

### Profile Analysis with ParaProf



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TAU Performance System<sup>®</sup> (*http://tau.uoregon.edu*)



- Parallel performance framework and toolkit
  - Supports all HPC platforms, compilers, runtime system
  - Provides portable instrumentation, measurement, analysis



### **TAU Performance System<sup>®</sup>**

- Instrumentation
  - Fortran, C++, C, UPC, Java, Python, Chapel
  - Automatic instrumentation
- Measurement and analysis support
  - MPI, OpenSHMEM, ARMCI, PGAS, DMAPP
  - pthreads, OpenMP, hybrid, other thread models
  - GPU, CUDA, OpenCL, OpenACC
  - Parallel profiling and tracing
  - Use of Score-P for native OTF2 and CUBEX generation
  - Efficient callpath profiles and trace generation using Score-P
- Analysis
  - Parallel profile analysis (ParaProf), data mining (PerfExplorer)
  - Performance database technology (PerfDMF, TAUdb)
  - 3D profile browser

VI-HPS TW15: VI-HPS Tuning Workshop, Saclay, France







- TAU supports both sampling and direct instrumentation
- Memory debugging as well as I/O performance evaluation
- Profiling as well as tracing
- Interfaces with Score-P for more efficient measurements
- TAU's instrumentation covers:
  - Runtime library interposition (tau\_exec)
  - Compiler-based instrumentation
  - PDT based Source level instrumentation: routine & loop
  - Event based sampling (TAU\_SAMPLING=1)
  - Callstack unwinding with sampling (TAU\_EBS\_UNWIND=1)
  - OpenMP Tools Interface (OMPT, tau\_exec –T ompt)
  - CUDA CUPTI, OpenCL (tau\_exec -T cupti -cupti)



module use /gpfslocal/pub/vihps/UNITE/local module load UNITE VI-HPS-TW cd tutorial/NPB3.3-MZ-MPI make suite cd bin; cp ../jobscript/mds/run.tau.ll Uncomment the first, then second run block: # Case 2: MPI with OpenMP (OpenMP Tools Interface (OMPT)) #mpirun -np \${LOADL\_TOTAL\_TASKS} tau\_exec -T ompt ./btmz\_B.4

llsubmit run.tau.ll
Wait and then launch after the job finishes:
paraprof (Right Click on node 0 or 1, Show Thread
Statistics Table. Show Source Code on an OMPT source
location. Also use paraprof on Score-P \*.cubex files.)
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## ParaProf Profile Analysis Framework VI-HPS



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#### **Parallel Profile Visualization: ParaProf**

## VI-HPS

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ParaProf Visualizer: cmod.128x128.128DC.ppk/128x128/aorsa2d/taudata/rs/sameer/Users/



#### **Parallel Profile Visualization: ParaProf**





#### **ParaProf: 3D Communication Matrix**





- The Tutorial contains Score-P experiments of BT-MZ
  - class "B", 4 processes with 4 OpenMP threads each
  - collected on a dedicated node of the SuperMUC HPC system at Leibniz Rechenzentrum (LRZ), Munich, Germany

```
% cd
% ls
periscope-1.5
README
run.out
scorep-20120913_1740_557443655223384
scorep_bt-mz_B_4x4_sum+mets
scorep_bt-mz_B_4x4_trace
```

• Start TAU's paraprof GUI with default profile report

```
% paraprof scorep-20120913_1740_557443655223384/profile.cubex
OR
% paraprof scorep bt-mz B 4x4 trace/scout.cubex
```

#### ParaProf: Manager Window: scout.cubex



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#### **ParaProf: Main window**



