TECHNISCHE UNIVERSITÄT DRESDEN

Vampir Performance Visualization

Argonne Training Program on Extreme-Scale Computing 2016

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Disclaimer

It is extremely easy to waste performance!

- Bad MPI (50-90%)
- No node-level parallelism (94%)
- No vectorization (75%)
- Bad memory access pattern (99%)
- In sum: 0.008% of the peak performance (785 GFLOPs of mira)

Disclaimer (2)

Performance tools will not automatically make your code run faster. They help you understand, what your code does and where to put in work.

Agenda

Welcome to the Vampir Tool Suite

- Mission
- Event Trace Visualization
- Parallel Performance Analysis Approaches

The Vampir Workflow

- Score-P: Instrumentation & Run-Time Measurement
- Vampir & VampirServer

Vampir Performance Charts

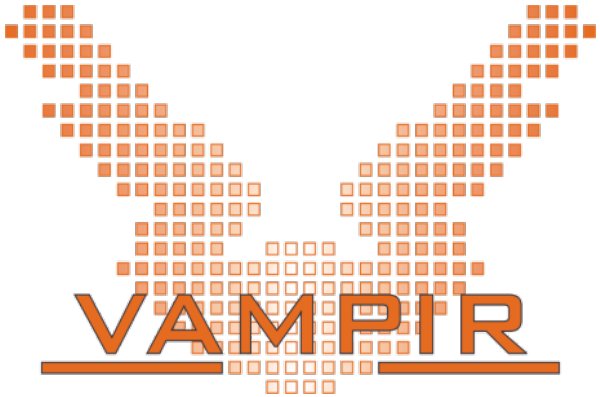
Vampir Demo

- Tracing and Visualizing NPB-MZ-MPI / BT

Conclusions

Mission

- Visualization of dynamics of concurrent processes
- Two components / steps
  - Monitor/Collector (Score-P)
  - Charts/Browser (Vampir)



Typical questions that Vampir helps to answer:

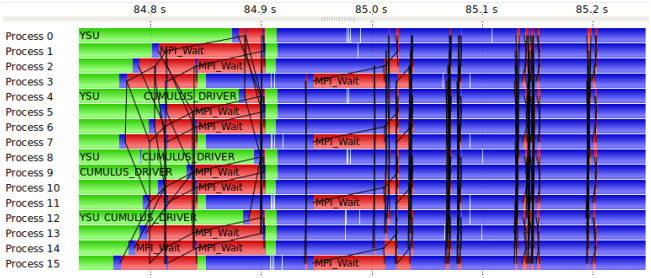
- What happens in my application execution during a given time in a given process or thread?
- How do the communication patterns of my application execute on a real system?
- Are there any imbalances in computation, I/O or memory usage and how do they affect the parallel execution of my application?

Event Trace Visualization with Vampir

- Show dynamic run-time behavior graphically at a fine level of detail
- Provide summaries (profiles) on performance metrics

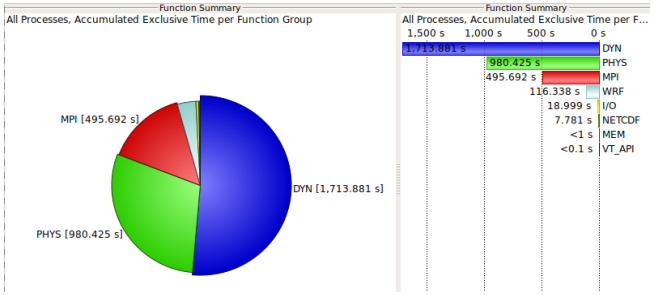
Timeline charts

– Show application activities and communication along a time axis

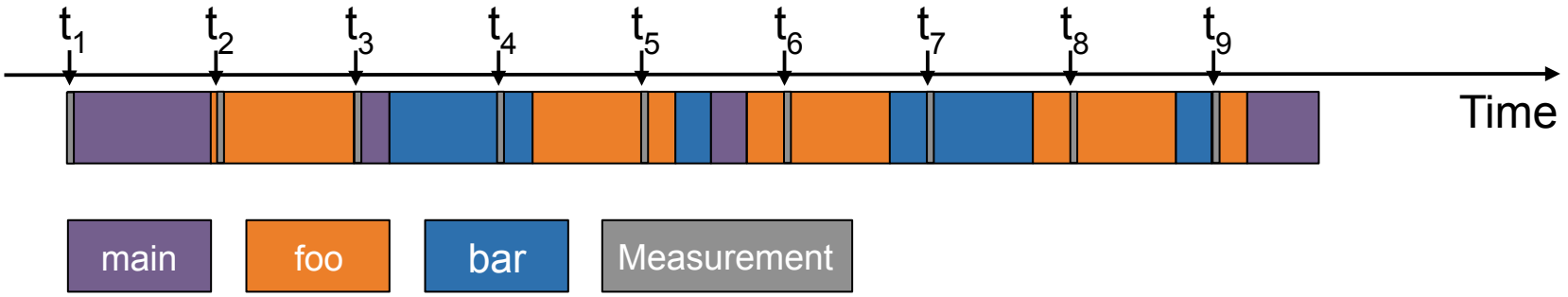


Summary charts

– Provide quantitative results for the currently selected time interval



Sampling



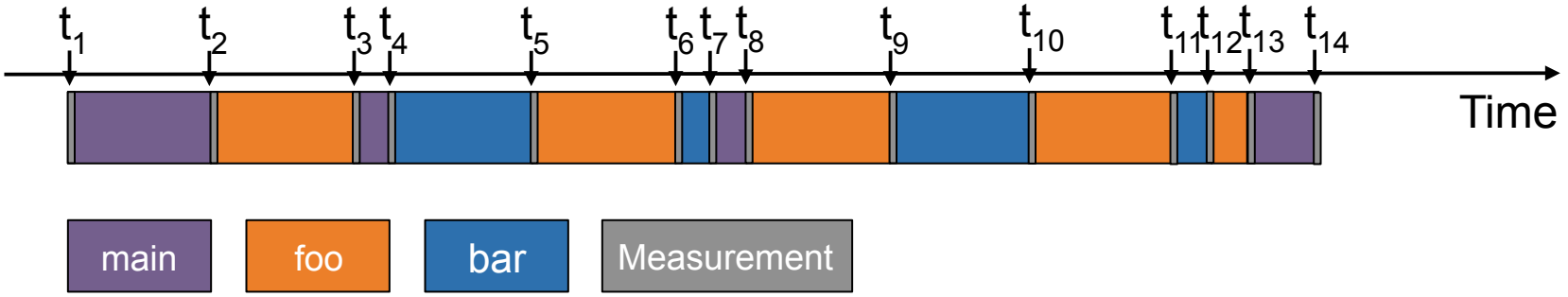
Running program is periodically interrupted to take measurement

Statistical inference of program behavior

- Not very detailed information on highly volatile metrics
- Requires long-running applications

Works with unmodified executables

Instrumentation



Measurement code is inserted such that every event of interest is captured directly

Advantage:

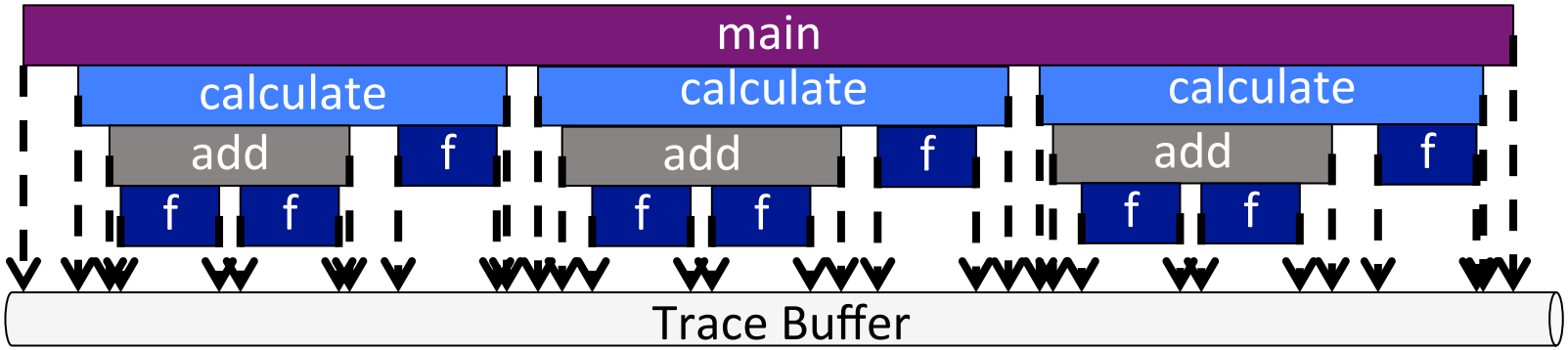
- Much more detailed information

Disadvantage:

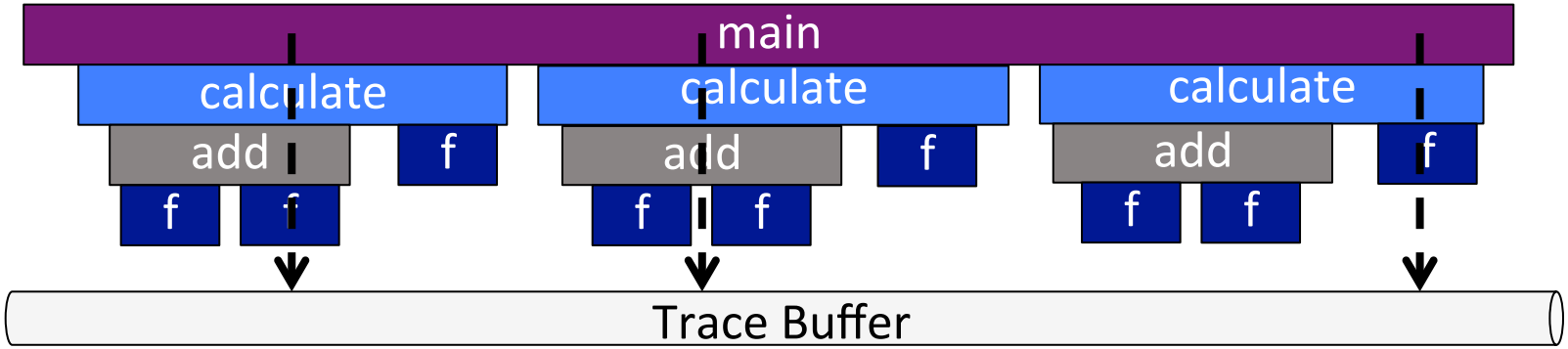
- Processing of source-code / executable necessary
- Large relative overheads for small functions

Sampling + Instrumentation

- Function Instrumentation:

