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Outline

Introduction to TAU

• How to compile

• Explaining functionalities of TAU/ParaProf

• Presenting basic steps of PerfExplorer



- Tuning and Analysis Utilities, developed at University of Oregon
- Scalable and flexible performance analysis toolkit
- Automatic instrumentation through Program Database Toolkit (PDT) for routines, loops, I/O, memory, phases, etc.
- Installed version on Summit: v2.28.1
- Module: tau
- Web site: https://www.cs.uoregon.edu/research/tau/home.php
- Email: tau-bugs@cs.uoregon.edu



Capability Matrix - TAU

Capability	Profiling	Tracing	Notes/Limitations
MPI, MPI-IO	Yes	Yes	
OpenMP CPU	Yes	Yes	
OpenMP GPU	Yes	Yes	Some restrictions apply regarding the CUPTI metrics
OpenACC	Yes	Yes	Some functionalities are not ready for production, no metrics available
CUDA	Yes	Yes	Some functionalities are not ready for production
POSIX I/O	Yes	Yes	
POSIX threads	Yes	Yes	
Memory – app-level	Yes	Yes	
Memory – func-level	Yes	Yes	
Hotspot Detection	Yes	Yes	
Variance Detection	Yes	Yes	
Hardware Counters	Yes	Yes	PC

Compilation

• There are mainly three approaches to use an application with TAU

- Use TAU Wrappers
 - For C: replace the compiler with tau_cc.sh
 - For C++: replace the compiler with tau_cxx.sh
 - For Fortran: replace the compiler with tau_f90.sh/tau_f77.sh
- Dynamic instrumentation, for example:
 - jsrun -n 4 -r 4 -a 1 -c1 tau_exec -T mpi ./test
- Rewrite the binary (support for x86_64):
 - tau_rewrite –T papi,pdf a.out –o a.inst



Compilation (cont.)

Method	Requires recompil- ing	Requires PDT	Shows MPI events	Routine- level event	Low level events (loops, phases, etc)	Throttling to reduce overhead	Ability to exclude file from in- strumenta- tion
Interposi- tion			Yes			Yes	
Compiler	Yes		Yes	Yes		Yes	Yes
Source	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Interposition: tau_exec

Compiler: tau_cc.sh -tau_options=-optCompInst Set the TAU_MAKEFILE

Source: tau_cc.sh The TAU_MAKEFILE should include the PDT



tau_exec

tau_exec -help

Options:

-V	Verbose mode
-S	Show what will be done but don't actually do anything (dryrun)
-io	Track I/O
-memory	Track memory allocation/deallocation
-memory_debug	Enable memory debugger
-cuda	Track GPU events via CUDA
-cupti	Track GPU events via CUPTI (Also see env. variable TAU_CUPTI_API)
-opencl	Track GPU events via OpenCL
-openacc	Track GPU events via OpenACC (currently PGI only)
-rocm	Track ROCm events via rocprofiler
-ompt	Track OpenMP events via OMPT interface
-ebs	Enable event-based sampling
-ebs_period= <count></count>	Sampling period (default 1000)
-ebs_source= <counter></counter>	Counter (default itimer)
-ebs_resolution= <file function l< td=""><td>ine> Choose sampling granularity.</td></file function l<>	ine> Choose sampling granularity.
-um	Enable Unified Memory events via CUPTI
-sass= <level></level>	Track GPU events via CUDA with Source Code Locator activity (kernel level or source level)
-CSV	Outputs sass profile in CSV
-env	Track GPU environment activity (power utilization, SM, memory frequency, temperature)
-T <cupti,disable,gnu,gn< td=""><td>U_MEM,MPI,OPENMP,PAPI,PDT,PGI,PGI_MEM,PROFILE,SERIAL> : Specify TAU tags</td></cupti,disable,gnu,gn<>	U_MEM,MPI,OPENMP,PAPI,PDT,PGI,PGI_MEM,PROFILE,SERIAL> : Specify TAU tags



TAU Environment Variables

Environment Variable	Default	Description
TAU_TRACE	0	Setting to 1 turns on tracing
TAU_CALLPATH	0	Setting to 1 turns on callpath profiling
TAU TRACK MEMORY LEAKS	0	Setting to 1 turns on leak detection
TAU_TRACK_HEAP	0	Setting to 1 turns on heap memory/headroom at routine entry & exit
TAU CALLPATH DEPTH	2	Specifies depth of callpath
TAU TRACK IO PARAMS	0	Setting to 1 with -optTrackIO
TAU_SAMPLING	1	Generates sample based profiles
TAU_COMM_MATRIX	0	Setting to 1 generates communication matrix display using
		context events
TAU_THROTTLE	1	Setting to 0 turns off throttling. Enabled by default to remove
		instrumentation in lightweight routines that are called frequently
TAU_THROTTLE_NUMCALLS	100000	Specifies the number of calls before testing for throttling
TAU_THROTTLE_PERCALL	10	Specifies value in microseconds. Throttle a routine if it is called
		over 100000 times and takes less than 10 usec of inclusive time
TAU_COMPENSATE	0	Setting to 1 enables runtime compensation of instrumentation
		overhead
TAU_PROFILE_FORMAT	Profile	Setting to "merged" generates a single file, "snapshot"
		generates snapshot per thread
TAU_METRICS	TIME	Setting to a comma separated list
		(TIME:PAPI_TOT_INS:PAPI_FP_OPS)