#### **ParaProf: Options**



#### **ParaProf:**



#### **ParaProf: Windows**



#### **ParaProf: Thread Statistics Table**

TAU: ParaProf: Statistics for: node 0, thread 0 - scout.cubex			_ 🗆 🗡		
File Options Windows Help					
Time		-			
Name	Exclusive Time 🗸 🔪	Inclusive Time	Calls	Child Calls	
<mark>⊢</mark> ∎!\$omp do @y_solve.f:52	5.81	5.817	3,216	0	
-solve.f:52	5.657	5.657	3,216	0	
-solve.f:54 @x_solve.f:54	5.609	5.609	3,216	0	
- <b>_</b> !\$omp do @rhs.f:191	0.609	0.609	3,232	0	
- 🔤 !\$omp do @rhs.f:80	0.583	583	3,232	0	
– MPI_Waitall	0.402			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
– 🔤 !\$omp implicit barrier	0.402	Click to sort by a given			
- 🔤 !\$omp do @rhs.f:301	0.36				
-somp implicit barrier	0.026	metric, ara	metric, drag and move to		
\$omp implicit barrier	0	rearrar	rearrange columns		
- 🔤 !\$omp do @rhs.f:37	0.343		rearrange ceramme		
e- <mark></mark> !\$omp do @rhs.f:62	0.225	0.228	3,232	3,232	
-somp implicit barrier	0.004	0.004	3,216	0	
	0	0	16	0	
– MPI_Init_thread	0.218	0.218	1	0	
– <mark>–</mark> !\$omp do @rhs.f:384	0.199	0.199	3,232	0	
🗢 🗖 !\$omp parallel do @add.f:22	0.099	0.111	3,216	3,216	
– <mark>–</mark> !\$omp do @rhs.f:428	0.069	0.069	3,232	0	
– MPI_Isend	0.043	0.043	603	0	
– <mark>–</mark> !\$omp do @initialize.f:50	0.04	0.04	32	0	
🗢 🗖 !\$omp parallel @rhs.f:28	0.03	2.536	3,232	51,712	
🗢 🗖 !\$omp parallel do @exch_qbc.f:215	0.021	0.029	6,432	6,432	
🗢 🗖 !\$omp parallel do @exch_qbc.f:255	0.02	0.033	6,432	6,432	
\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	0.02	0.053	6,432	6,432	
\$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$	0		FinderScre	enSnapz003.png	

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FinderScreenSnapz003.png



TAU: ParaProf: Statistics for: node 0, thread 0 - profile.cubex				
File Options Windows Help				
Name	Exclusive Time 🗸	Inclusive Time	Calls	Child Calls
♀ APPLU [{lu.f} {46,7}-{162,9}]	0	8.035	1	19 📤
SSOR [{ssor.f} {4,7}-{241,9}]	0.064	6.225	2	37,643
∽ 🔄 RHS [{rhs.f} {5,7}-{504,9}]	0.743	2.524	303	606
⊷ 🗖 BLTS [{blts.f} {4,7}-{259,9}]	0.613	0.658	9,331	18,662
P ■ BUTS [{buts.f} {4,7}-{259,9}]	0.612	1.871	9,331	18,662
EXCHANGE_1 [{exchange_1.f} {5,7}-{177,9}]	0.024	1.259	18,662	18,662
- MPI_Recv	1.235	1.235	18,662	0
MPI_Send	0	0	0	0
— 🗖 JACU [{jacu.f} {5,7}-{384,9}]	0.532	0.532	9,331	0
JACLD [{jacld.f} {5,7}-{384,9}]	0.522	0.522	9,331	0
- MPI_Allreduce	0.018	0.018	2	0
← <mark></mark> L2NORM [{l2norm.f} {4,7}-{68,9}]	0	0.035	4	4
— MPI_Barrier	0	0	2	0
TIMER_START [{timers.f} {23,7}-{37,9}]	0	0	2	0
TIMER_STOP [{timers.f} {43,7}-{59,9}]	0	0	2	0
— TIMER_CLEAR [{timers.f} {4,7}-{17,9}]	0	0	2	0
TIMER_READ [{timers.f} {65,7}-{77,9}]	0	0	2	0
∽	0.043	0.111	2	95,232
PROC_GRID [{proc_grid.f} {5,7}-{34,9}]	0.011	0.011	1	0
∽ <mark>—</mark> ERHS [{erhs.f} {4,7}-{536,9}]	0.004	0.108	1	2
∽	0.004	0.009	1	7,937
← 🗖 SETBV [{setbv.f} {5,7}-{79,9}]	0.002	0.004	2	3,400
• READ_INPUT [{read_input.f} {5,7}-{125,9}]	0	0.001	1	2
VERIFY [{verify.f} {5,9}-{403,11}]	0	0	1	0
PRINT_RESULTS [{print_results.f} {2,7}-{115,12}]	0	0	1	0
∽	0	0	1	6
← 🗖 INIT_COMM [{init_comm.f} {5,7}-{57,9}]	0	1.565	1	4
– MPI_Finalize	0	0	1	0
SETHYPER [{sethyper.f} {5,7}-{94,9}]	0	0	1	0
– NEIGHBORS [{neighbors.f} {5,7}-{48,9}]	0	0	1	0
SETCOEFF [{setcoeff.f} {5,7}-{157,9}]	0	0	1	0

