Introduction to the TAU Performance System®

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These slides are available on Cetus/Intrepid in

/soft/perftools/tau/ppt

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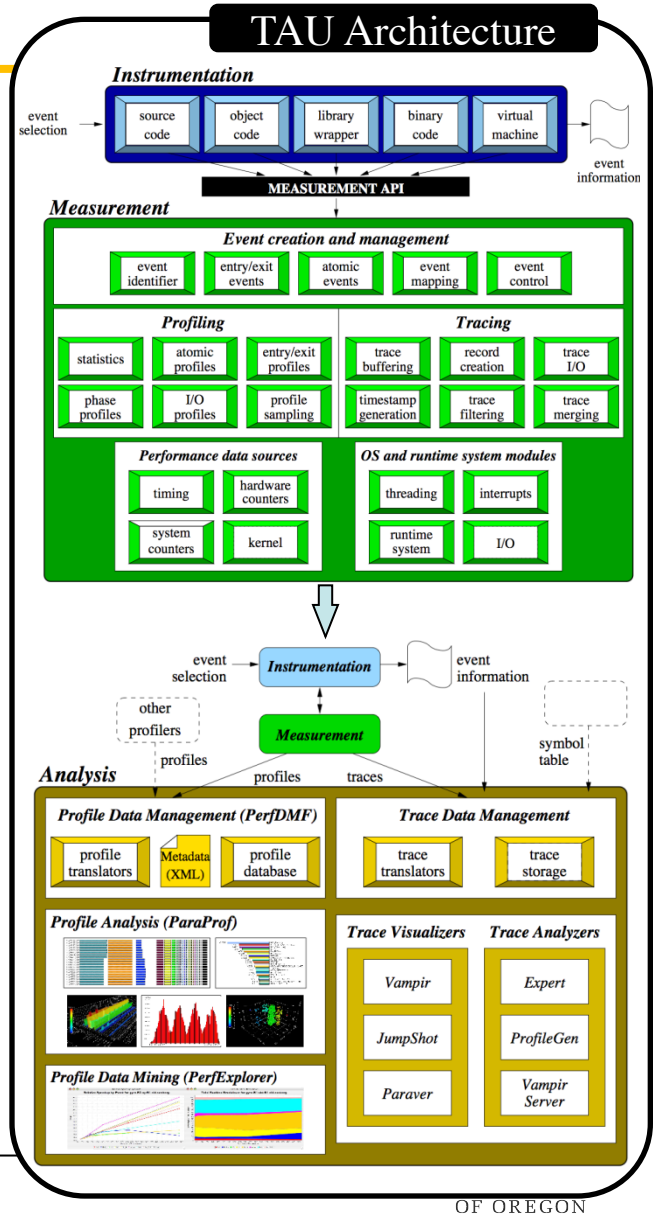
What is TAU?

- TAU is a performance evaluation tool
- It supports parallel profiling and tracing toolkit
- Profiling shows you how much (total) time was spent in each routine
- Tracing shows you *when* the events take place in each process along a timeline
- Profiling and tracing can measure time as well as hardware performance counters from your CPU
- TAU can automatically instrument your source code (routines, loops, I/O, memory, phases, etc.)
- It supports C++, C, Chapel, UPC, Fortran, Python and Java
- TAU runs on all HPC platforms and it is free (BSD style license)
- TAU has instrumentation, measurement and analysis tools
- To use TAU, you need to set a couple of environment variables and substitute the name of the compiler with a TAU shell script

TAU Performance System®

- Integrated toolkit for performance problem solving
  - Instrumentation, measurement, analysis, visualization
  - Portable performance profiling and tracing facility
  - Performance data management and data mining
- Based on direct performance measurement approach
- Open source
- Available on all HPC platforms
- http://tau.uoregon.edu