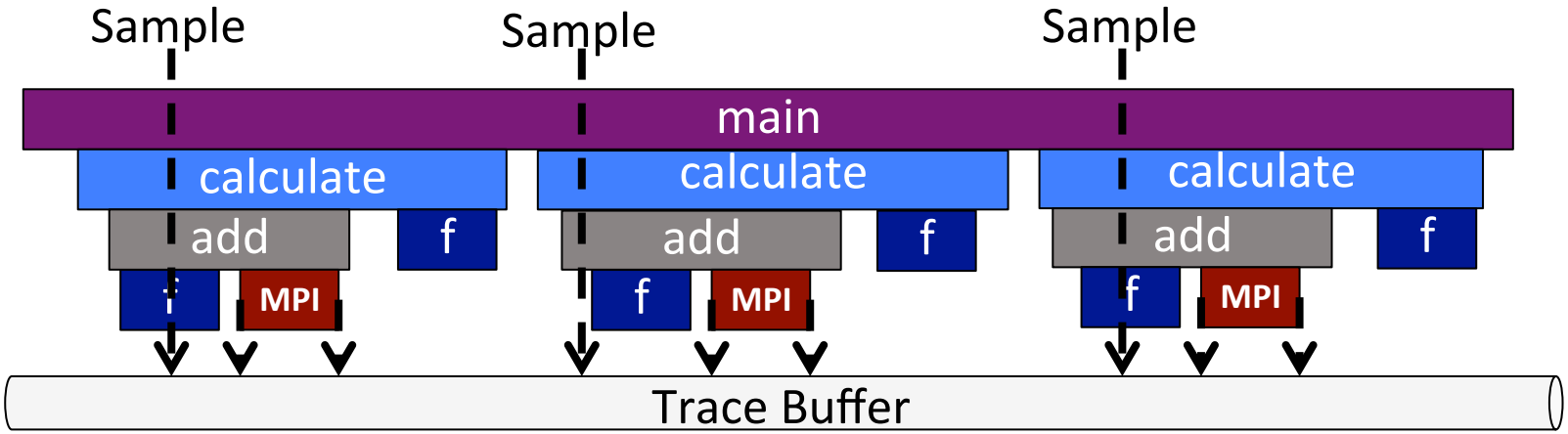


- Sampling:



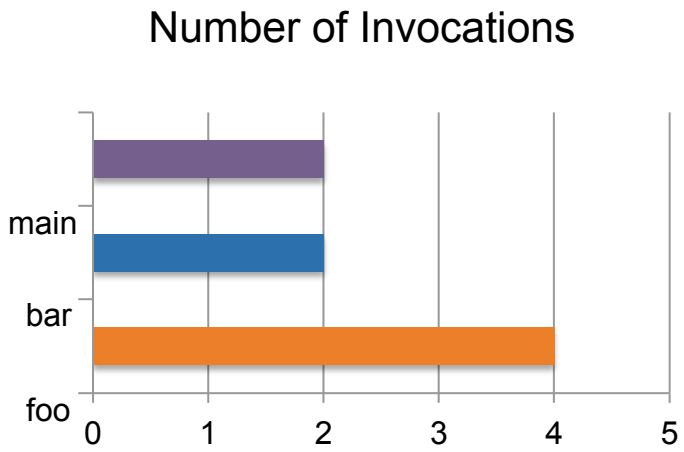
Sampling + Instrumentation

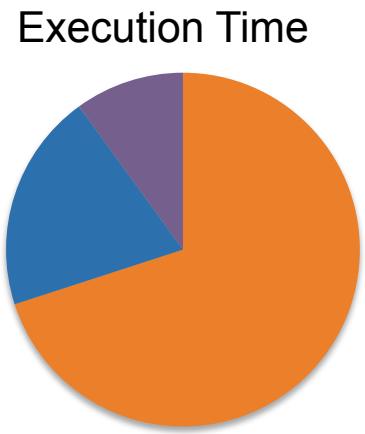
- Long running applications:
  - Requires large buffers or heavy filtering
  - Creating a filter requires runs in advance
- Codes with many small functions (e.g.: C++):
  - Function instrumentation a challenge
- **Score-P: Sampling+Tracing**