TAU Compile-Time Environment Variables

-optVerbose	Turn on verbose debugging messages				
-optCompInst	Use compiler based instrumentation				
-optNoCompInst	Do not revert to compiler instrumentation if				
	source instrumentation fails				
-optTrackIO	Wrap POSIX I/O call and calculates vol/bw of				
	I/O operations				
-optKeepFiles	Does not remove .pdb and .inst.* files				
-optPreProcess	Preprocess Fortran sources before instrumen-				
	tation				
-optTauSelectFile=" <file"< p=""></file"<>	Specify selective instrumentation file for				
	tau_instrumentor				
-optTauWrapFile=" <file>"</file>	Specify path to link_options.tau generated by				
	tau_gen_wrapper				
-optHeaderInst	Enable instrumentation of headers				
-optLinking=""	Options passed to the linker				
-optCompile=""	Options passed to the compiler				
-optPdtF95Opts=""	Add options for Fortran parser in PDT				
-optPdtF95Reset=""	Reset options for Fortran parser in PDT				
-optPdtCOpts=""	Options for C parser in PDT				
-optPdtCxxOpts=""	Options for C++ parser in PDT				

For using free format in .f files, use: % export TAU_OPTIONS=`-optPdtF95Opts=``-R free'''



How TAU works?

- Instrumentation:
 - Adds probes to perform measurements
 - Source code instrumentation
 - Wrapping external libraries (I/O, CUDA, OpenACC, OpenCL)
 - Rewriting the binary executable
- Measurement:
 - Profiling or Tracing
 - Direct instrumentation
 - Sampling
 - Throttling
- Analysis:
 - Visualization of profiles and traces
 - 3D visualization
 - Trace conversion tools



TAU Instrumentation/Measurement





Tau_exec

Usage: tau_exec [options] [--] <exe> <exe options>

Options:

- -v Verbose mode
- -vv Very Verbose mode (enables TAU_VERBOSE=1)
- -s Show what will be done but don't actually do anything (dryrun)
- -io Track I/O
- -memory Track memory allocation/deallocation
- -memory_debug Enable memory debugger
- -cuda Track GPU events via CUDA
- -cupti Track GPU events via CUPTI (Also see env. variable TAU_CUPTI_API)
- -opencl Track GPU events via OpenCL
- -openacc Track GPU events via OpenACC (currently PGI only)
- -rocm Track ROCm events via rocprofiler
- -ompt Track OpenMP events via OMPT interface
- -power Track power events via PAPI's perf RAPL interface
- -numa Track remote DRAM, total DRAM events (needs papi with recent perf support for x86_64)
- -ebs Enable event-based sampling
- -ebs_period=<count> Sampling period (default 1000)
- -um Enable Unified Memory events via CUPTI
- -sass=<level> Track GPU events via CUDA with Source Code Locator activity (kernel level or source level)
- -csv Outputs sass profile in CSV



MiniWeather MPI compilation

- module load pgi
- module load tau
- export

TAU_MAKEFILE/sw/summit/tau/2.28.1_patched/ibm64linux/lib/Makef ile.tau-pgi-papi-mpi-pdt-pgi

- Replace mpicxx with tau_cxx.sh in the Makefile
- export TAU_OPTIONS='-optLinking=-Ipnetcdf -optVerbose'
- make mpi



MiniWeather MPI – Execution - Profiling

export TAU_METRICS=TIME:PAPI_TOT_INS:PAPI_TOT_CYC:PAPI_FP_OPS #export TAU_CALLPATH=1 #export TAU_CALLPATH_DEPTH=10 export TAU_PROFILE=1 export TAU_TRACK_MESSAGE=1 export TAU_COMM_MATRIX=1

```
jsrun -n 64 -r 8 -a 1 -c 1 ./miniWeather_mpi
Or if compiled with mpicxx
jsrun -n 64 -r 8 -a 1 -c 1 tau_exec ./miniWeather_mpi
```



MiniWeather MPI - Execution

- When the execution finished, there is one folder for each TAU_METRICS declaration with the format MULTI___
- If there is no TAU_METRICS declared, then by default is used the metric TIME and the profiling files are not in a folder, in this case you need to pack them and execute paraprof:

summit> paraprof _pack name.ppk
summit> paraprof name.ppk

• To visualize the results execute paraprof (check also pprof for text mode)