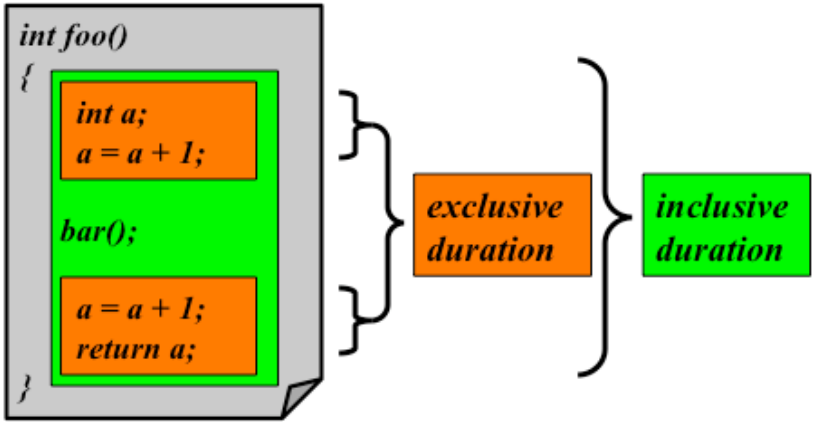


Performance Evaluation

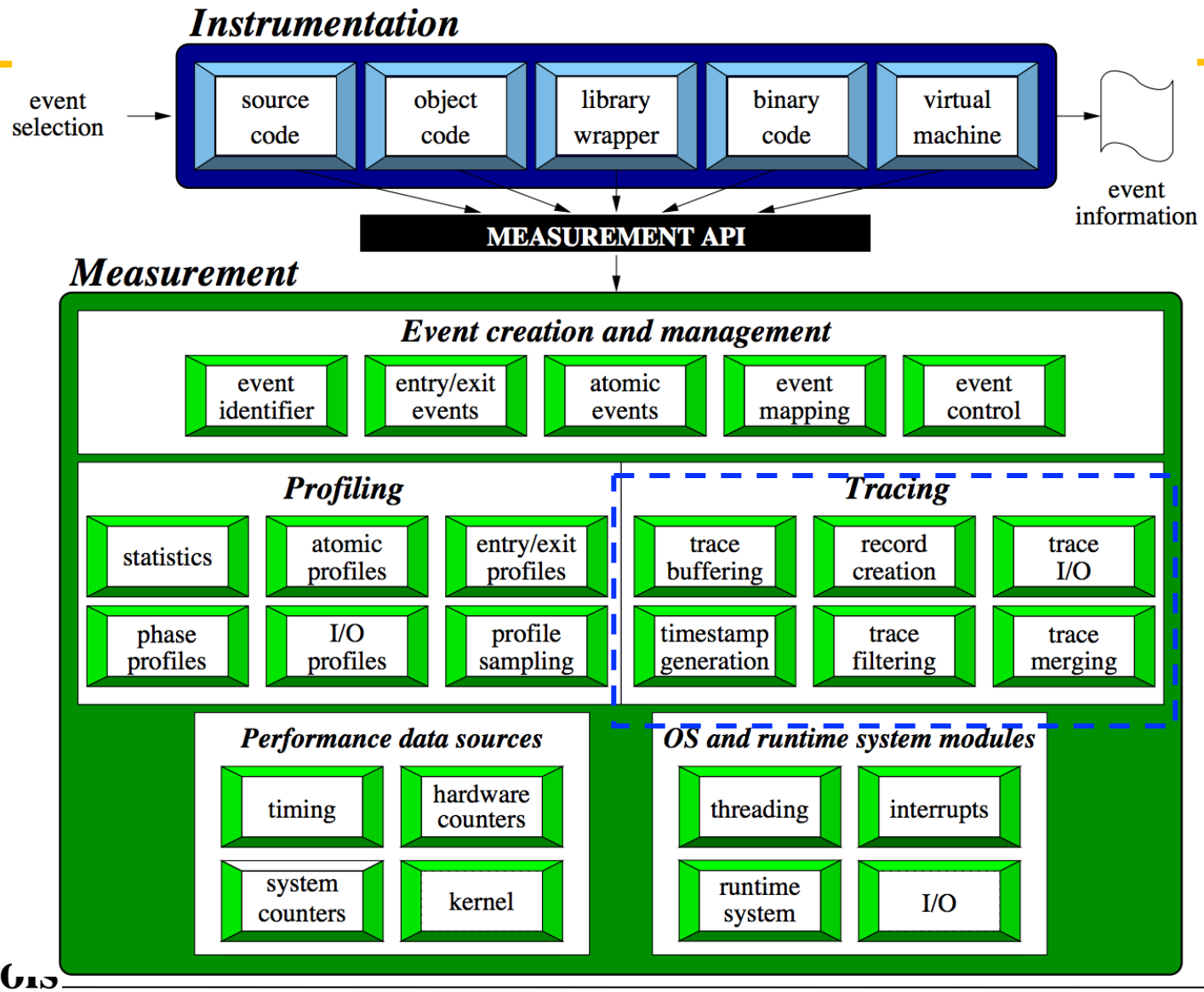
- Profiling
  - Presents summary statistics of performance metrics
    - number of times a routine was invoked
    - exclusive, inclusive time/hpm counts spent executing it
    - number of instrumented child routines invoked, etc.
    - structure of invocations (calltrees/callgraphs)
    - memory, message communication sizes also tracked
- Tracing
  - Presents when and where events took place along a global timeline
    - timestamped log of events
    - message communication events (sends/receives) are tracked
      - shows when and where messages were sent
    - large volume of performance data generated leads to more perturbation in the program