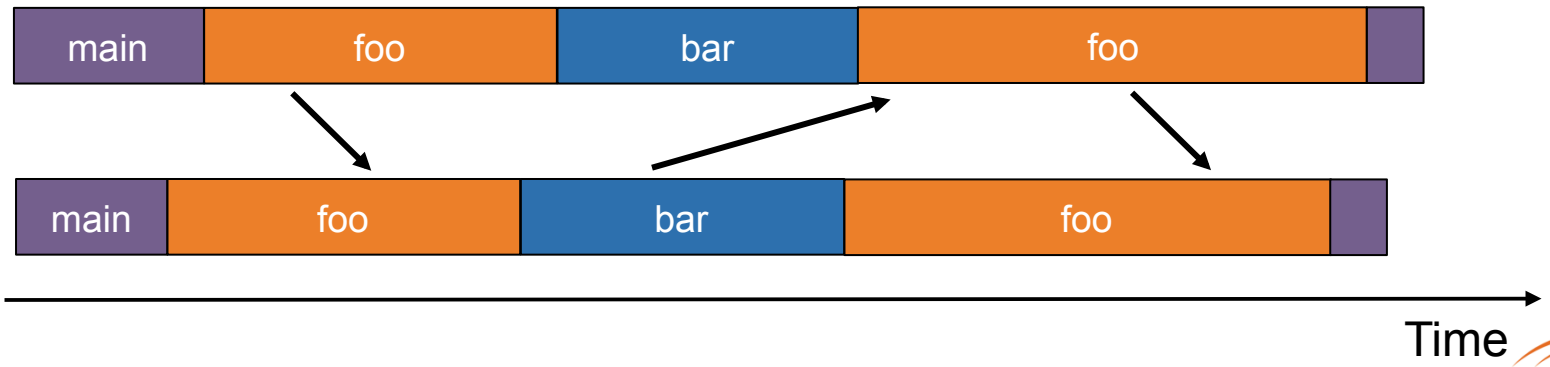
Profiling vs. Tracing

Statistics

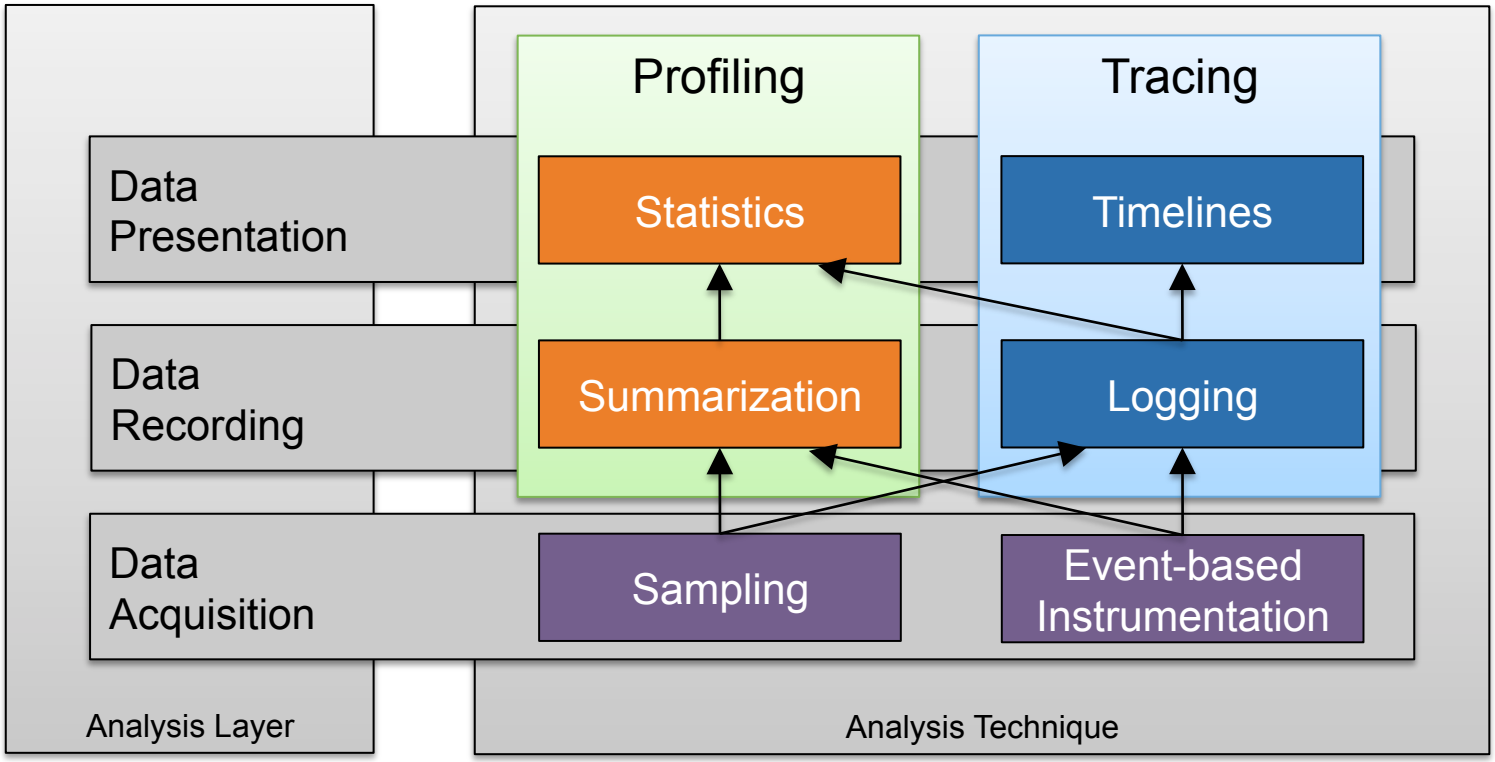




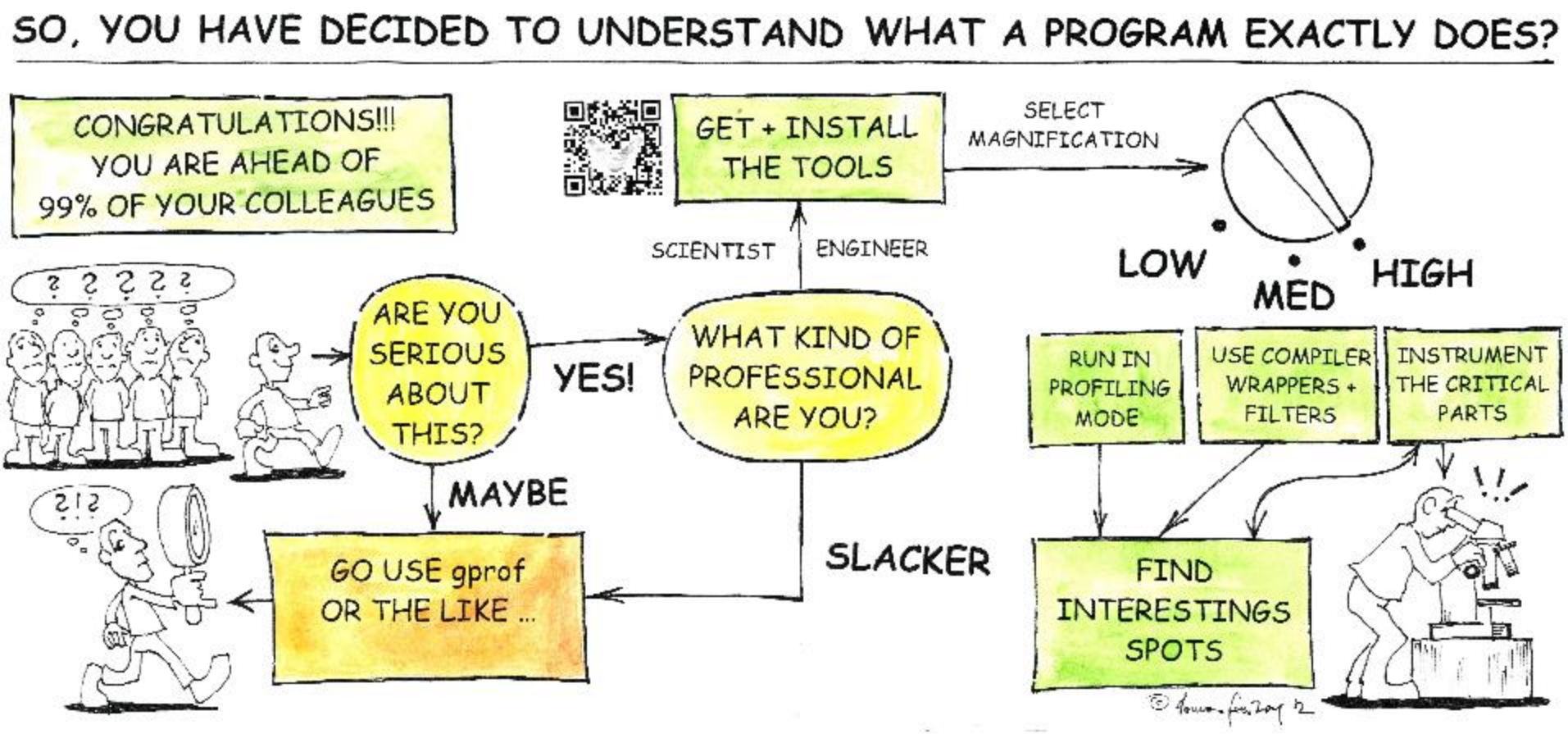
- Timelines



Terms Used and How They Connect



So what is the right choice?



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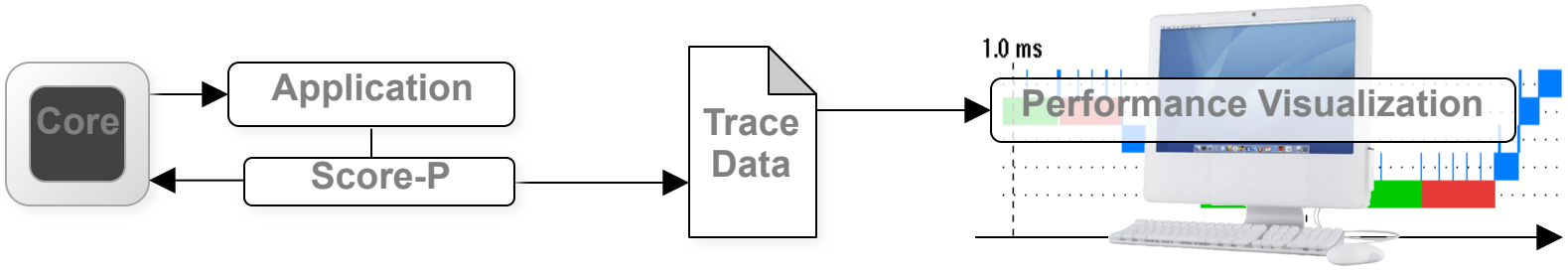
Vampir Performance Charts

Vampir Hands-on

- Tracing and Visualizing NPB-MZ-MPI / BT

Conclusions

Tracing – Overview



- Workflow:
  - Attach Score-P to application
  - Run with the attached monitor
    - ⇒ Result: **trace**/profile data
  - Analyze the trace with Vampir
- Repeat to:
  - Adapt instrumentation (“what you measure”)
  - Evaluate result of a change

Score-P: Workflow / Instrumentation

```
CC      = icc
CXX     = icpc
F90     = ifc
MPICC = mpicc
```

```
CC      = scorep <options> icc
CXX     = scorep <options> icpc
F90     = scorep <options> ifc
MPICC = scorep <options> mpicc
```

- To see all available options for instrumentation:

```
$ scorep --help
This is the Score-P instrumentation tool. The usage is:
scorep <options> <original command>

Common options are:
...
  --instrument-filter=<file>
                  Specifies the filter file for filtering functions during
                  compile-time. It applies the same syntax, as the one
                  used by Score-P during run-time.

  --user          Enables user instrumentation.
```

Score-P: Workflow / Measurement

- Measurements are configured via environment variables

```
$ scorep-info config-vars --full

SCOREP_ENABLE_PROFILING
    [...]
SCOREP_ENABLE_TRACING
    [...]
SCOREP_TOTAL_MEMORY
  Description: Total memory in bytes for the measurement system
    [...]
SCOREP_EXPERIMENT_DIRECTORY
  Description: Name of the experiment directory
    [...]
```

- Example for generating a profile:

```
$ export SCOREP_ENABLE_PROFILING=true
$ export SCOREP_ENABLE_TRACING=false
$ export SCOREP_EXPERIMENT_DIRECTORY=profile

$ mpirun <instrumented binary>
```

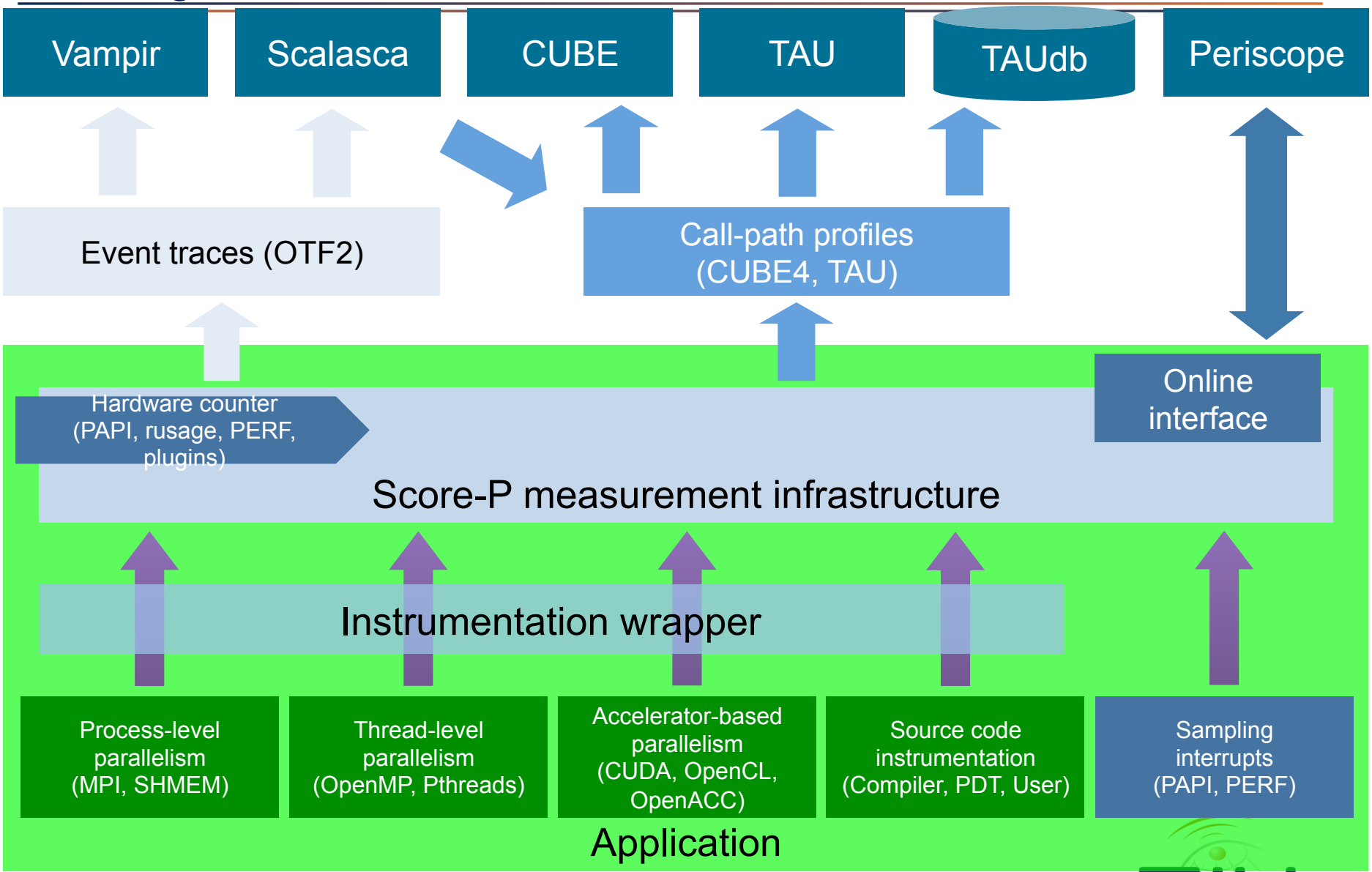
Score-P: Sampling + Instrumentation

- Score-P since 2.0 supports a combination of:
  - Instrumentation for MPI/OpenMP events
  - Sampling for everything else

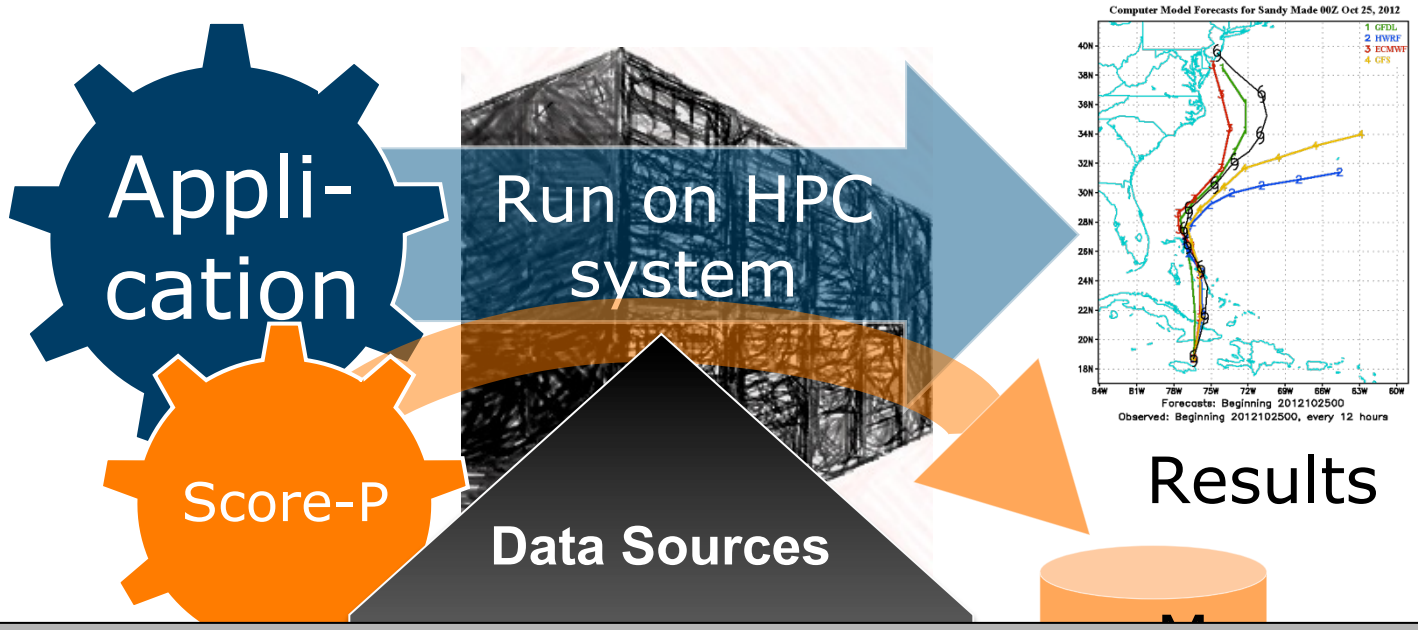
- Simple configuration, e.g.:

```
% export SCOREP_ENABLE_TRACING=true
% export SCOREP_ENABLE_UNWINDING=true
% export SCOREP_SAMPLING_EVENTS=perf_cycles@2000000
```