MiniWeather MPI - Paraprof

😣 😑 💷 TAU: ParaProf Manager		
File Options Help		😣 😑 💷 🛛 TAU: ParaProf: /home/gmarkomanolis/Downloads/mpi_64
TAU: ParaProf Manager File Options Help Applications Standard Applications Default App	MetricField Value Name TIME Application ID 0 Experiment ID 0 Trial ID 0 Metric ID 0	TAU: ParaProf: /home/gmarkomanolis/Downloads/mpi_64 File Options Windows Help Metric: TIME Value: Exclusive Std. Dev. Mean Max Min node 0 node 1 node 2 node 3 node 4 node 5 node 6
		node 8 node 9 node 10 node 11 node 12 node 13 node 14 node 15 node 16

- The default metric is TIME
- Each color is a different call
- Each horizontal line is a process or Std.Dev./mean/max/min



- Options -> Uncheck Stack Bars Together
- It is easier to check the load imbalance
- We will call this window as the main one





• Click on any color, values per process, name of routine with callpath (if activated), units in seconds, value exclusive, max, min, mean, std, values.

🛽 🕒 🔲 TAU: ParaProf: /home/gmarkon	- 🥴 🗇 💷 🛛 TAU: ParaProf: Function Data Window: /home/gmarkomanolis/Down	loads/mpi_6₄
File Options Windows Help	File Options Windows Help	
Metric: TIME Value: Exclusive	Name: MPI_File_open() Metric Name: TIME Value: Exclusive	
Std. Dev.	onics: seconds	
Mean		
Max	9.042	max 🗅
Min 📃 🛛 🔤	9.042	node 18
node 0 📃	9.039	node 22
node 1 📃	9.039	node 21
node 2 📃	9.038	node 17
node 3 📃	9,038	node 20
node 4 📃	9,032	node 16
node 5 📃	9,032	node 25
node 6 📃	9,030	node 29 node 20
node 7 🗖	9,030	node 23
node 8	9,034	node 26
node 9	9,034	node 19
node 10	9,033	node 27
node 11	9.031	node 2/
node 12	8.03	node 30
node 13	9,029	node 37
node 14	9.029	node 36
node 15	9.028	node 31
node 16	9.028	node 34
node 1/	9.024	node 38
	9.024	node 39
	9.023	node 33
	9.02	node 32
	9.019	node 35
node 22	9.014	node 59
node 24	9.014	node 60
node 25	9.013	node 63
	9.011	node 58



• Scroll down

😂 🖨 🔲 TAU: ParaProf: /home/gmarkon	🛛 😻 🚍 💷 🛛 TAU: ParaProf: Function Data Window: /home/gmarkomanolis/Down	loads/mpi_6∠
File Options Windows Help	File Options Windows Help	
Metric: TIME Value: Exclusive	Name: MPI_File_open() Metric Name: TIME Value: Exclusive	
Value: Exclusive Std. Dev.	Metric Name: HME Value: Exclusive Units: seconds 8.991 8.991 8.991 8.991 8.991 8.991 8.991 8.991 8.992 8.982 8.982 8.982 8.982 8.983 8.984 8.982 8.982 8.982 8.983 8.984 8.939 8.938 8.939 8.938 8.939 8.938 8.939 8.938 8.939 8.938 8.939 8.938 8.939 8.938 8.939 8.938 8.939 8.939 8.930 8.931 8.006 2.638 1.038 1.034 1.033	node 51 node 12 node 8 node 53 node 54 node 49 node 55 node 40 node 44 node 45 node 43 node 41 node 43 node 41 node 42 mean std. dev. node 1 node 3
node 20 node 21 node 22 node 2	1.032 1.032 1.03 1.03	node 4 node 5 node 2
node 24	1.01 1.003 1.003	node 7 min node 6



• Click on any label on the left (node 0, mean, etc.). You can see immediately which calls take more time





Paraprof – Thread Statistics Text Window

• Right click on any label of the main window, select "Show Thread Statistics Text Window"