TAU Performance Profiling

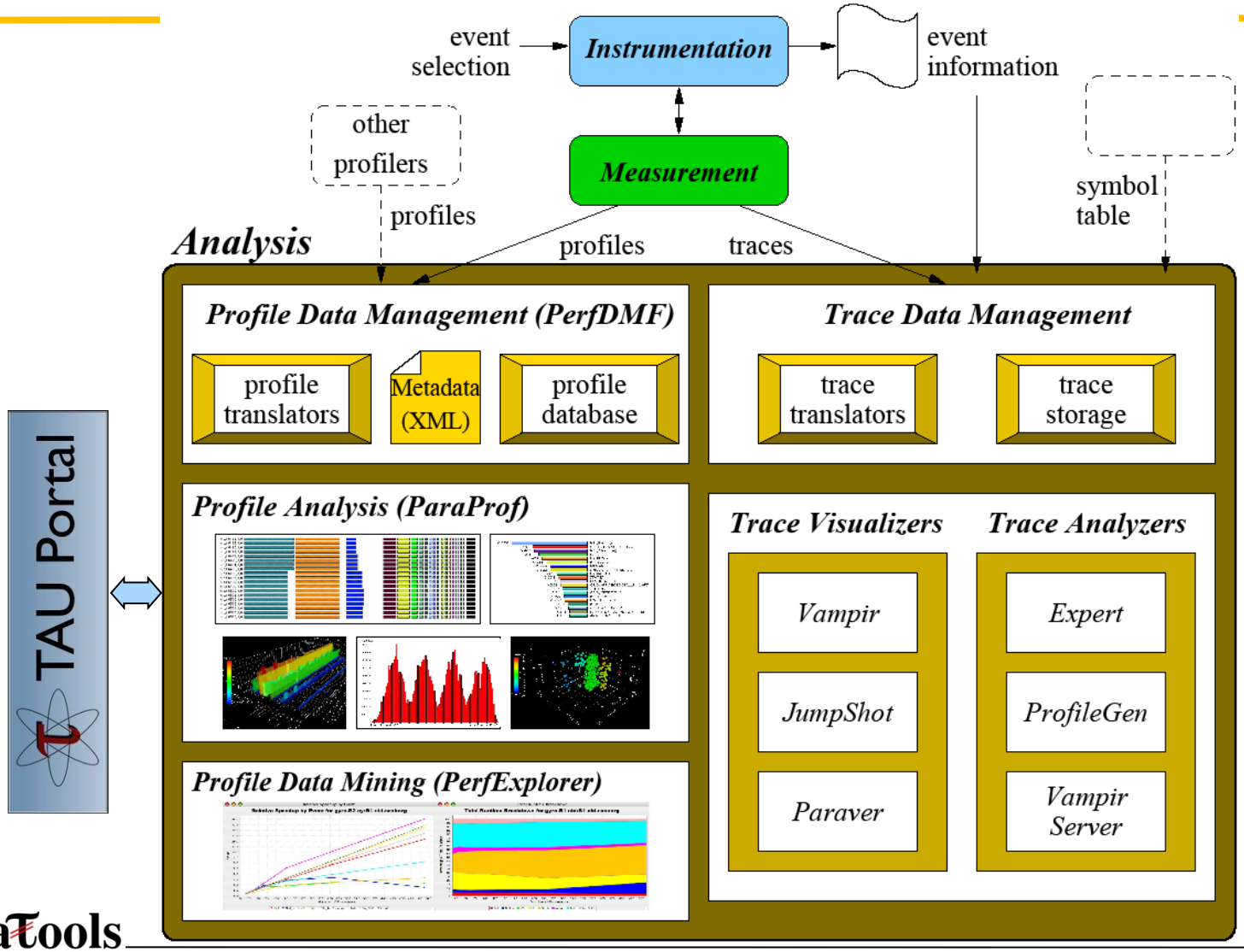
- Performance with respect to nested event regions
  - Program execution event stack (begin/end events)
- Profiling measures inclusive and exclusive data
- Exclusive measurements for region only performance
- Inclusive measurements includes nested “child” regions
- Support multiple profiling types
  - Flat, callpath, and phase profiling