Tracing – Score-P Architecture



Tracing – Data Sources



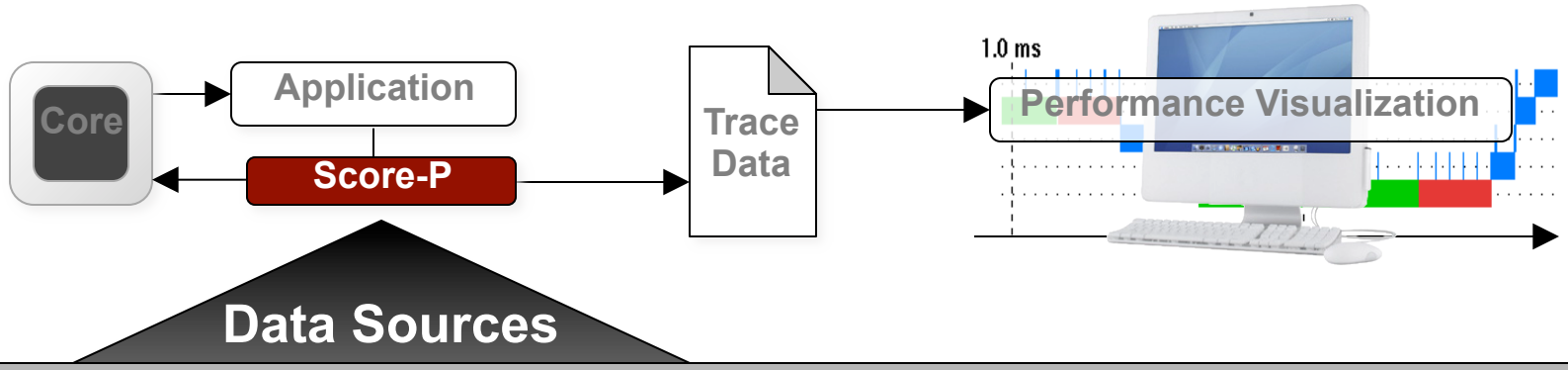
User Code
- Compiler instrum.
- Compiler plugin
- Sampling ***NEW***
- Manual
- Java (*Experimenal*)

Parallel Paradigms
- MPI
- Pthreads
- OpenMP (via Opari)
  - via OMPT (*Experimental*) ⇒ XeonPhi Offload
- XeonPhi Native *NEW*
- CUDA
- OpenACC/OpenCL ***NEW***
- OpenShmem (+Cray)

Hardware
- Performance counters (PAPI)
- Plugin counters

Operating System
- Resource usage

Tracing – Instrumentation



Data Sources

Source level
- Compiler
- Manual
- OpenMP with Opari2
- Tau PDT

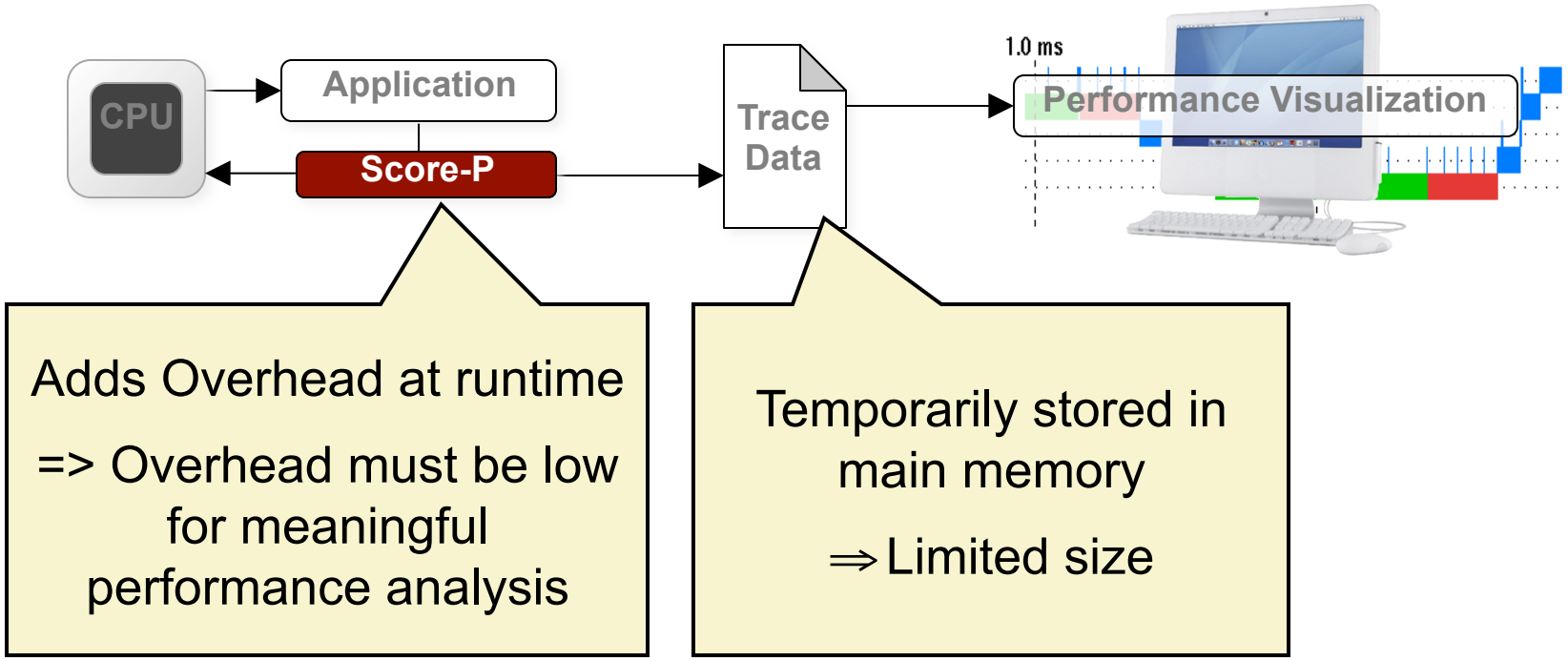
MPI Profiling Interface
- MPI

Runtime/Library
- Pthreads
- NVIDIA CUDA
- OpenSHMEM (Cray-SHMEM)
- External counters
- Plugin counters
- OpenCL
- OpenACC

Operating System
- Resource usage

Hardware
- Performance counters

Tracing – The Hard Part



- Event tracing requires trade-off's:
  - ⇒ Only add the data sources you need
  - ⇒ Limit granularity (i.e., filtering)
- Thus: Score-P default is a profiling experiment

Score-P: Workflow / Filtering

- Use scorep-score to define a filter
  - Exclude short frequently called functions from measurement
    - For profiling: reduce measurement overhead (if necessary)
    - For tracing: reduce measurement overhead and total trace size

```
$ scorep-score -r profile/profile.cubex
Estimated aggregate size of event trace:                   40GB
Estimated requirements for largest trace buffer (max_buf): 10GB
Estimated memory requirements (SCOREP_TOTAL_MEMORY):       10GB
  [...]
Flt type     max_buf[B]        visits time[s] time[%] time/visit[us]  region
  [...]
     USR  3,421,305,420   522,844,416  144.46    13.4           0.28  matmul_sub
     USR  3,421,305,420   522,844,416  102.40     9.5           0.20  matvec_sub
     USR  3,421,305,420   522,844,416  200.94    18.6           0.38  binvcrhs
     USR    150,937,332    22,692,096    5.58     0.5           0.25  binvrhs
     USR    150,937,332    22,692,096   13.21     1.2           0.58  lhsinit
```

- Filter file:

```
$ vim scorep.filt
SCOREP_REGION_NAMES_BEGIN EXCLUDE
  matmul_sub
  matvec_sub
  binvcrhs
```

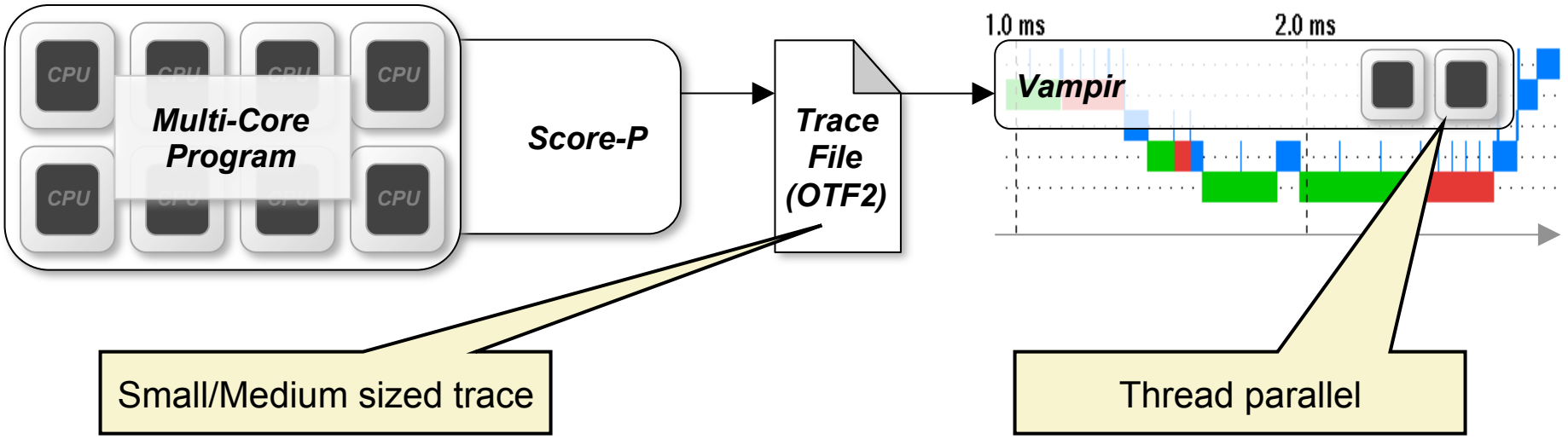
Tracing – Good Practices

- Traces can become large; Their handling challenging
  - Trace size proportional to: number of processes/threads (width), duration (length), and measurement detail (depth)
- Intermediate flushes => High degree of perturbation
  - Either use less detail or larger trace buffers
- Traces should be written to a parallel file systems
  - E.g. “/work”, “/scratch”, or “/p/lscratchc”
- Moving large traces can become challenging
  - However, systems with more memory/core can analyze larger traces
  - Alternatively, undersubscribe for increased memory/core ratios

