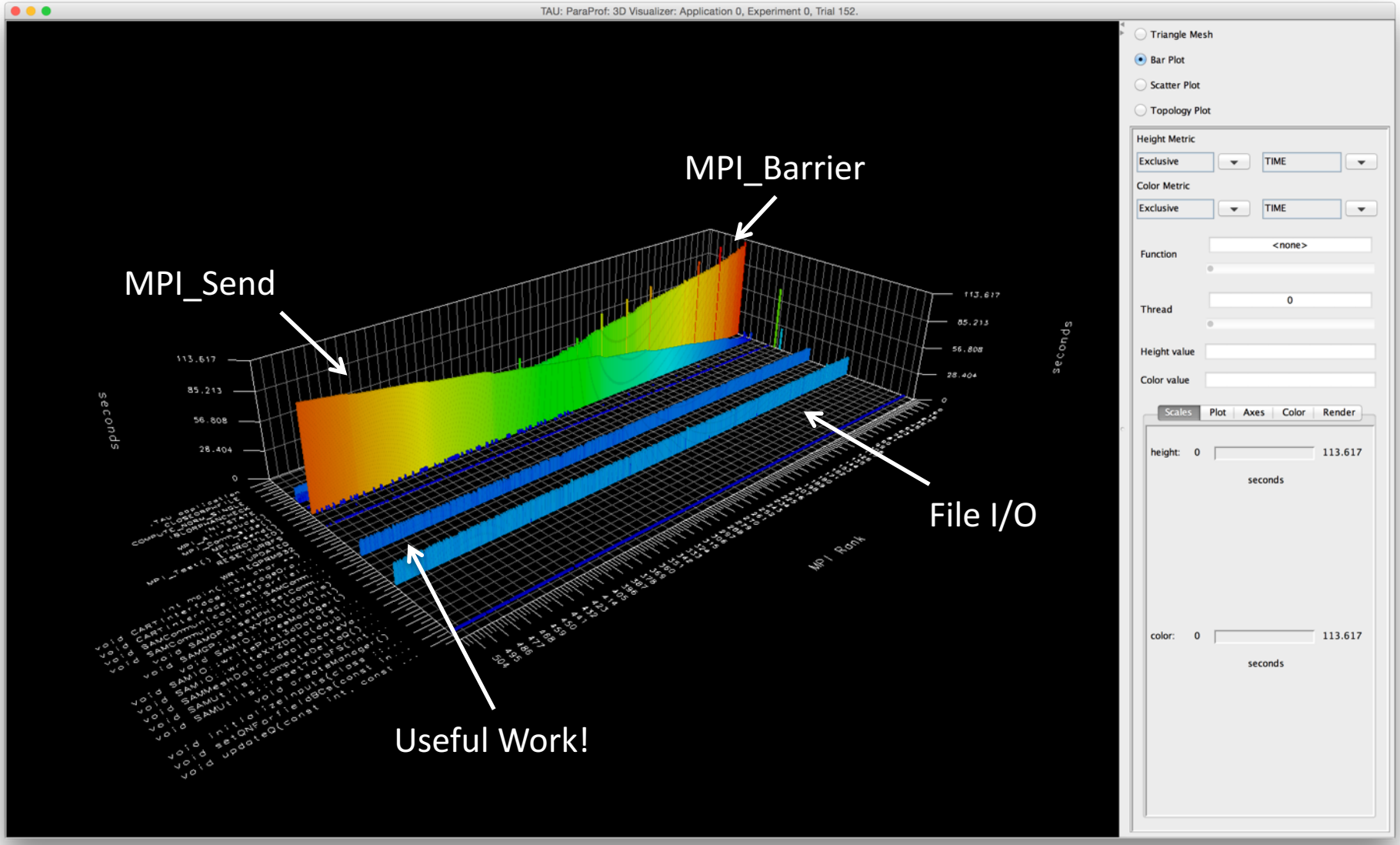




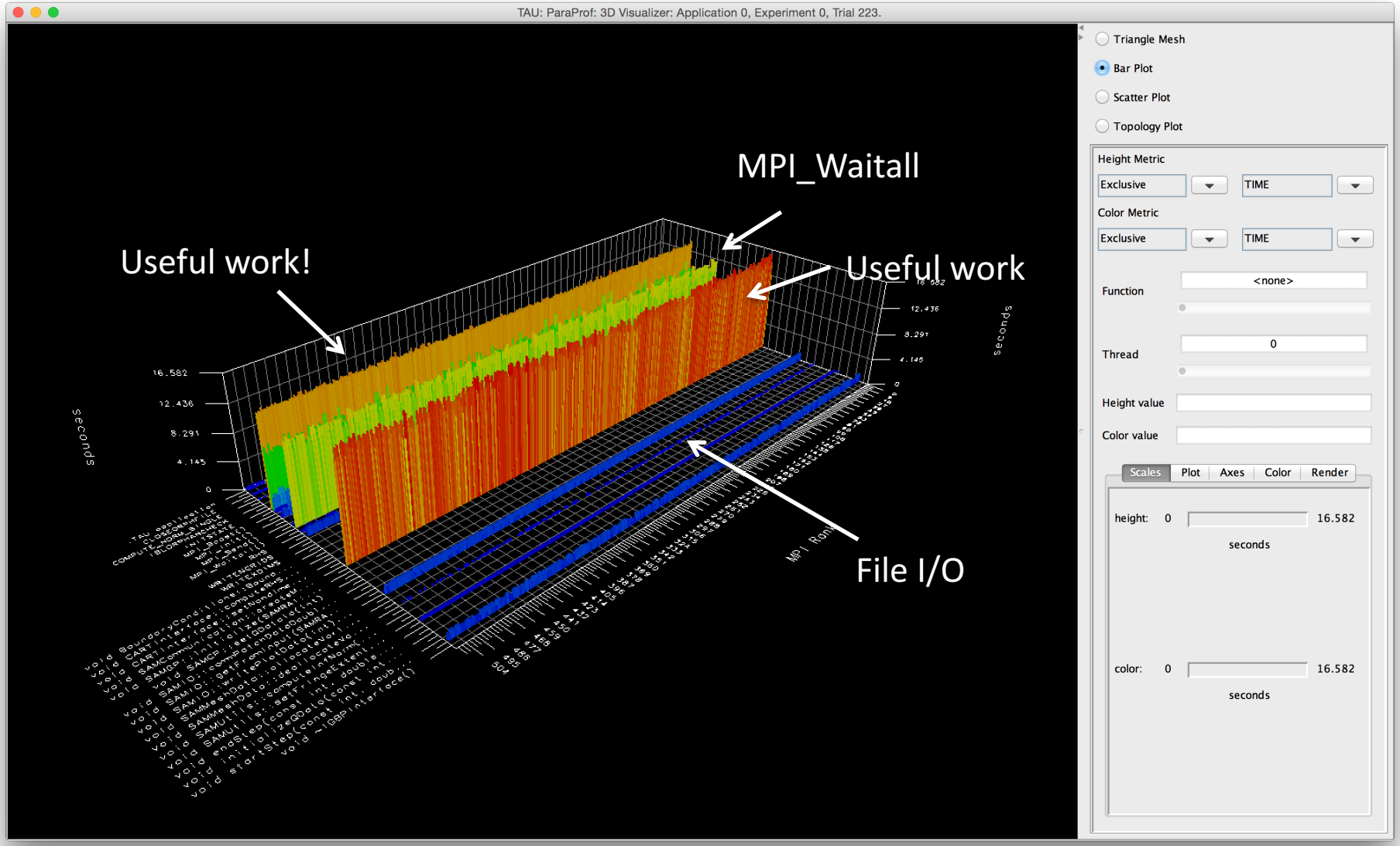




Initial Profile

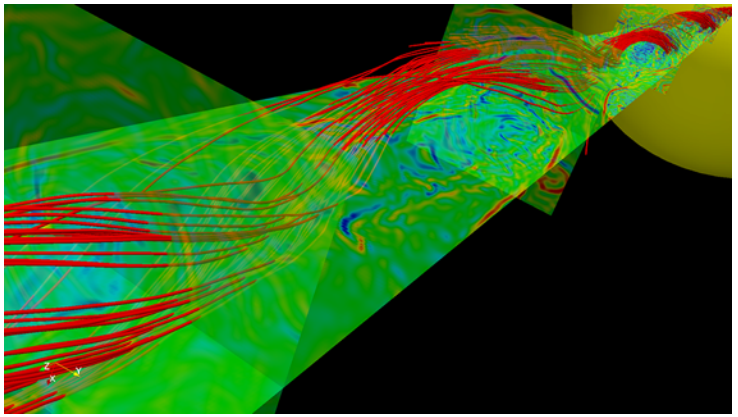


After Hot Spot Optimization

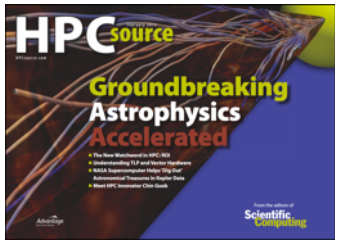


DOE IRMHD

- INCITE magnetohydrodynamcis simulation to understand solar winds and coronal heating