😣 🗐 🗊 🛛 TAU: Paral	Prof: node 0 - /ho	me/gmarkomanol	is/Downlo	ads/mpi_64		
File Options Wind	dows Help					
Metric: TIME Sorted By: Exclusive Units: seconds						
%Total Time	Exclusive	Inclusive	#Calls	#Child Calls	Inclusive/Call	Name
15.3	5.295	5,295	750		0.007	MPI Allreduce()
14.1	4.881	4.881	600	1200	0.008	MPI File write at all()
13.8	4,769	4.769	27000	0	1.8E-4	void compute tendencies x(double *, d
12.6	4.349	4.349	27000	0	1.6E-4	void compute tendencies z(double *, d
11.0	3.814	3.814	451	601	0.008	MPI File write at()
6.9	2,392	2,392	54000	0	4.4E-5	MPI Waitall() =
15.0	1.848	5.183	27000	162000	1.9E-4	void set halo values x(double *) [{mi
45.6	1.463	15.775	54000	108000	2.9E-4	void semi_discrete_step(double *, dou
4.2	1.448	1.448	1	0	1.448	MPI_Init()
3.0	1.034	1.035	300	299	0.003	MPI_File_open()
2.7	0.918	0.918	54000	0	1.7E-5	MPI_Isend()
47.2	0.548	16.323	9000	54000	0.002	<pre>void perform_timestep(double *, doubl</pre>
46.9	0.48	16.23	150	39139	0.108	<pre>void output(double *, double) [{miniW</pre>
1.0	0.333	0.333	300	0	0.001	MPI_File_close()
0.6	0.2	0.208	19173	19173	1.1E-5	void injection(double, double, double
5.4	0.196	1.853	1	19177	1.853	<pre>void init(int *, char ***) [{miniWeat</pre>
0.5	0.158	0.158	300	0	5.3E-4	MPI_Bcast()
100.0	0.111	34,572	1	9152	34.572	int main(int, char **) [{miniWeather
0.3	0.1	0.1	750	0	1.3E-4	MPI File set view()
0.2	0.083	0.083	150	0	5.5E-4	MPI Comm dup()
0.2	0.055	0.055	1	1	0.055	MPI_Finalize()
0.1	0.036	0.036	150	0	2.4E-4	MPI_Comm_free()
0.1	0.025	0.025	54000	0	4.7E-7	MPI_Irecv()
0.0	0.011	0.011	27000	0	4.2E-7	<pre>void set_halo_values_z(double *) [{mi</pre>
0.0	0.008	0.008	19173	0	4.1E-7	void hydro_const_theta(double, double
•			05800		<u> </u>	



Paraprof – Thread Statistics Table

• Right click on any label of the main window, select "Show Thread Statistics Table"

😣 🔿 🗊 TAU: ParaProf: Statistics for: node 0 - /home/gmar	komanolis/Downloads/mp	i_64		
File Options Windows Help				
Name 🛆	Exclusive TIME	Inclusive TIME	Calls	Child Calls
TAU application	0	34.572	1	1 🔺
– MPI_Allreduce()	5.295	5.295	750	0
– MPI_Barrier()	0.001	0.001	1	0
— MPI_Bcast()	0.158	0.158	300	0
– MPI_Comm_dup()	0.083	0.083	150	0
- MPI_Comm_free()	0.036	0.036	150	0
— MPI_Comm_get_attr()	0	0	299	0
— MPI_Comm_rank()	0.001	0.001	1,504	0
- MPI_Comm_size()	0	0	2	0
- MPI_File_close()	0.333	0.333	300	0
— MPI_File_get_info()	0.001	0.001	150	0
— MPI_File_open()	1.034	1.035	300	299
MPI_File_set_view()	0.1	0.1	750	0
— MPI_File_write_at()	3.814	3.814	451	601
— MPI_File_write_at_all()	4.881	4.881	600	1,200
— MPI_Finalize()	0.055	0.055	1	1
— MPI_Get_address()	0.008	0.008	25,032	0
— MPI_Get_count()	0	0	149	0
- MPI_Info_free()	0.001	0.001	150	0
— MPI_Init()	1.448	1.448	1	0
- MPI_Irecv()	0.025	0.025	54,000	0
— MPI_lsend()	0.918	0.918	54,000	0
— MPI_Status_set_elements()	0.001	0.001	1,950	0
— MPI_Type_commit()	0.001	0.001	1,800	0
— MPI_Type_create_hvector()	0.001	0.001	600	0
— MPI_Type_create_struct()	0.001	0.001	600	0
— MPI_Type_create_subarray()	0.002	0.002	600	0
— MPI_Type_free()	0.001	0.001	1,800	0
— MPI_Type_free_keyval()	0	0	1	0
			75.0	



Paraprof – User Bar Chart

• Right click on any label of the main window, select "Show User Bar Chart"

😣 🖨 🗊 🛛 TAU: ParaPr	rof: User Event Window: /home/gmarkomanolis/Downloads/mpi_64
File Options Windo	ows Help
File Options Windo Thread: node 0 Value Type: Number of 3 54000 54000 54000 54000 27 27 27 27	OP: User Event Window: /home/gmarkomanolis/Downloads/mpi_64 ws Help Samples Message size sent to all nodes Message size received from all nodes Message size received in wait Message size received in wait : int main(int, char **) [{miniWeather Message size sent to node 1 7000 7000 Message size sent to node 1 : int main(int, char **) [{miniWeather Message size sent to node 63 : int main(int, char **) [{miniWeather Message size sent to node 63 : int main(int, char **) [{miniWeather Message size sent to node 63 : int main(int, char **) [{miniWeather Message size for all-reduce 00 1051 MPI-I0 Write Bandwidth (MB/s) : int main(int, char **) [{miniWeather 600 MPI-I0 Write Bandwidth (MB/s) : int main(int, char **) [{miniWeather 600 MPI-I0 Write Bandwidth (MB/s) : int main(int, char **) [{miniWeather 600 MPI-I0 Bytes Written : int main(int, char **) [{miniWeather_mpi.cpp 451 MPI-I0 Bytes Written : int main(int, char **) [{miniWeather_mpi.cpp 300 Message size for broadcast