Vampir – Visualization Modes (1)

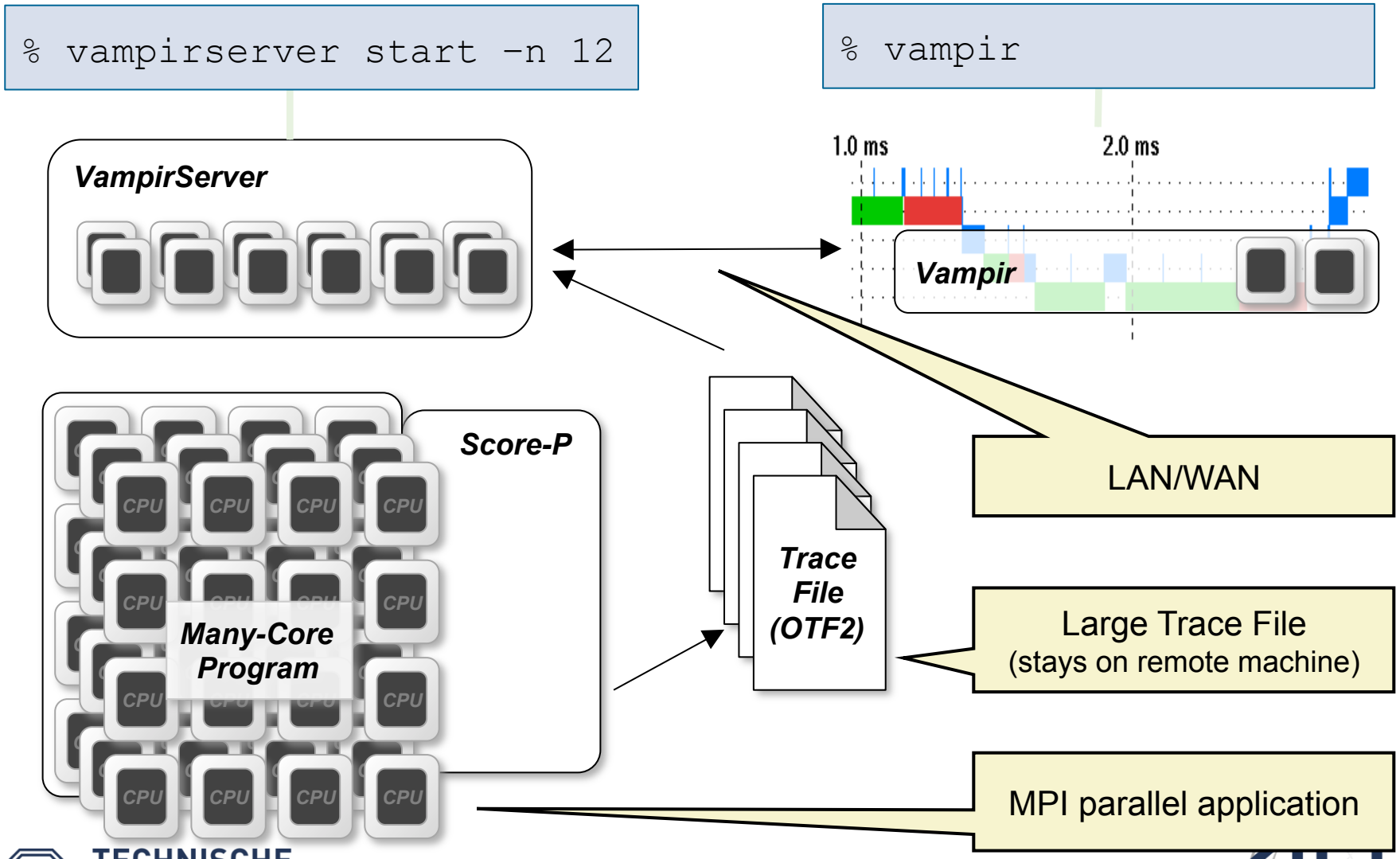
Directly on front end or local machine

```
% vampir
```

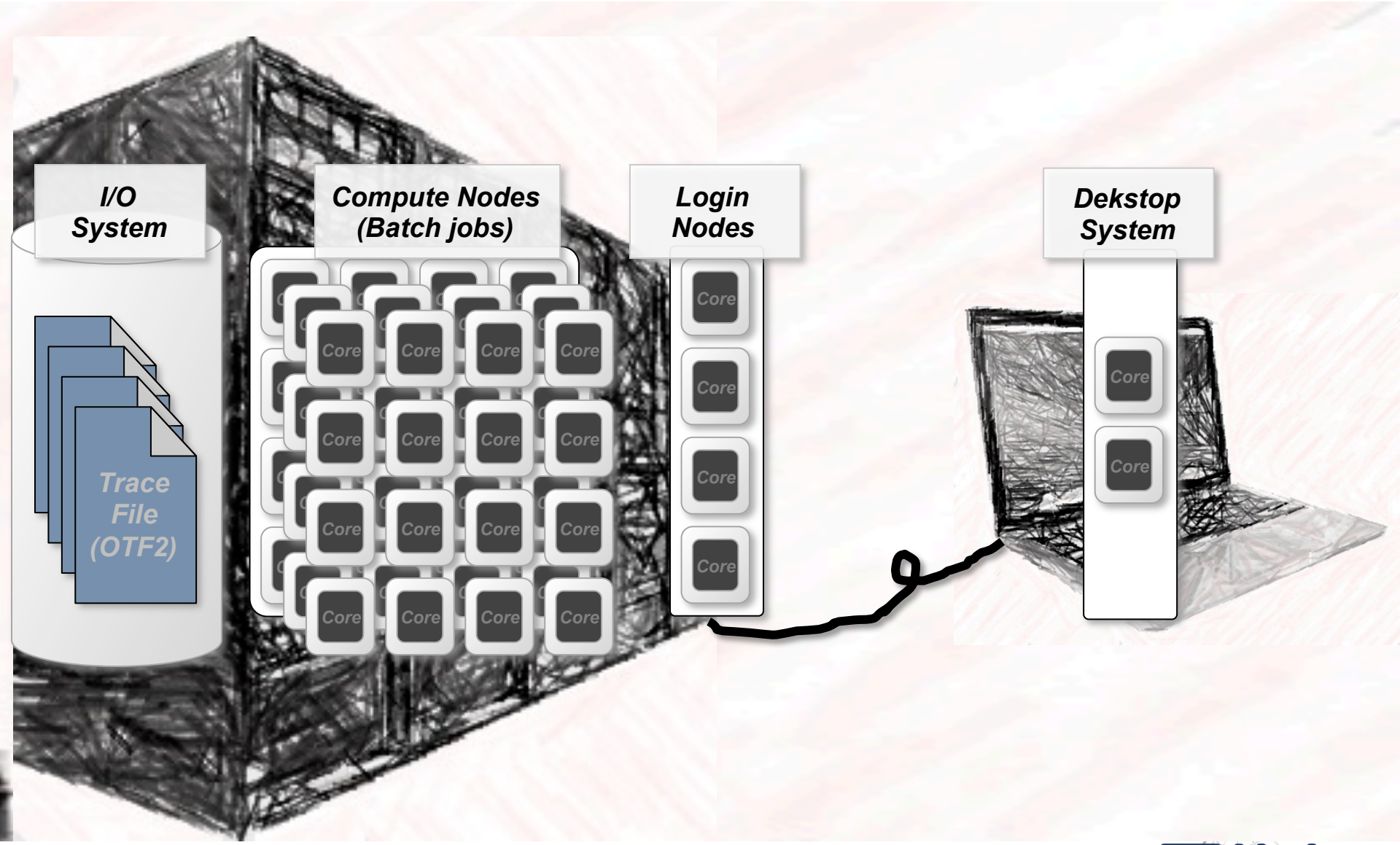


Vampir – Visualization Modes (2)

On local machine with remote VampirServer

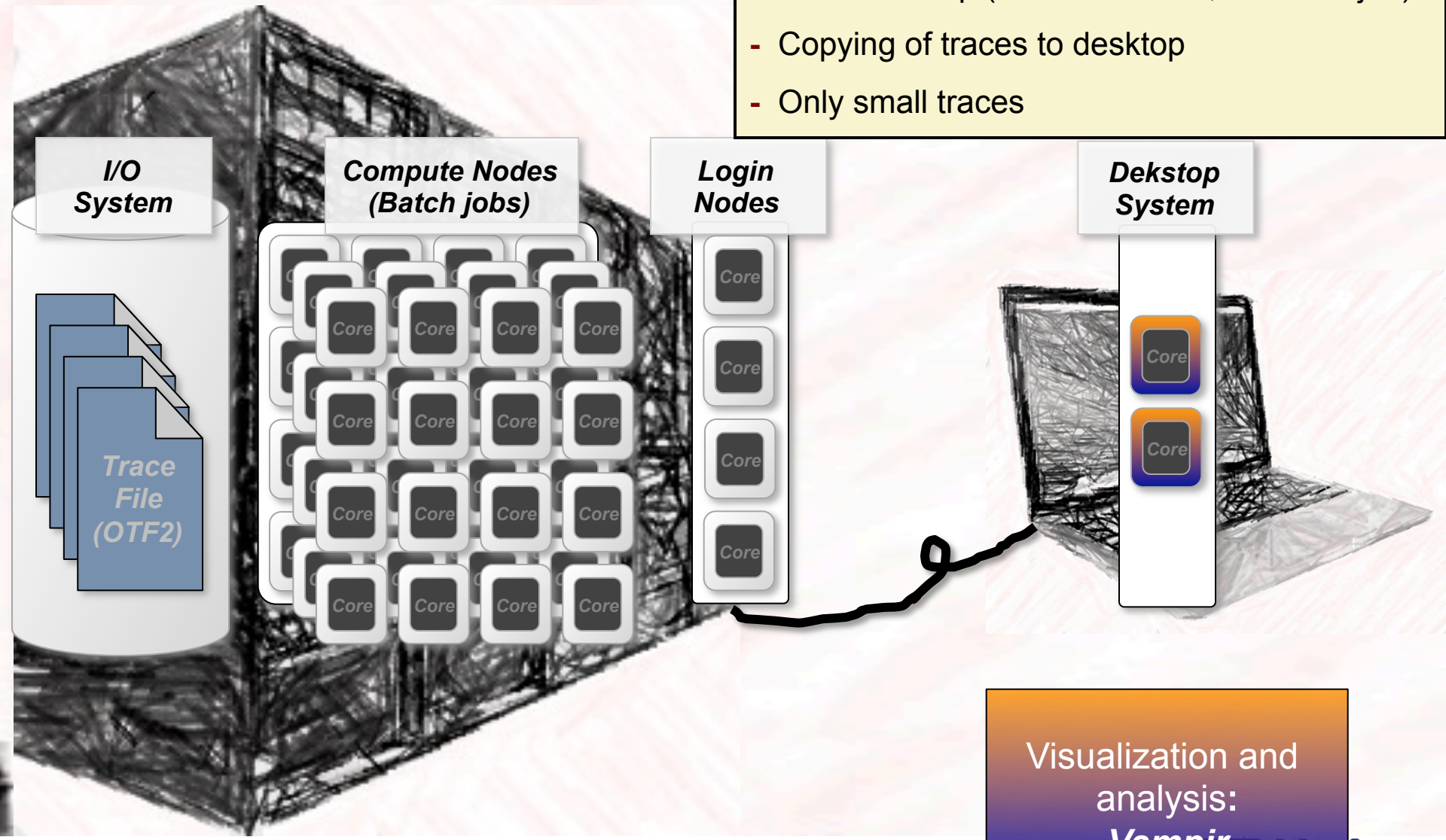


Visualization: After Tracing



Visualization: Most simple (Analysis on Desktop)