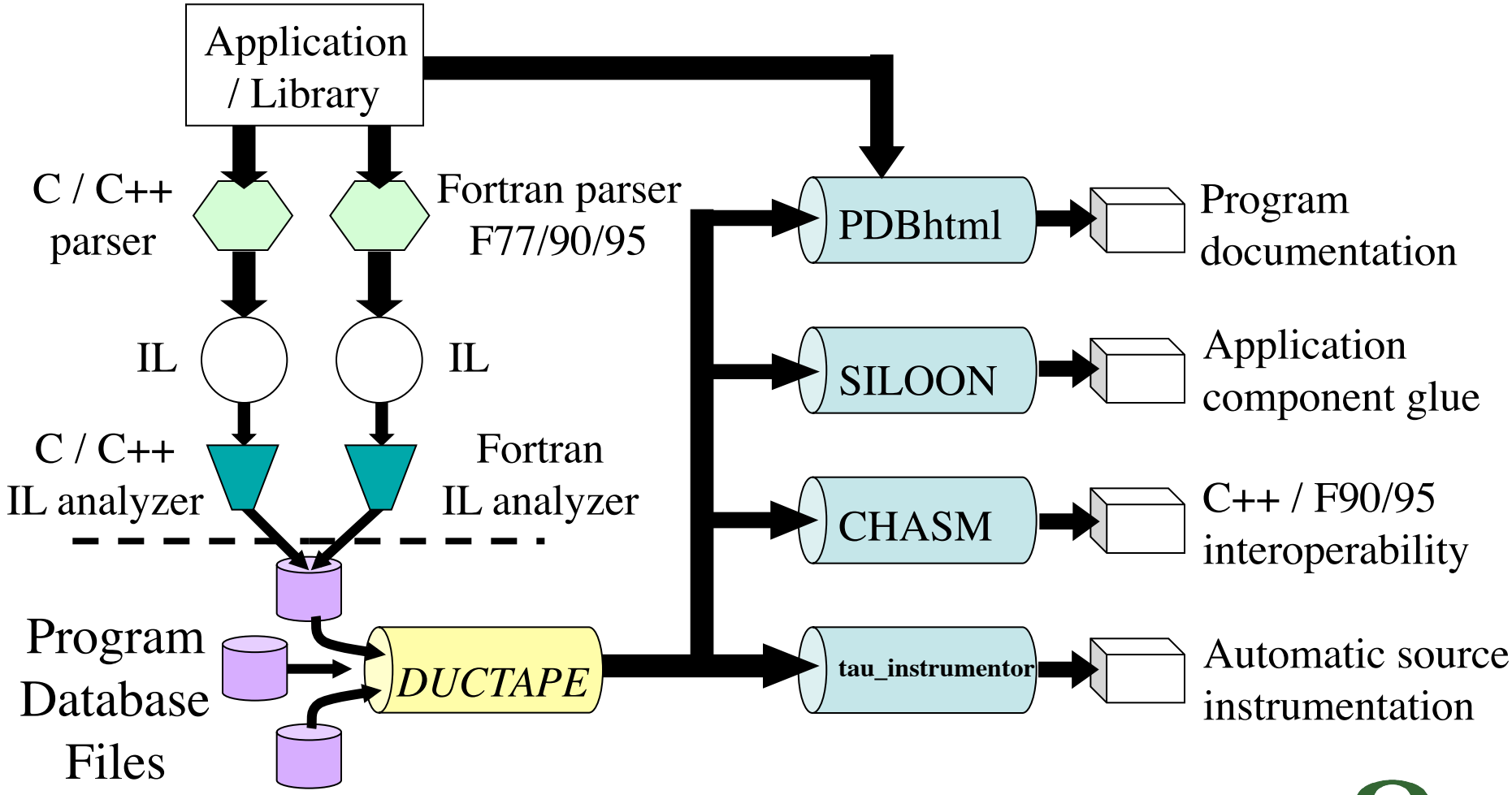
TAU Performance System Architecture



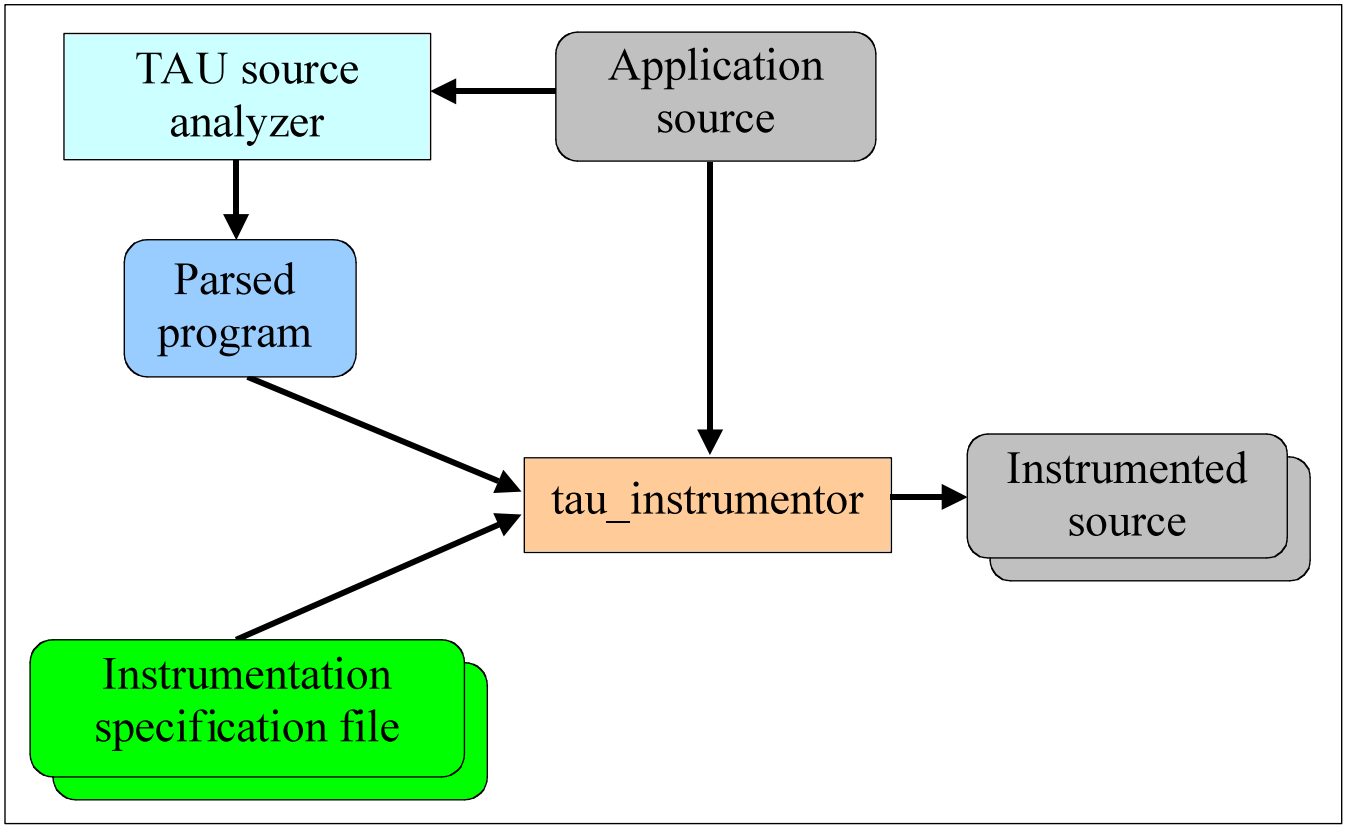
TAU Performance System Architecture



Program Database Toolkit (PDT)



Automatic Source-Level Instrumentation in TAU



Using TAU: A brief Introduction

- TAU supports several measurement options (profiling, tracing, profiling with hardware counters, etc.)
- Each measurement configuration of TAU corresponds to a unique stub makefile that is generated when you configure it
- To instrument source code using PDT
  - Choose an appropriate TAU stub makefile in <arch>/lib:

```
% soft add +tau-latest (on BG/Q)
% export TAU_MAKEFILE=/soft/perftools/tau/tau_latest/bgq/lib/Makefile.tau-bgqtimers-mpi-pdt
% export TAU_OPTIONS='-optVerbose …' (see tau_compiler.sh -help)
```

  And use tau_f90.sh, tau_cxx.sh or tau_cc.sh as Fortran, C++ or C compilers:

```
% mpixlf90_r foo.f90
```

  changes to

```
% tau_f90.sh foo.f90
% qsub –A <…> ./a.out     (to submit the job)
```

- Execute application and analyze performance data:

```
% pprof   (for text based profile display)
% paraprof  (for GUI)
```

TAU Measurement Configuration on BG/Q

```
% cd /soft/perftools/tau/tau_latest/bgq/lib; ls Makefile.*
Makefile.tau-pdt
Makefile.tau-mpi-pdt
Makefile.tau-bgqtimers-mpi-pdt
Makefile.tau-bgqtimers-gnu-mpi-pdt
Makefile.tau-mpi-papi-pdt
Makefile.tau-papi-mpi-openmp-opari-pdt
Makefile.tau-pthread-pdt…
```

- For an MPI+F90 application, you may want to start with:

Makefile.tau-mpi-pdt

- Supports MPI instrumentation & PDT for automatic source instrumentation

```
– % soft add +tau-latest
– % export TAU_MAKEFILE=$TAU/Makefile.tau-bgqtimers-mpi-pdt
– % make CC=tau_cc.sh CXX=tau_cxx.sh F90=tau_f90.sh
– % qsub -n 2 -mode c16 -t 10 -A <account> ./a.out
– % paraprof
```

TAU Measurement Configuration on BG/P

```
% cd /soft/perftools/tau/tau_latest/bgp/lib; ls Makefile.*
Makefile.tau-pdt
Makefile.tau-mpi-pdt
Makefile.tau-bgptimers-mpi-pdt
Makefile.tau-opari-openmp-mpi-pdt
Makefile.tau-mpi-papi-pdt
Makefile.tau-papi-mpi-openmp-opari-pdt
Makefile.tau-pthread-pdt…
```