Paraprof – User Event

• Options -> Select Value Type -> Max. Value

Message size for broadcast 2800 Message size sent to node 1 2800 Message size sent to node 1: int main(int, char **) [{miniWeather_mpi.cpp} {118.1}-{161.1}] => void perform_times 2800 Message size received in wait 2800 Message size received in wait 2800 Message size received in wait 2800 Message size sent to node 63 int main(int, char **) [{miniWeather_mpi.cpp} {118.1}-{161.1}] => void perform_time 2800 Message size sent to node 63 2800 Message size sent 63 280 Message size sent 63 28



Paraprof – User Event Statistics Window

• Right click on any label of the main window, select "Show User Event Statistics Window"

TAU: ParaProf: node 0 - /home/gmarkomanolis/Downloads/mpi_64							
Sorted By: Numb	er of Samples						
 Total	NumSamples	Мах	Min	Mean	Std. Dev	Name	
6.912E8 6.912E8 6.912E8 3.456E8 3.456E8 3.456E8 3.456E8 5762684 - 6000 - 2684 3.906E7	54000 54000 54000 27000 27000 27000 1051 1051 1051 750 600 600 451 451 300	12800 12800 12800 12800 12800 12800 12800 9600 10.538 8 10.538 9600 0.381 284 262144	12800 12800 12800 12800 12800 12800 12800 12800 4 8.1E-5 8 0.053 9600 8.1E-5 4 4	12800 12800 12800 12800 12800 12800 12800 5483.049 1.374 8 2.34 9600 0.089 5.951 130200	0 0 0 0 0 0 4748.581 1.352 0 1.008 0 0.114 13.242 131067.087	Message size sent to all nodes Message size received from all Message size received in wait Message size received in wait Message size sent to node 1 Message size sent to node 63 MPI-IO Bytes Written MPI-IO Write Bandwidth (MB/s) MESSAGE size for all-reduce MPI-IO Write Bandwidth (MB/s) MPI-IO Bytes Written : int mai MPI-IO Bytes Written : int mai MESSAGE size for broadcast	
1						Þ	



Paraprof – Context Event Window

• Right click on any label of the main window, select "Show Context Event Window" (with callpath)

😣 🖱 💷 TAU: ParaProf: Context Events for: node 0 - /home/gmarkomanolis/Downloads/mpi_64						
File Windows Help						
Name 🛆	Total	NumSamp	MaxValue	Min∨alue	MeanValue	Std. Dev.
MPI-IO Bytes Written	5,762,684	1,051	9,600	4	5,483.049	4,748.581
— MPI-IO Write Bandwidth (MB/s)		1,051	10.538	0	1.374	1.352
 Message size for all-reduce 	6,000	750	8	8	8	0
 Message size for broadcast 	39,060,060	300	262,144	4	130,200.2	131,067.087
 Message size received from all nodes 	691,200,000	54,000	12,800	12,800	12,800	0
 Message size received in wait 	691,200,000	54,000	12,800	12,800	12,800	0
 Message size sent to all nodes 	691,200,000	54,000	12,800	12,800	12,800	0
– Message size sent to node 1	345,600,000	27,000	12,800	12,800	12,800	0
– Message size sent to node 63	345,600,000	27,000	12,800	12,800	12,800	0
int main(int, char **) [{miniWeather_mpi.cpp} {118,1}-{161,1}]						
void output(double *, double) [{miniWeather_mpi.cpp} {721,1}-{8	1					
P-MPI_File_write_at()						
 MPI-IO Write Bandwidth (MB/s) 		451	0.381	0	0.089	0.114
MPI-IO Bytes Written	2,684	451	284	4	5.951	13.242
P MPI_File_write_at_all()						
— MPI-IO Write Bandwidth (MB/s)		600	10.538	0.053	2.34	1.008
MPI-IO Bytes Written	5,760,000	600	9,600	9,600	9,600	0
void perform_timestep(double *, double *, d						
void semi_discrete_step(double *, double *, double *, double, int	t					
void set_halo_values_x(double *) [{miniWeather_mpi.cpp} {3	с.					
<mark>ዮ</mark> − MPI_Isend()						
 Message size sent to node 1 	345,600,000	27,000	12,800	12,800	12,800	0
Message size sent to node 63	345,600,000	27,000	12,800	12,800	12,800	0
🔶 MPI_Waitall()						
Message size received in wait	691,200,000	54,000	12,800	12,800	12,800	0



Paraprof – Add Thread to Comparison Window

• Right click on node 0 and select "Add Thread to Comparison Window", similar for node 12. You could use any number of processes that you prefer.