  - First direct numerical simulations of Alfvén wave (AW) turbulence in extended solar atmosphere accounting for inhomogeneities
  - Team
    - University of New Hampshire (Jean Perez and Benjamin Chandran)
    - ALCF (Tim Williams)
    - University of Oregon (Sameer Shende)

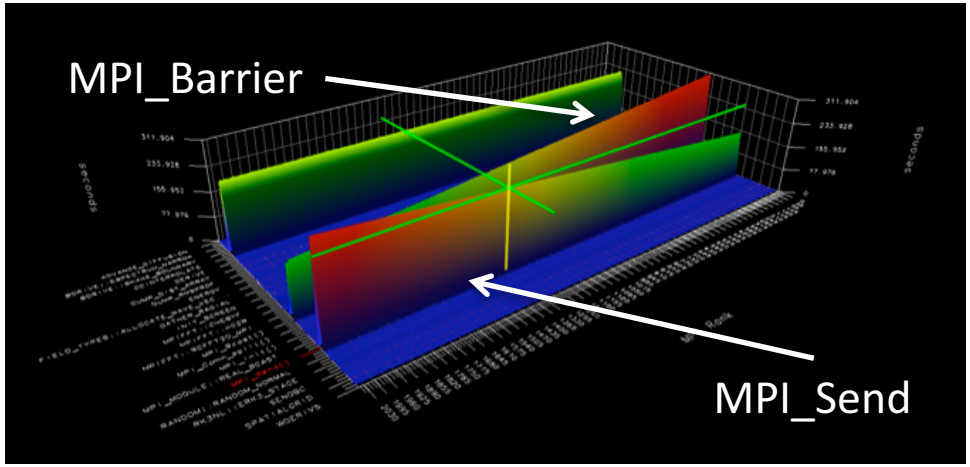


- IRMHD (Inhomogeneous Reduced Magnetohydrodynamics)
  - Fortran 90 and MPI
  - Excellent weak and strong scaling properties
  - Tested and benchmarked on Intrepid and Mira
- HPC Source article and ALCF news
  https://www.alcf.anl.gov/articles/furthering-understanding-coronal-heating-and-solar-wind-origin