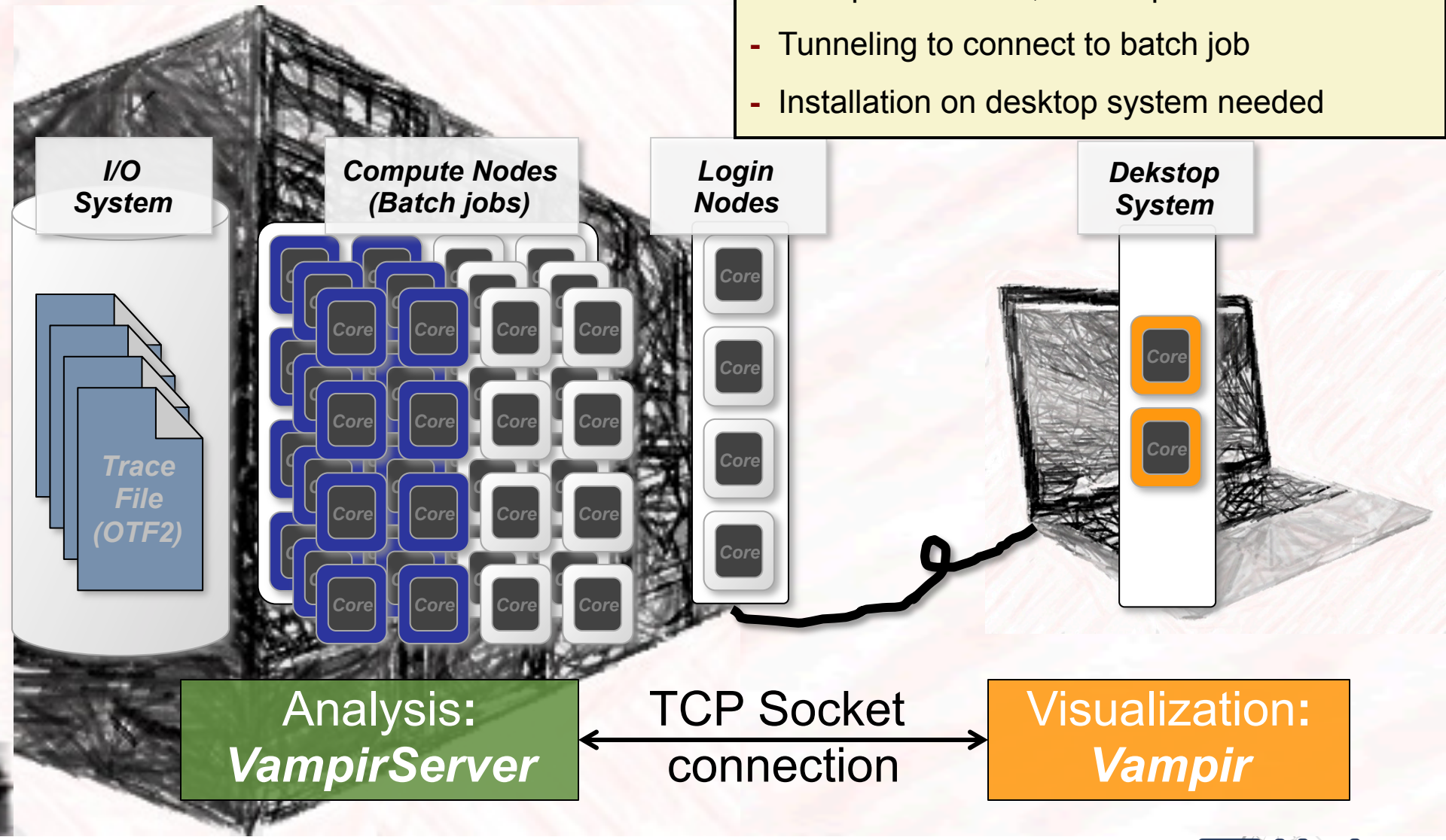
+ Minimal setup (no installations, no batch job)
- Copying of traces to desktop
- Only small traces



Visualization and analysis: ***Vampir***

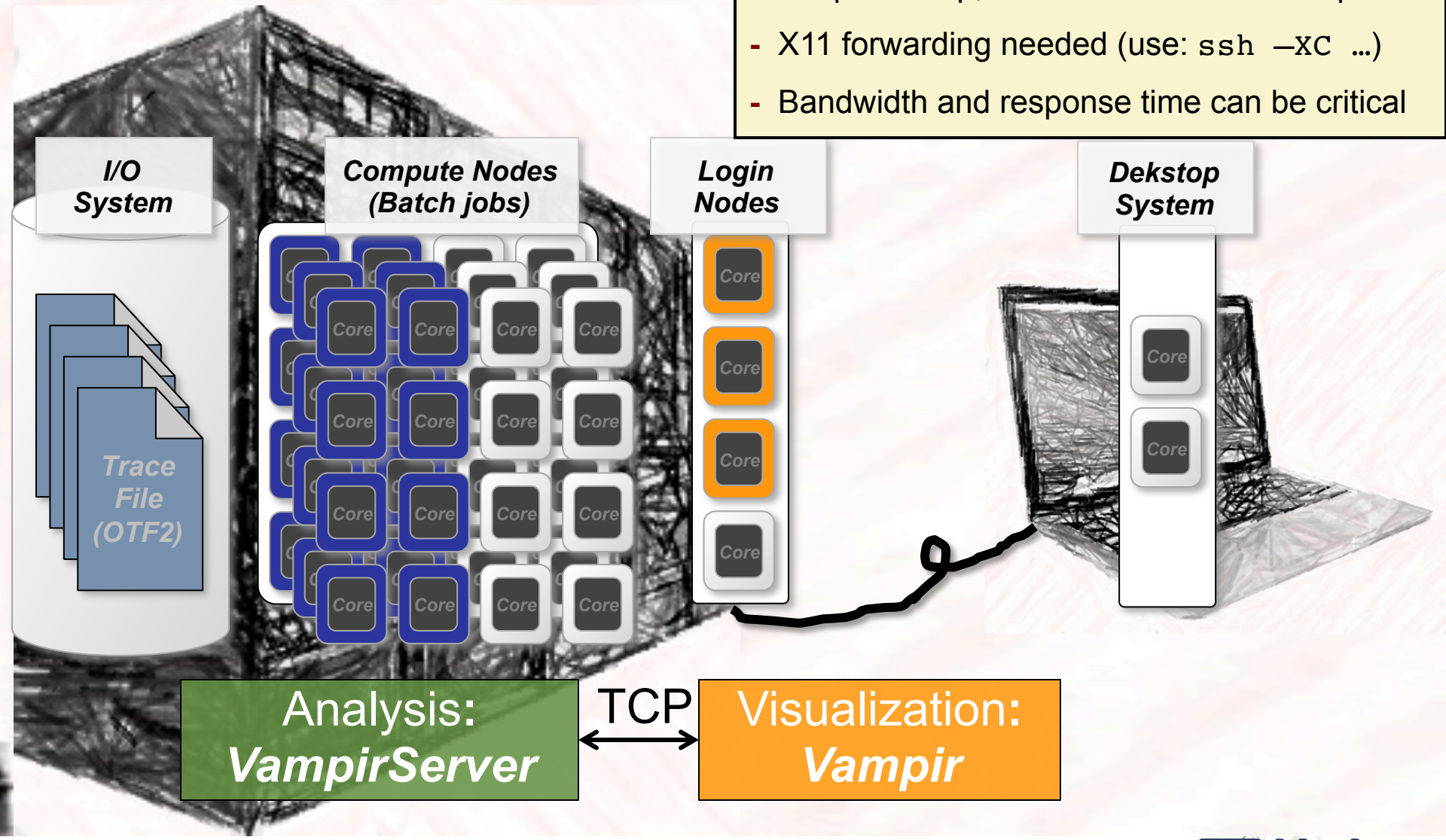
Visualization: Best Option (Analysis on HPC system)

+ Best performance, low response time
- Tunneling to connect to batch job
- Installation on desktop system needed