#### ParaProf: Thread Callgraph Window

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### ParaProf: Callpath Thread Relations Window

## VI-HPS

		TAU: F	ParaProf: Call Path D	Data n,c,t, 0,0,0 - scout.cubex	_ 🗆 ×
File Opti	ons Windows H	lelp			
Metric N Sorted B Units: se	ame: Time y: Exclusive econds				
>	0.04 0.04	0.04 0.04	32/32 32	!\$omp parallel @initialize.f:28 !\$omp do @initialize.f:50	
>	0.03 0.03 9.8E-4 0.225 0.002 0.002 0.199 0.002 0.343 0.016 0.014 0.609 0.36 0.583 0.019 0.006	2.536 2.536 9.8E-4 0.228 0.002 0.199 0.002 0.343 0.016 0.027 0.609 0.386 0.583 0.019 0.006	3232/3232 3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232 3232/3232	<pre>compute_rhs_ !\$omp parallel @rhs.f:28 !\$omp master @rhs.f:424 !\$omp do @rhs.f:62 !\$omp master @rhs.f:74 !\$omp master @rhs.f:293 !\$omp do @rhs.f:384 !\$omp master @rhs.f:183 !\$omp do @rhs.f:37 !\$omp do @rhs.f:372 !\$omp do @rhs.f:413 !\$omp do @rhs.f:191 !\$omp do @rhs.f:301 !\$omp do @rhs.f:400 !\$omp do @rhs.f:400 !\$omp implicit barrier</pre>	
>	0.069 0.015 0.021 0.021 0.007	0.069 0.015 0.029 0.029 0.007	3232/3232 3232/3232 6432/6432 6432 6432/51680	!\$omp do @rhs.f:428 !\$omp do @rhs.f:359 !\$omp parallel @exch_qbc.f:215 !\$omp parallel do @exch_qbc.f:215 !\$omp implicit barrier	
>	0.02 0.013	0.033 0.013	6432 6432/51680	!\$omp parallel do @exch_qbc.f:255 !\$omp implicit barrier	<b>•</b>

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#### **ParaProf:Windows -> 3D Visualization -> Bar Plot**



#### ParaProf: 3D Scatter Plot



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#### **ParaProf: Scatter Plot**





#### **ParaProf: 3D Topology View for a Routine**





#### ParaProf: Topology View 3D Torus (IBM BG/P)





# ParaProf:Topology View (6D Torus Coordinates BG/Q)

● ○ ○ TAU: ParaProf: 3D Visualizer:	rmhd_cetus_512p_np4.ppk
	Triangle Mesh
	O Bar Plot
	Scatter Plot
	Topology Plot
	Layout Events
18.47	Minimum Visible 5.527 seconds
	Maximum Visible 18.47 seconds
	Lock Range
	X Axis
E X C	Y Axis
5.527	Z Axis
	Avg Color Value: 11.654 seconds
	Topology BGQ map
	X Axis 20 👘
	Y Axis 20 🖕
	Z Axis 20