Derived Metrics

Options -> Show Derived Metric Panel, select the metrics and then operator and then click Apply. Then uncheck the Show Derived Metric

😣 🖨 💷 TAU: ParaProf Manager		
File Options Help		
Applications	TrialField	Value
🕈 🗂 Standard Applications	Name	mpi_64/Downloads/gmarkom
🕈 🗂 Default App	Application ID	0
🗣 🚍 Default Exp	Experiment ID	0
mpi 64/Downloads/gmarkomanolis/home/	Trial ID	0
- IME	Ending Timestamp	1564716343055440
- PAPI_FP_OPS	File Type Index	1
- PAPI_TOT_INS	File Type Name	TAU profiles
- PAPI_TOT_CYC		
□ □ □ □ (PAPI_TOT_INS / PAPI_TOT_CYC)		
perfexplorer_working (jdbc:h2:/home/gmarkomanolis/.Pa		
← 🛄 paim (jdbc:h2:/home/gmarkomanolis/.ParaProf/paim/perf		
	<u> </u>	
Expression: "PAPI TOT INS"/"PAPI TOT CVC"		Clear
		clear
	Apply	
	Арріу	



Paraprof - IPC

• Click on the new metric, PAPI_TOT_INS/PAPI_TOT_CYC





Paraprof – Mean IPC

Click on the label mean





Paraprof – IPC for thread 0

• From the main window with the PAPI_TOT_INS/PAPI_TOT_CYC metric, right click on node 0 and select Show Thread Statistics Table

😣 🔵 🔲 TAU: ParaProf: Statistics for: node 0 - /home/gma	komanolis/Downloads/mp	pi_64		
File Options Windows Help				
Name 🛆	Exclusive (PAPI_TOT_I	Inclusive (PAPI_TOT_IN	Calls	Child Calls
- MPI Finalize()	0.588	0.588	1	1
MPI Get address()	0.791	0.791	25,032	0
MPI Get count()	0.612	0.612	149	0
MPI Info free()	0.47	0.47	150	0
- MPI Init()	1.197	1.197	1	0
- MPI_Irecv()	0.73	0.73	54,000	0
- MPI_Isend()	0.869	0.869	54,000	0
- MPI_Status_set_elements()	0.581	0.581	1,950	0
- MPI_Type_commit()	0.73	0.73	1,800	0
- MPI_Type_create_hvector()	0.7	0.7	600	0
— MPI_Type_create_struct()	0.683	0.683	600	0
— MPI_Type_create_subarray()	0.624	0.624	600	0
- MPI_Type_free()	0.685	0.685	1,800	0
— MPI_Type_free_keyval()	0.425	0.425	1	0
— MPI_Type_size()	0.721	0.721	750	0
- MPI_Waitall()	1.406	1.406	54,000	0
- int main(int, char **) [{miniWeather_mpi.cpp} {118,1}-{161,1}]	0.956	1.421	1	9,152
void compute_tendencies_x(double *, double *, double *) [{mini}	Ve; 0.812	0.812	27,000	0
void compute_tendencies_z(double *, double *, double *) [{miniv	Ve: 1.069	1.069	27,000	0
void finalize() [{miniWeather_mpi.cpp} {825,1}-{841,1}]	0.619	0.588	1	1
void hydro_const_theta(double, double &, double &) [{miniWeat	hei 0.825	0.825	19,173	0
void init(int *, char ***) [{miniWeather_mpi.cpp} {448,1}-{583,1	}] 0.838	1.047	1	19,177
-void injection(double, double, double &, doub	.835 Idu	0.831	19,173	19,173
<pre>void ncwrap(int, int) [{miniWeather_mpi.cpp} {816,1}-{822,1}]</pre>	0.755	0.755	2,104	0
<pre>- void output(double *, double) [{miniWeather_mpi.cpp} {721,1}-</pre>	{8 0.787	1.97	150	39,139
-void perform_timestep(double *, double *, double *, double *, do	ub 0.728	1.075	9,000	54,000
void semi_discrete_step(double *, double *, double *, double, int	, d 2.715	1.076	54,000	108,000
<pre>-void set_halo_values_x(double *) [{miniWeather_mpi.cpp} {351,"</pre>	1.178	1.248	27,000	162,000
void set halo values z(double *) [{miniWeather mpi.cpp} {411,2	1.044	1.044	27,000	0 👻



Paraprof

• From the main window select Options -> Select Metric... -> Exclusive -> PAPI_FP_OPS





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Exclusive Time and Exclusive Floating operations





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Specific routine and thread





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Exclusive time and total instructions





Menu Windows -> 3D Visualization (3D demands OpenGL)





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Exclusive time and instructions per cycle





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Bar Plot





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Scatter Plot





- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Topology Plot





Paraprof – 3D Communication Matrix

- Menu Windows -> 3D Visualization (3D demands OpenGL)
- Max message size vs Number of calls





Paraprof

Menu Windows -> Communication Matrix





Which loops require the most time?