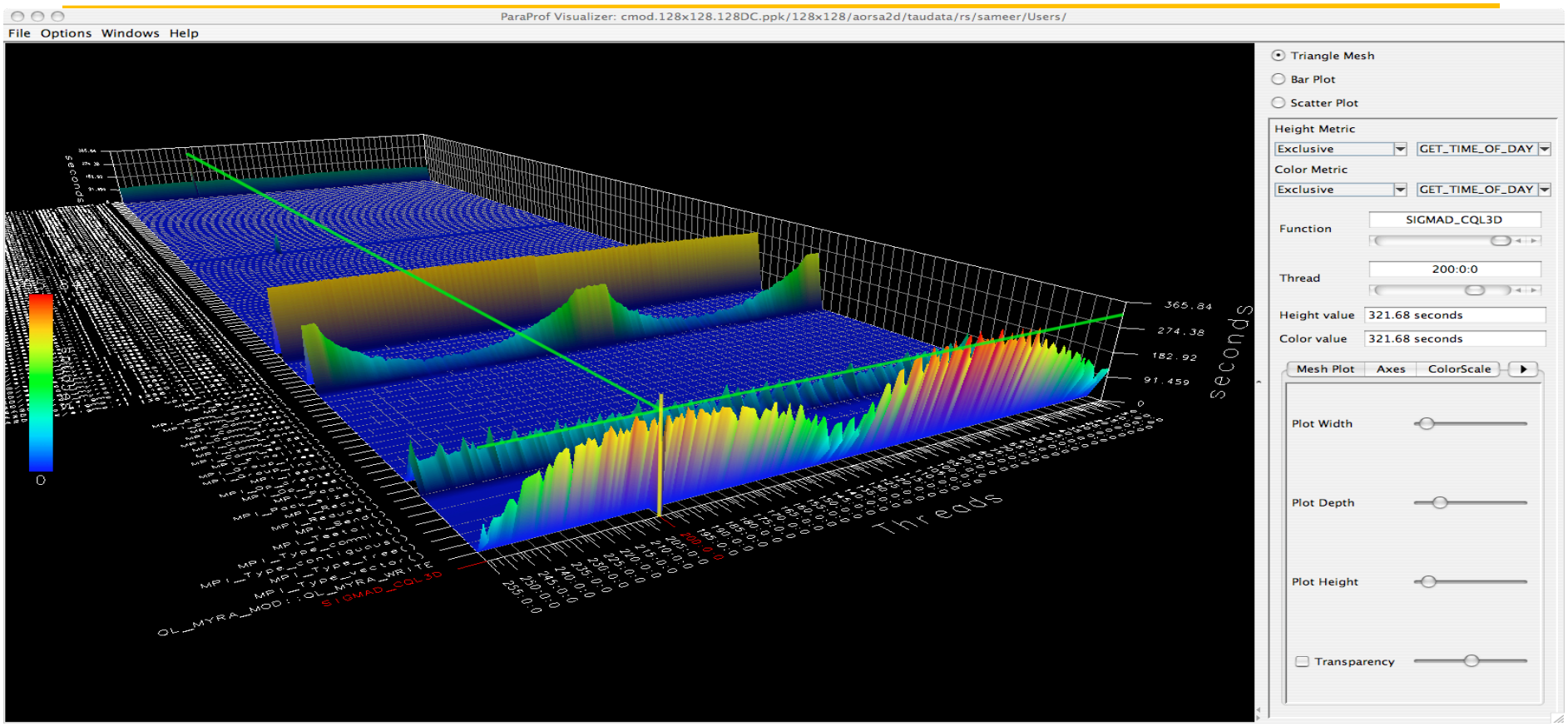
- For an MPI+F90 application, you may want to start with:

Makefile.tau-mpi-pdt

- Supports MPI instrumentation & PDT for automatic source instrumentation

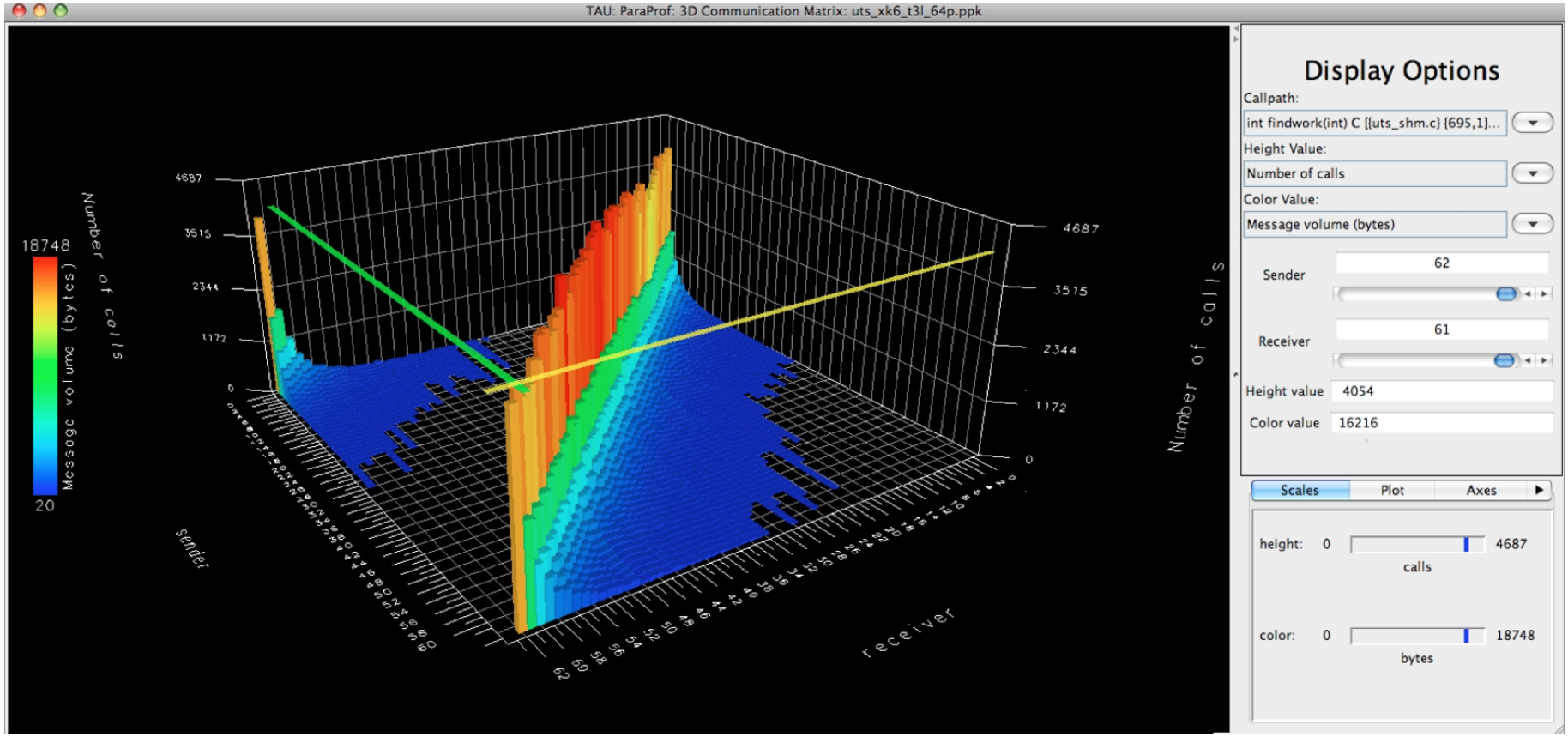
```
– % soft add +tau-latest
– % export TAU_MAKEFILE=$TAU/Makefile.tau-bgptimers-mpi-pdt
– % make CC=tau_cc.sh CXX=tau_cxx.sh F90=tau_f90.sh
– % qsub -n 2 -mode smp -t 10 -A <account> ./a.out
– % paraprof
```