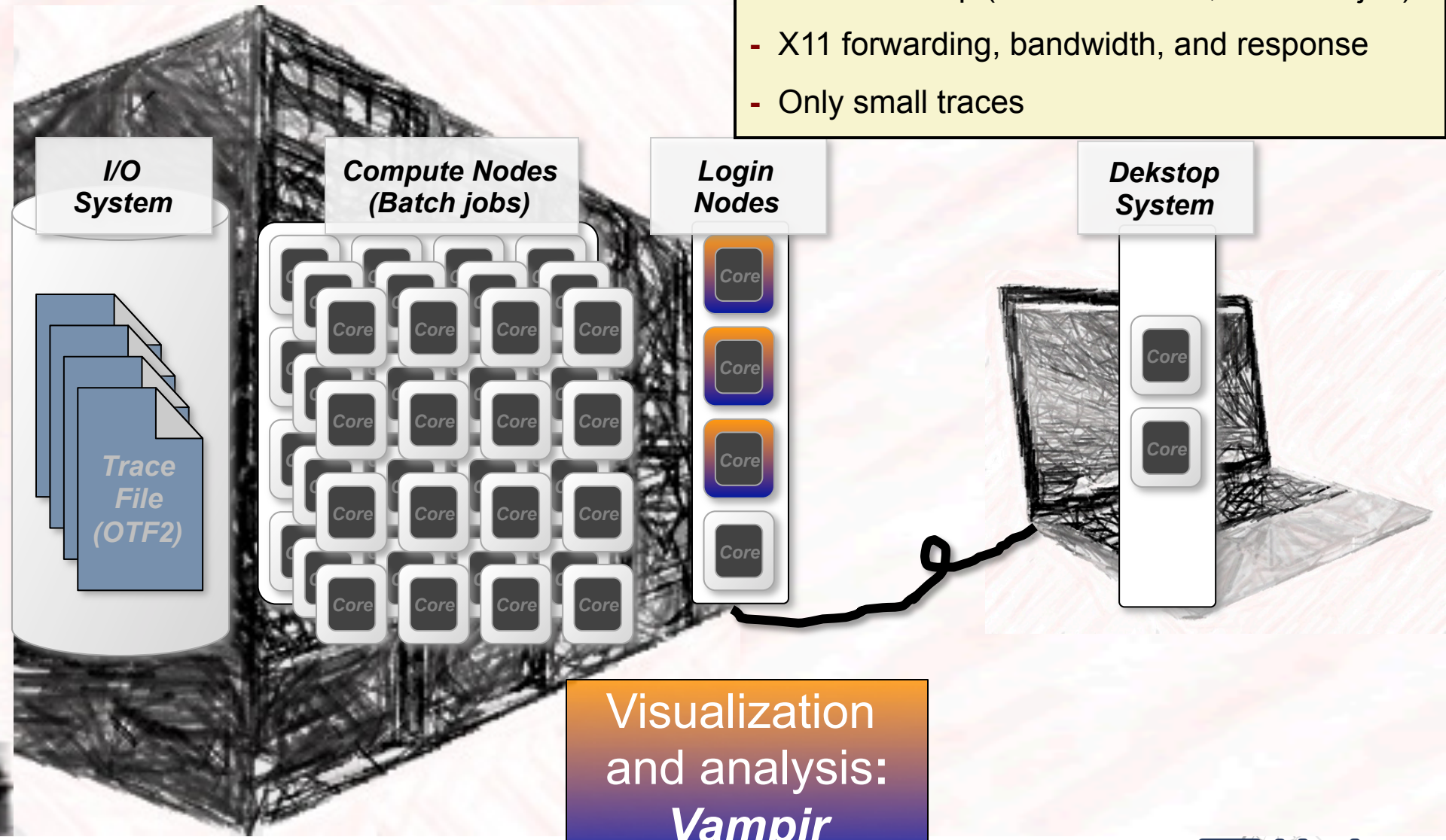
Visualization: Alternative (Analysis on HPC system)

+ Simpler setup, no installation on desktop
- X11 forwarding needed (use: `ssh –XC …`)
- Bandwidth and response time can be critical



Visualization: Most simple (Analysis on Frontend)

+ Minimal setup (no installations, no batch job)
- X11 forwarding, bandwidth, and response
- Only small traces



Visualization and analysis: ***Vampir***

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Conclusions

Vampir: Main Performance Charts

Timeline Charts


Master Timeline ➡ *all threads' activities over time per thread*


Summary Timeline ➡ *all threads' activities over time per activity*


Performance Radar ➡ *all threads' perf-metric over time*


Process Timeline ➡ *single thread's activities over time*


Counter Data Timeline ➡ *single threads perf-metric over time*

Summary Charts


Function Summary


Process Summary

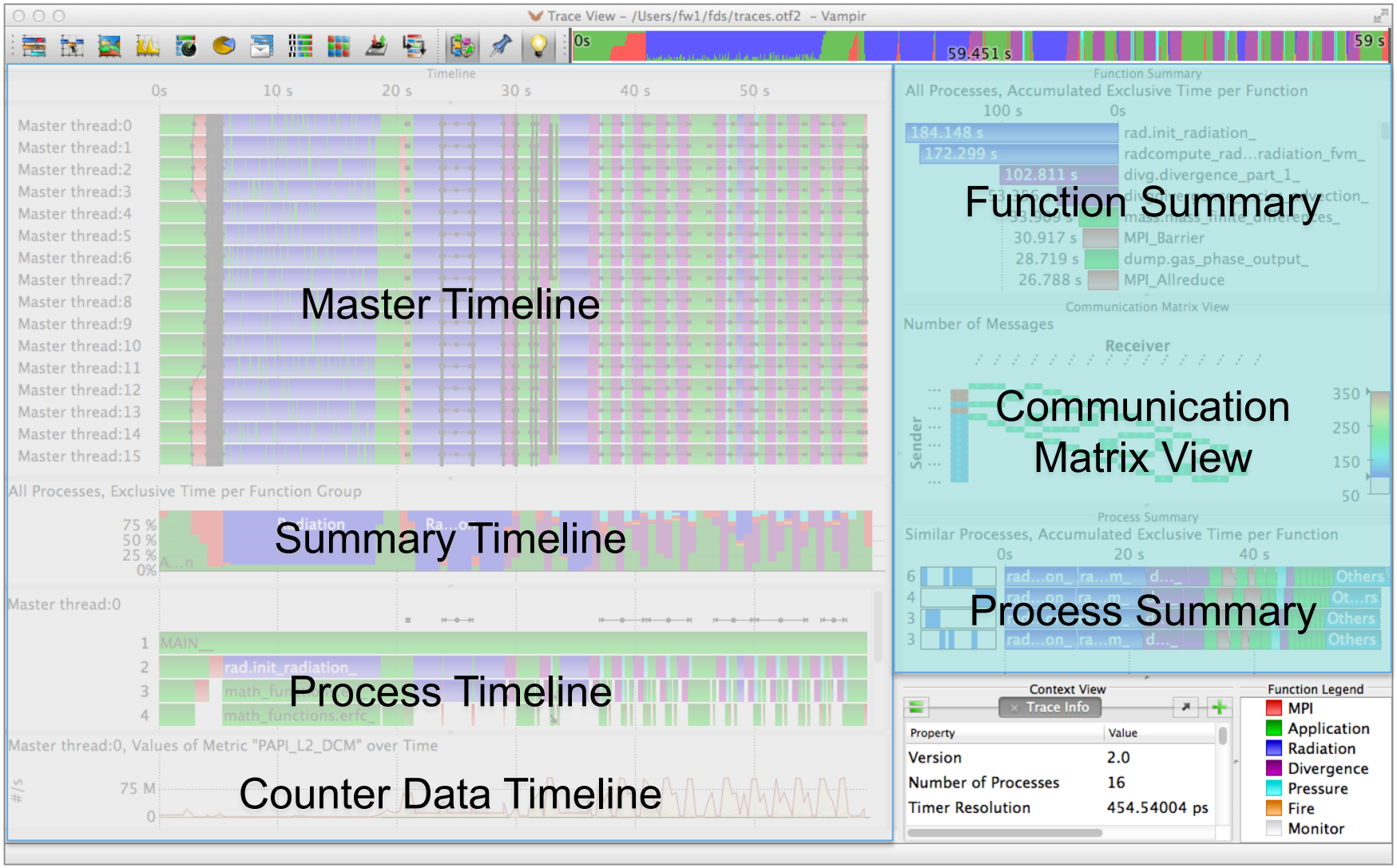

Message Summary


Communication Matrix View


I/O Summary

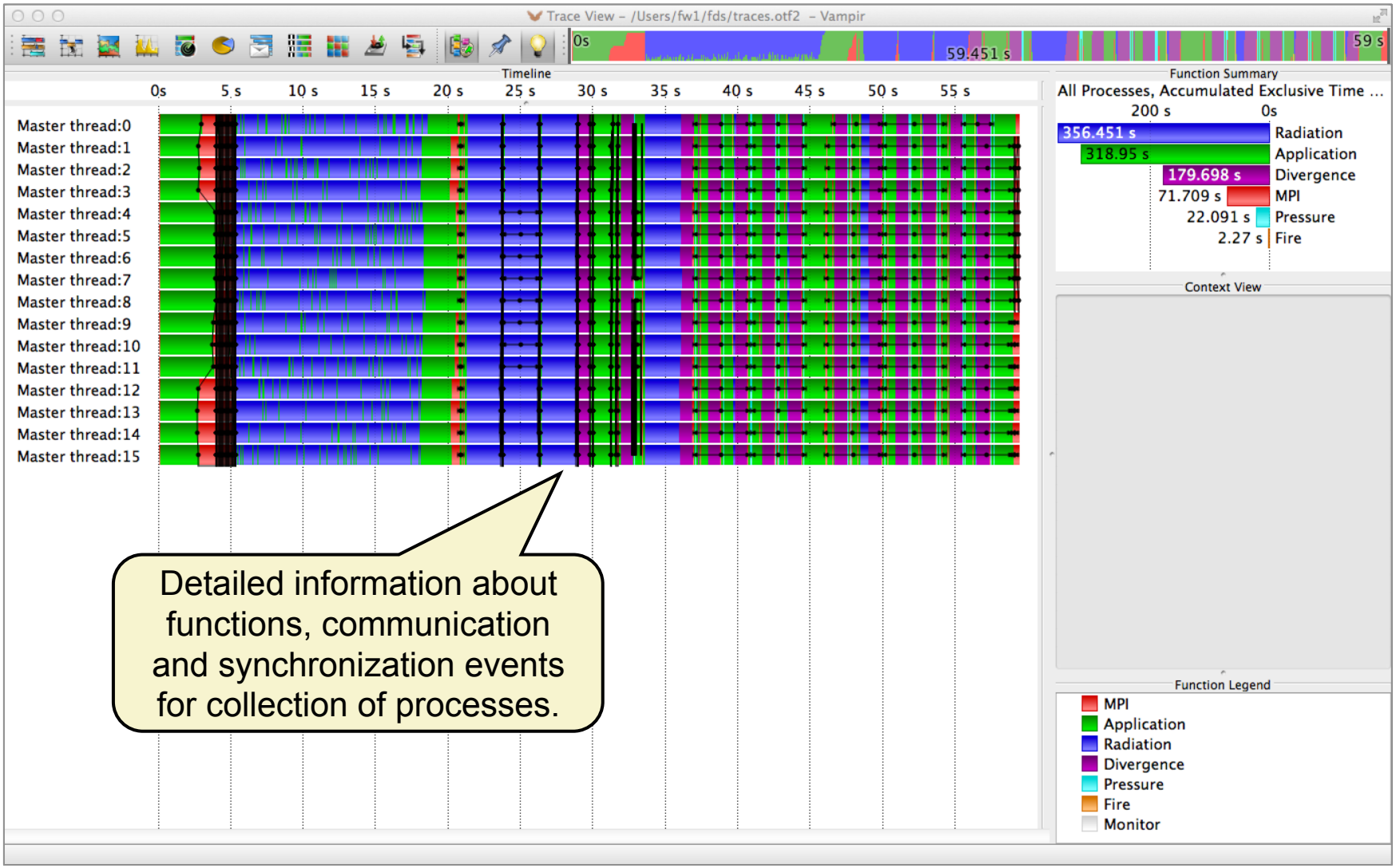
Vampir: Performance Charts

Trace visualization of FDS (Fire Dynamics Simulator)