• File select.tau:

```
BEGIN_INSTRUMENT_SECTION
```

loops routine="#"

END_INSTRUMENT_SECTION

• Declare TAU options:

export TAU_OPTIONS="-optTauSelectFile=select.tau -optLinking=-Ipnetcdf - optVerbose"

- Do not forget to unset TAU_OPTIONS when not required
- Execute as before



😣 🗇 🗊 TAU: ParaProf: Mean - /home/gmarkomanolis/Downloads/patched/loop_64					
File Options Windows Help					
Metric: TIME Value: Exclusive Units: seconds					
7.864 6.206 4.545 4.046 2.247 1.635 1.458 1.086 0.553 0.548 0.543 0.543 0.365 0.363 0.0266 0.159 0.085 0.081 0.073 0.081 0.052	<pre>MPI_File_open() MPI_Alreduce() Loop: void compute_tendencies_x(double *, double *, double *) {{miniWeather_mpi.cpp} {241,3}-{268,3}} Loop: void compute_tendencies_x(double *, double *, double *) {{miniWeather_mpi.cpp} {300,3}-{327,3}} void set_halo_values_x(double *, f{miniWeather_mpi.cpp} {351,1}-{406,1}} void set_indo_values_x(double *, double *, double *, double *, double *, double *) {{miniWeather_mpi.cpp} {198,1}-{225,1}} MPI_Waitail() void compute_tendencies_x(double *, double *, double *) {{miniWeather_mpi.cpp} {232,1}-{284,1}} void compute_tendencies_c(double *, double *, double *) {{miniWeather_mpi.cpp} {232,1}-{347,1}} void compute_tendencies_c(double *, double *, double *) {{miniWeather_mpi.cpp} {232,1}-{347,1}} void compute_tendencies_c(double *, double *, double *) {{miniWeather_mpi.cpp} {211,1}-{347,1}} void compute_tendencies_c(double *, double *, double *) {{miniWeather_mpi.cpp} {171,1}-{192,1}} MPI_File_write_at_ail() Loop: void compute_tendencies_c(double *, double *, double *) {{miniWeather_mpi.cpp} {333,3}-{346,3}} void output(double *, double) {{miniWeather_mpi.cpp} {721,1}-{812,1}} Loop: void semi_discrete_step(double *, double *, double *, double *, {double *, double *, double *, double *, {double *, double *, {double *, double *, {double *, double *, {double *, double *, double *, double *, {double *, double *, double *, double *, {double *, double *, {double *, double *, double *, {double *, double *, double *, double *, {double *, double *, {double *, double *, double *, double *, {double *, double *, double *, double *, {double *, {double *, {double *, double *, double *, {double *, double *, {double *, double *, {double *, {d</pre>				



Select Options -> Select Metric... -> Exclusive... -> PAPI_TOT_INS

😣 🖨 🗊 🛛 TAU: 1	ParaProf: Mean - /home/gmarkoma	nolis/Downloads/patched/loop_64
File Options W	/indows Help	
Metric: PAPI_TOT_ Value: Exclusive Units: counts	INS	
4.9926E10	1.2842E10 1.1184E10 8.4776E9 6.265E9 3.8514E9 3.6775E9 2.8437E9 2.6936E9 1.7667E9 5.4722E8 4.1549E8 3.527E8 3.2527E8 3.2527E8 3.2527E8 2.8623E8 2.6706E8 1.2031E8 1.1198E8 1.0235E8 1.0235E8 9.5866E7 8.0849E7 6.8418E7 5.8895E7	MPI_Allreduce() Loop: void compute_tendencies_z(double *, double *, double *) [{miniWeather_mpi.cpp} {300,3}-{327,3}] Loop: void compute_tendencies_x(double *, double *, double *) [{miniWeather_mpi.cpp} {241,3}-{268,3}] MPI_File_open() Loop: void semi_discrete_step(double *, double *, l{miniWeather_mpi.cpp} {361,3}-{368,3}] Loop: void set_halo_values_x(double *) [{miniWeather_mpi.cpp} {378,3}-{385,3}] MPI_lsend() void compute_tendencies_x(double *, double *, double *) [{miniWeather_mpi.cpp} {291,1}-{347,1}] void compute_tendencies_x(double *, double *, double *) [{miniWeather_mpi.cpp} {291,1}-{347,1}] void compute_tendencies_x(double *, double *, double *) [{miniWeather_mpi.cpp} {232,1}-{284,1}] MPI_Comm_dup() void output(double *, double *, doub
	3.9652E7	