Parallel Profile Visualization: ParaProf




```
% soft add +tau-latest
% paraprof  (Windows -> 3D Visualization)
```

ParaProf: 3D Communication Matrix




```
% qsub –env TAU_COMM_MATRIX=1 …
% paraprof (Windows -> 3D Communication Matrix)
```

Interval, Atomic and Context Events in TAU

```
File  Edit  View  Terminal  Tabs  Help
Reading Profile files in profile.*

NODE 0;CONTEXT 0;THREAD 0:
---------------------------------------------------------------------------------------
%Time    Exclusive    Inclusive       #Call      #Subrs  Inclusive Name
              msec   total msec                          usec/call
---------------------------------------------------------------------------------------
100.0        0.007        0.256           1           5        256 MAIN
 97.3        0.132        0.249           5           5         50 FOO
 40.6        0.104        0.104           5           0         21 BAR
 36.3        0.013        0.093           3           3         31 G
---------------------------------------------------------------------------------------

USER EVENTS Profile :NODE 0, CONTEXT 0, THREAD 0
---------------------------------------------------------------------------------------
NumSamples   MaxValue   MinValue  MeanValue  Std. Dev.  Event Name
---------------------------------------------------------------------------------------
         1         16         16         16          0  MEMORY LEAK! malloc size <file=foo.f90, variable=X, line=7> : MAIN => FOO => BAR
         2         52         48         50          2  MEMORY LEAK! malloc size <file=foo.f90, variable=X, line=7> : MAIN => FOO => G => BAR
         1         80         80         80          0  free size <file=foo.f90, variable=X, line=10>
         1         80         80         80          0  free size <file=foo.f90, variable=X, line=10> : MAIN => FOO => G => BAR
         1        180        180        180          0  free size <file=foo.f90, variable=X, line=15>
         1        180        180        180          0  free size <file=foo.f90, variable=X, line=15> : MAIN => FOO => BAR
         1        180        180        180          0  malloc size <file=foo.f90, variable=X, line=13>
         1        180        180        180          0  malloc size <file=foo.f90, variable=X, line=13> : MAIN => FOO => BAR
         4         80         16         49      22.69  malloc size <file=foo.f90, variable=X, line=7>
         1         16         16         16          0  malloc size <file=foo.f90, variable=X, line=7> : MAIN => FOO => BAR
         3         80         48         60      14.24  malloc size <file=foo.f90, variable=X, line=7> : MAIN => FOO => G => BAR
---------------------------------------------------------------------------------------
                                                                                    1,1           All
```