#### **ParaProf: Node View**

# VI-HPS

TAU: Pa	raProf: node O, thread O – profile.cubex	ı x
File Options Windows Help		
Metric: Time Value: Exclusive Units: seconds		
3.71 3.71 3.593 3.593 3.593 3.55 3.55 0.4 0.398 0.383 0.381 0.382 0.299 0.298 0.298 0.298 0.298 0.298 0.298 0.298 0.298 0.298 0.298 0.298 0.299 0.298 0.299 0.214 0.214 0.214 0.161 0.161 0.161 0.161 0.161 0.161 0.15 0.15 0.141 0.141 0.141 0.141 0.127 0.127 0.127 0.127	<pre>MAIN_ =&gt; adi =&gt; y_solve_ =&gt; !\$omp parallel @y_solve.f:43 =&gt; !\$omp do @y_solve.f:52 !\$omp do @y_solve.f:52 MAIN_ =&gt; adi =&gt; z_solve_ =&gt; !\$omp parallel @z_solve.f:43 =&gt; !\$omp do @z_solve.f:52 !\$omp do @z_solve.f:54 !\$omp do @x_solve.f:54 !\$omp do @rhs.f:191 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:191 !\$omp do @rhs.f:80 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:80 !\$omp parallel @rhs.f:28 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:80 !\$omp do @rhs.f:30 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:37 !\$omp do @rhs.f:30 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:37 !\$omp do @rhs.f:62 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:301 !\$omp do @rhs.f:62 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:301 !\$omp do @rhs.f:62 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:62 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:62 MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:62 MAIN_ =&gt; exch_qbc_ =&gt; copy_x_face_ copy_x_face_ MAIN_ =&gt; exch_qbc_ =&gt; copy_x_face_ copy_x_face_ MAIN_ =&gt; exch_qbc_ =&gt; copy_y_face_ copy_x_face_ MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:384 MAIN_ =&gt; exch_qbc_ !\$omp do @rhs.f:384 MAIN_ =&gt; exch_qbc_ =&gt; MPI_Waitall MPI_waitall MPI_waitall MPI_waitall MAIN_ =&gt; adi_ =&gt; di</pre>	
0.103 0.094 0.094	adı_ MAIN => adi_ => add_ => !\$omp parallel @add.f:22 => !\$omp parallel do @add.f:22 !\$omp parallel do @add.f:22	•

#### ParaProf: Add Thread to Comparison Window



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#### VI-HPS **ParaProf: Score-P Profile Files, Database** o x TAU: ParaProf Manager File Options Help Applications TrialField Value 🛉 🗂 Standard Applications Name profile.cubex 🔶 📑 Default App Application ID 0 Experiment ID 0 🔶 🚞 Default Exp 0 Trial ID File Type Index 9 🔋 Time File Type Name Cube Minimum Inclusive Time Maximum Inclusive Time PAPI TOT CYC. PAPI TOT INS PAPI FP INS 🛯 ru utime 🛯 ru stime 🕑 ru maxrss 🕒 ru ixrss ru idrss 🥥 ru isrss 🕒 ru minflt 🕒 ru majflt 💿 ru nswap ru inblock ru oublock ru msgsnd ru msgrcv 🕑 ru nsignals ru nvcsw 🥥 ru nivosw bytes sent bytes received 🖕 🗂 Default (jdbc:h2:/home/livetau/.ParaProf//perfdmf;AUTO\_SERVER=TRUE) Add Application perfexplorer working (jdbc:h2:/home/livetau/.ParaProf/perfexplorer wo TRUE) Add Experiment Add Trial

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#### **ParaProf: File -> Preferences**



ParaProf Preferences –			
File			
Font SansSerif Bold Size	n,c,t 0,0,0 n,c,t 0,0,1 n,c,t 0,0,2		
Italic I I I I I I I I I I I I I I I I I I I			
Window defaults	Settings		
Units Seconds 💌	<ul> <li>Show Path Title in Reverse</li> <li>Reverse Call Paths</li> <li>Interpret threads that do not call a given function as a 0 value for statistics computation</li> </ul>		
Show Values as Percent	Generate data for reverse calltree (requires lots of memory) (does not apply to currently loaded profiles) Show Source Locations Auto label node/context/threads		
Restore Defaults	Apply	Cancel	

### ParaProf: Group Changer Window



TAU: ParaProf: Group Changer: profile.cubex _ 💷 🗙				
Region	Current	Available		
filter:		new group		
!\$omp atomic @error.f:104         !\$omp atomic @error.f:51         !\$omp do @error.f:33         !\$omp do @error.f:91         !\$omp do @exact_rhs.f:147         !\$omp do @exact_rhs.f:147         !\$omp do @exact_rhs.f:247         !\$omp do @exact_rhs.f:31         !\$omp do @exact_rhs.f:346         !\$omp do @exact_rhs.f:46         !\$omp do @initialize.f:100         !\$omp do @initialize.f:137	CUBE_DEFAULT	<		
<pre>!\$omp do @initialize.f:156 !\$omp do @initialize.f:174 !\$omp do @initialize.f:192 !\$omp do @initialize.f:31 </pre>		>		