Select Options -> Select Metric... -> Exclusive... -> PAPI_TOT_INS/PAPI_TOT_CYC





Select Options -> Select Metric... -> Exclusive... -> PAPI_FP_OPS

😣 😑 🗉 🛛 TAU: ParaProf: Mean - /home/gmarkom	anolis/Downloads/patched/loop_64
File Options Windows Help	
Metric: PAPL_FP_OPS Value: Exclusive Units: counts	
3.7196E9 3.2226E9 2.7054E8 2.3922E8 1.8387E8 5274703 4266000 2160010 1689000 1531296 1512000 1531296 1512000 1532000 1672693 891000 837407.078 647856 546750	<pre>Loop: void compute_tendencies_x(double *, double *, double *) [{miniWeather_mpi.cpp} {241,3}-{268,3}] Loop: void sem_idiscrete_step(double *, double *, double *, double, int, double *, double *, 1{miniWeather_mpi.cpp} {300,3}-{327,3}] Loop: void sem_idiscrete_step(double *, double *, double *, double, int, double *, double *, 1{miniWeather_mpi.cpp} {333,3}-{346,3}] Loop: void compute_tendencies_x(double *, double *, double *, double *, double *, 1{miniWeather_mpi.cpp} {274,3}-{283,3}] void set_halo_values_x(double *, double *, double *, double *, double *, double *, [{miniWeather_mpi.cpp} {274,3}-{283,3}] void set_halo_values_x(double *, double *, double *, double *, double *, [{miniWeather_mpi.cpp} {274,3}-{283,3}] void set_halo_values_x(double *, double *, double *, double *, double *, [{miniWeather_mpi.cpp} {274,3}-{283,3}] void set_halo_values_x(double *, double *, double *, double *, double *, [{miniWeather_mpi.cpp} {274,3}-{283,3}] void set_halo_values_x(double *, double *, double *, double *, double *, [{miniWeather_mpi.cpp} {777,3}-{778,3}] void set_halo_values_x(double *, double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{283,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{283,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, [{miniWeather_mpi.cpp} {232,1}-{284,1}] void compute_tendencies_x(double *, double *, double *, double *, double *, [{miniWeather_mpi.c</pre>



Paraprof

From the main window select a node







Paraprof – Function Histogram

From the main window select a node





Callpath

export TAU_METRICS=TIME:PAPI_TOT_INS:PAPI_TOT_CYC:PAPI_FP_OPS export TAU_CALLPATH=1 export TAU_CALLPATH_DEPTH=10 export TAU_PROFILE=1 export TAU_TRACK_MESSAGE=1 export TAU_COMM_MATRIX=1

jsrun -n 64 -r 8 -a 1 -c 1 ./miniWeather_mpi



Paraprof - Callpath

From the main Window right click on any label (node 0, mean etc.) and select "Show Thread Call Graph"





Paraprof - Callpath

From the main Window right click on any label (node 0, mean etc.) and select "Show Thread Statistics Table"

😣 🗇 💷 TAU: ParaProf: Statistics for: node 0 - /home/gmarkomanolis/Downloads/mpi_64_callpath						
File Options Windows Help						
Name 🛆	Exclusive TIME	Inclusive TIME	Calls	Child Calls		
🕆 🗖 .TAU application	0	35.142	1	1		
🛉 🗖 int main(int, char **) [{miniWeather_mpi.cpp} {118,1}-{161,1	0	35.142	1	4		
🖕 🗖 Loop: int main(int, char **) [{miniWeather_mpi.cpp} {142,0	0.11	33.474	1	9,149		
🕶 🔄 void output(double *, double) [{miniWeather_mpi.cpp}	0.436	15.976	149	39,187		
💠 🗖 void perform_timestep(double *, double *, double *, dou	0.544	17.388	9,000	54,000		
👇 🗖 void semi_discrete_step(double *, double *, double *	1.679	16.844	54,000	162,000		
Loop: void semi_discrete_step(double *, double *	0.373	0.373	54,000	0		
🖕 🗖 void compute_tendencies_x(double *, double *, d	0.57	5.361	27,000	54,000		
Loop: void compute_tendencies_x(double *, double *, d	4.413	4.413	27,000	0		
Loop: void compute_tendencies_x(double *, do	0.378	0.378	27,000	0		
🐅 🗖 void compute_tendencies_z(double *, double *, d	0.565	4.931	27,000	54,000		
– 🗖 Loop: void compute_tendencies_z(double *, dc	3.908	3.908	27,000	0		
Loop: void compute_tendencies_z(double *, dc	0.458	0.458	27,000	0		
void set_halo_values_x(double *) [{miniWeather_r	2.594	4.19	27,000	243,000		
Loop: void set_halo_values_x(double *) [{mini\	0.054	0.054	27,000	0		
Loop: void set_halo_values_x(double *) [{mini\	0.053	0.053	27,000	0		
Loop: void set_halo_values_x(double *) [{mini\	0.043	0.043	27,000	0		
— MPI_Irecv()	0.049	0.049	54,000	0		
— MPI_Isend()	0.127	0.127	54,000	0		
MPI_Waitall()	1.271	1.271	54,000	0		
🖕 🗖 void set_halo_values_z(double *) [{miniWeather_r	0.288	0.31	27,000	27,000		
void finalize() [{miniWeather_mpi.cpp} {825,1}-{841,1}]	0	0.048	1	1		
MPI_Finalize()	0.047	0.047	1	1		
🗢 🗖 void init(int *, char ***) [{miniWeather_mpi.cpp} {448,1}-{	0.001	1.102	1	7		
🖕 🗖 void output(double *, double) [{miniWeather_mpi.cpp} {72	0.075	0.517	1	102		