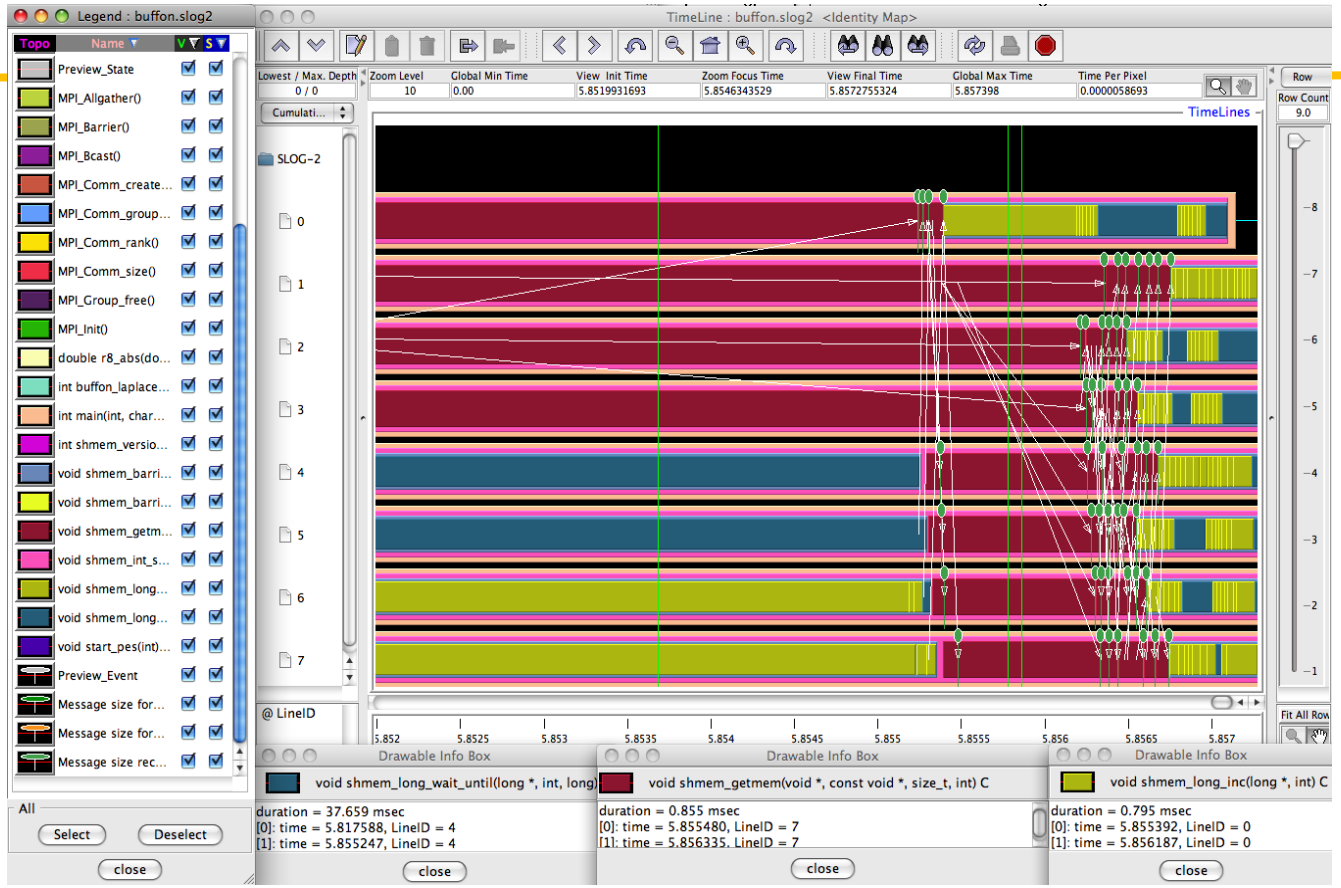
Interval Event

Context Event

Atomic Event

```
% pprof
```

Jumpshot [ANL]: Trace Visualization




```
% qsub –env TAU_TRACE=1 …
% tau_treemerge.pl
% tau2slog2 tau.trc tau.edf –o app.slog2
% jumpshot app.slog2
```

% cat /tmp/tau.txt

To use TAU on Cetus:

```
soft add +tau-latest
cp /soft/perftools/tau/tau_latest/examples/matmult/matmult.f90 .
export TAU_MAKEFILE=$TAU/Makefile.tau-bgqtimers-mpi-pdt
tau_f90.sh matmult.f90 -o matmult
qsub -A <YOUR_ACCOUNT> -n 2 --mode c8 -t 10 ./matmult
paraprof
```

Or use tracing:

```
qsub -A <YOUR_ACCOUNT> -n 2 --mode c8 -t 10 --env TAU_TRACE=1 ./matmult
tau_treemerge.pl
tau2slog2 tau.trc tau.edf -o app.slog2
jumpshot app.slog2
```

To profile an application on a large number of nodes:

```
qsub -A <YOUR_ACCOUNT> -n 64 --mode c16 -t 10 --env TAU_PROFILE_FORMAT="merged" ./matmult
```

See slides on Cetus: /soft/perftools/tau/ppt/*.ppt

Download TAU from http://tau.uoregon.edu for your desktop.

tau.uoregon.edu/tau.dmg or tau.uoregon.edu/tau.exe or tau.uoregon.edu/tau.tgz

Want more examples? Download workshop examples from:

/soft/perftools/tau/workshop.tar.gz

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