#### TAU: ParaProf Manager File Options Help Applications ۰ MetricField Value 🔶 🗂 Standard Applications Name Time 🔶 📑 Default App Application ID 0 Experiment ID 0 🔶 📑 Default Exp Trial ID 0 🛉 📑 profile.cubex Metric ID 0 Time Minimum Inclusive Time Maximum Inclusive Time PAPI TOT CYC. PAPI TOT INS. PAPI FP INS 🔋 ru utime 🔋 ru stime 🔋 ru maxrss ru ixrss 🔋 ru idrss 🕒 ru isrss 🔋 ru minflt 🛯 ru majflt 💿 ru nswap ru inblock ru oublock ru msgsnd ru msgrcv ru\_nsignals 🔊 ru nvcsw Expression: "PAPI\_FP\_INS"/"Time" Clear ) Apply +( =

#### **ParaProf: Options -> Derived Metric Panel**

### **Sorting Derived Flops Metric by Exclusive Time**

TAU: ParaProf: node 0, thread 0 - profile.cubex

VI-HPS

\_ 0

#### File Options Windows Help

		-
Metric: ( PAPI_FP_INS / Time )		
Value: Exclusive		
Units: Derived metric shown in seconds format		
Sorted By: Exclusive (Time)		
3.0217E9	MAIN => adi => v solve => !\$omp parallel @v solve.f:43 => !\$omp do @v solve.f:52	-
3.0217E9	I \$ omp do @v solve.f:52	
3.2421E9	MAIN => adi => z solve => !\$omp parallel @z solve.f:43 => !\$omp do @z solve.f:52	
3.2421E9	I\$omp do @z solve.f:52	
3.0673E9	MAIN => adi => x solve => !\$omp parallel @x solve.f:46 => !\$omp do @x solve.f:54	
3.0673E9	I\$omp do @x solve.f:54	
3.3299E9	Isomp do @rhs.f:191	
3.3298E9	MAIN_ => adi_ => compute_rhs_ => !\$omp parallel @rhs.f:28 => !\$omp do @rhs.f:191	
3.5138E9	] !\$omp do @rhs.f:80	
3.514E9	MAIN_ => adi_ => compute_rhs_ => !\$omp parallel @rhs.f:28 => !\$omp do @rhs.f:80	
1965740.083	!\$omp implicit barrier	
2518815.107	I \$omp parallel @rhs.f:28	
2518981.066	MAIN_ => adi_ => compute_rhs_ => !\$omp parallel @rhs.f:28	
3.502E8	Isomp do @rhs.f:37	
3.49/5E8	<pre>/ MAIN_ =&gt; adi_ =&gt; compute_rhs_ =&gt; !\$omp parallel @rhs.f:28 =&gt; !\$omp do @rhs.f:37</pre>	
4.0207E9	I (\$omp do @rns.f:301 Maille	
4.0205E9	] MAIN_ => adi_ => compute_rns_ => !\$omp parallel @rns.ft:28 => !\$omp do @rns.ft:301	
393140.074	:\$0mp do @ms.i:o∠   M0N> adi _> compute ris> Itamp parallel @ris.f.39 _> Itamp de @ris.f.63	
595024.445	T_MAIN=> aut_=> compute_rits_=> (\$omp parallel @rits.i:20 => (\$omp up @rits.i:02	
60.754	MAIN=> hpisetup_=> MFi_int_thread	
2218222 902	$  Min_min_min_max$	
2218222.002	I convix face	
2217983.431	MAIN => exch obc => copy v face	
2217983.431	copy v face	
2691052.918	MAIN => exch abc	
2691052.918	exch gbc	
1.5944E9	somp do @rhs.f:384	
1.5944E9	] MAIN_ => adi_ => compute_rhs_ => !\$omp parallel @rhs.f:28 => !\$omp do @rhs.f:384	
65007.137	MAIN_ => exch_qbc_ => MPI_Waitall	-
•		•