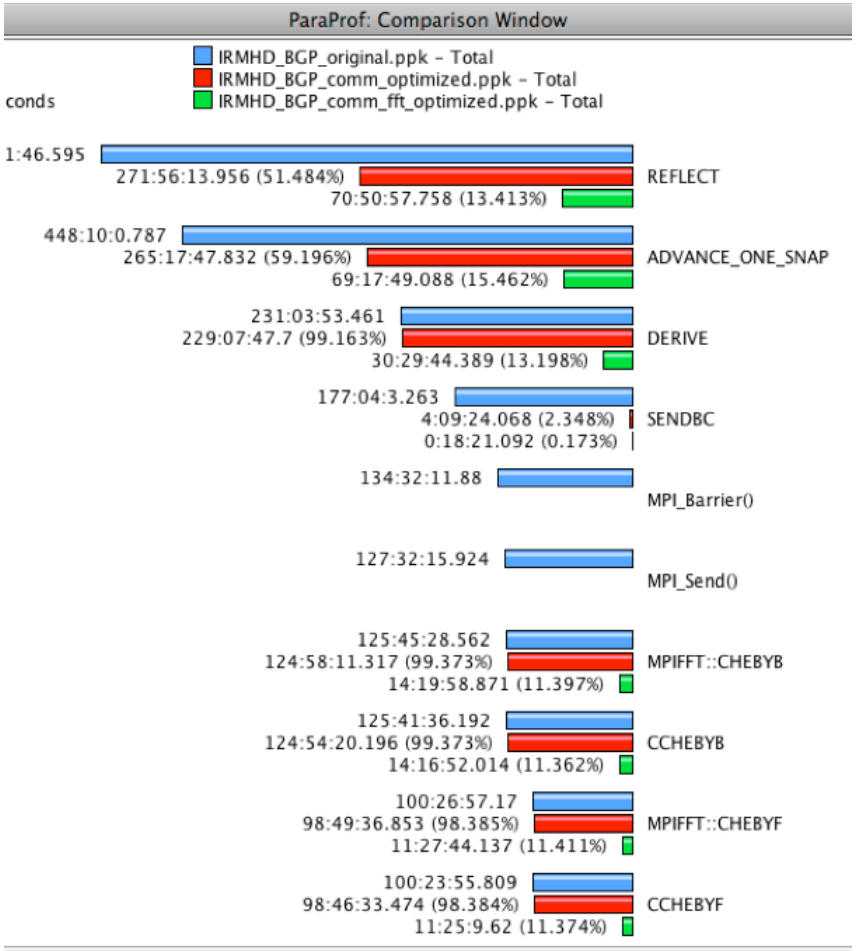
IRMHD Communication Analysis

- Source-based (direct) instrumentation
- MPI instrumentation and volume measurement
- IRMHD exhibited significant synchronous communication bottlenecks
- On 2,408 cores:
  - **MPI_Send** and **MPI_Bcast** take significant time
  - Opportunities for communication/ computation overlap
  - Identified possible targets for computation improvements



IRMHD Optimization

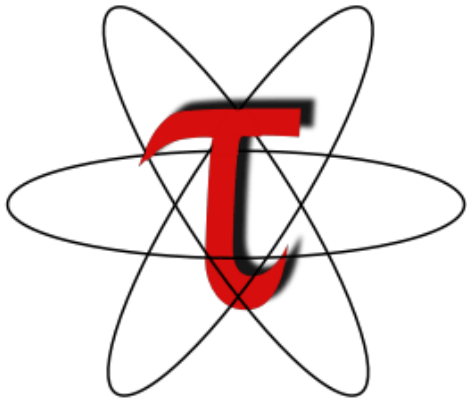
- On 2,408 cores, overall execution time reduced from 528.18 core hours to 70.8 core hours **(>7x improvement)**
- Non-blocking communication substrate
- More efficient implementation of underlying FFT



Python Performance Evaluation

CONCLUSION

Try it out!



http://www.paratools.com/TAU

http://www.paratools.com/ThreadSpotter

Free download, open source, BSD license

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