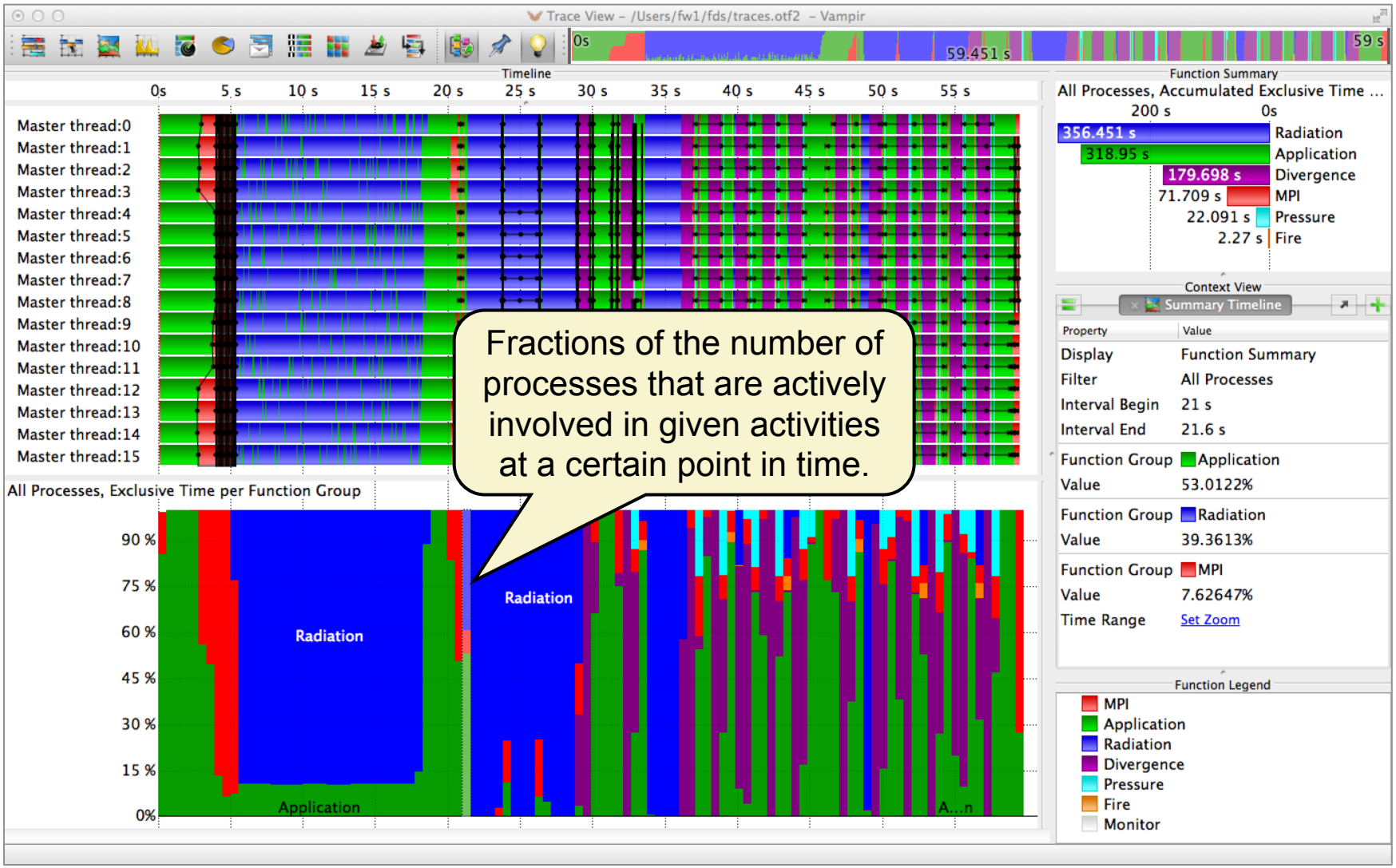
Vampir: Performance Charts

Master Timeline



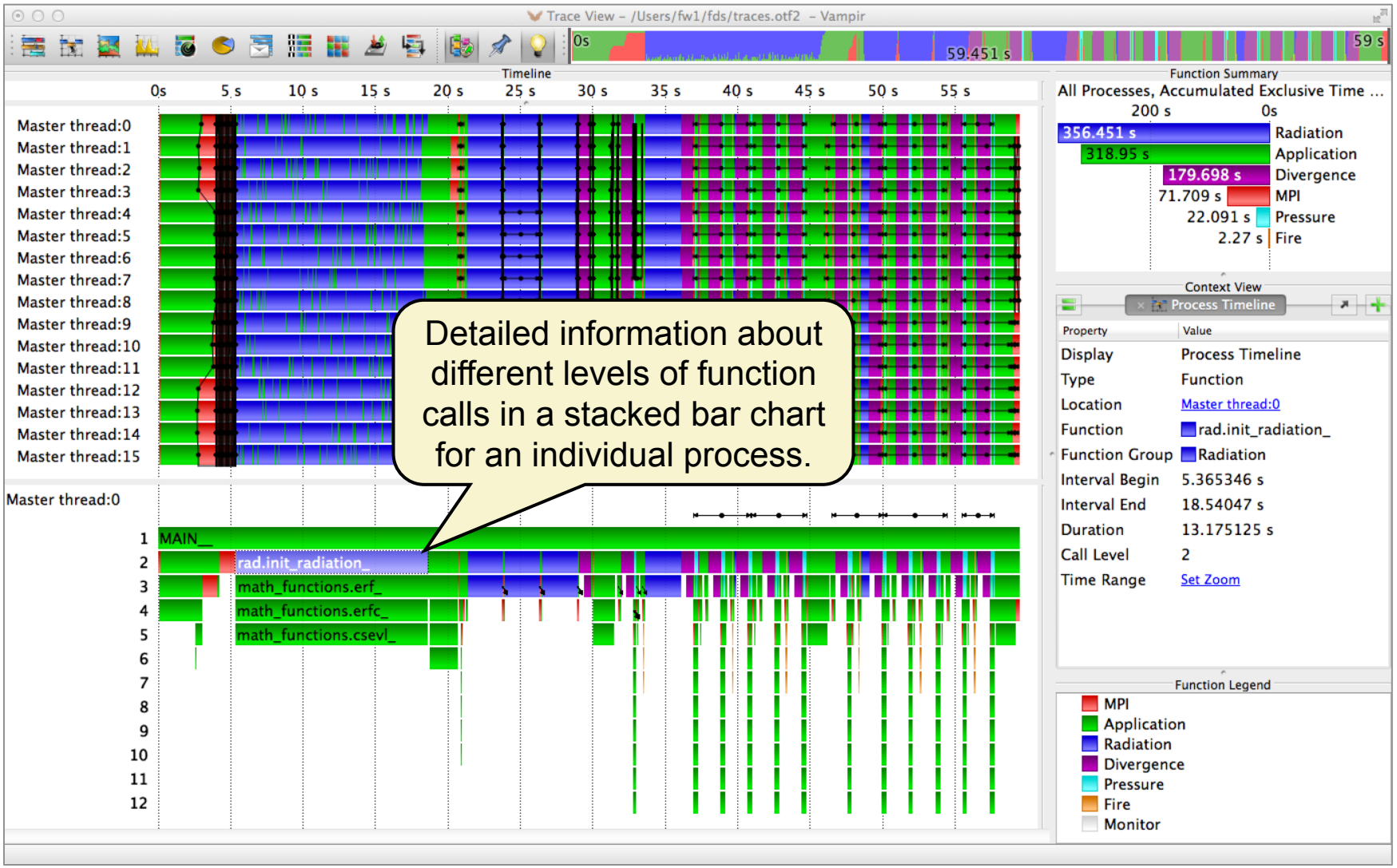
Vampir: Performance Charts

Summary Timeline



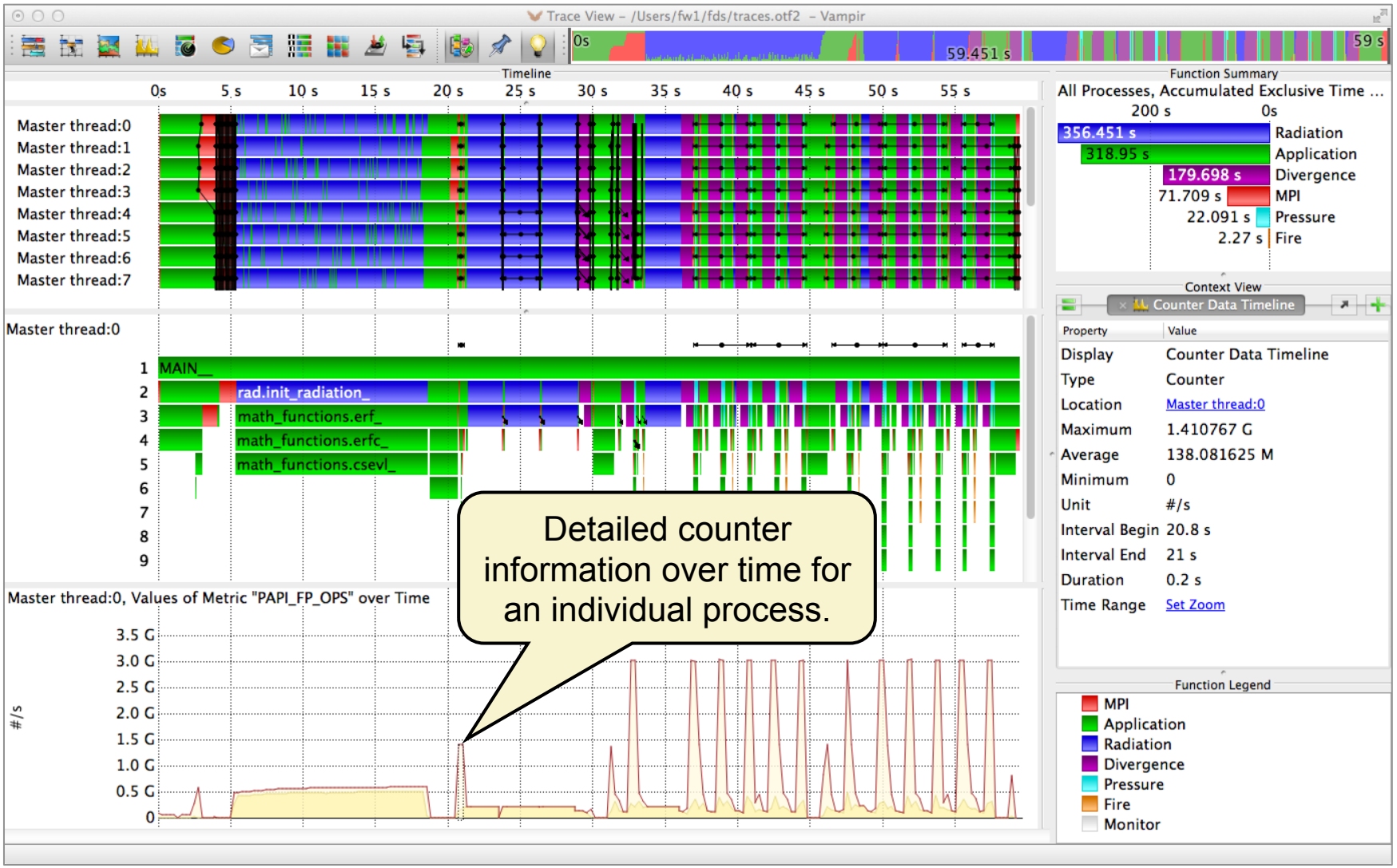
Vampir: Performance Charts

Process Timeline



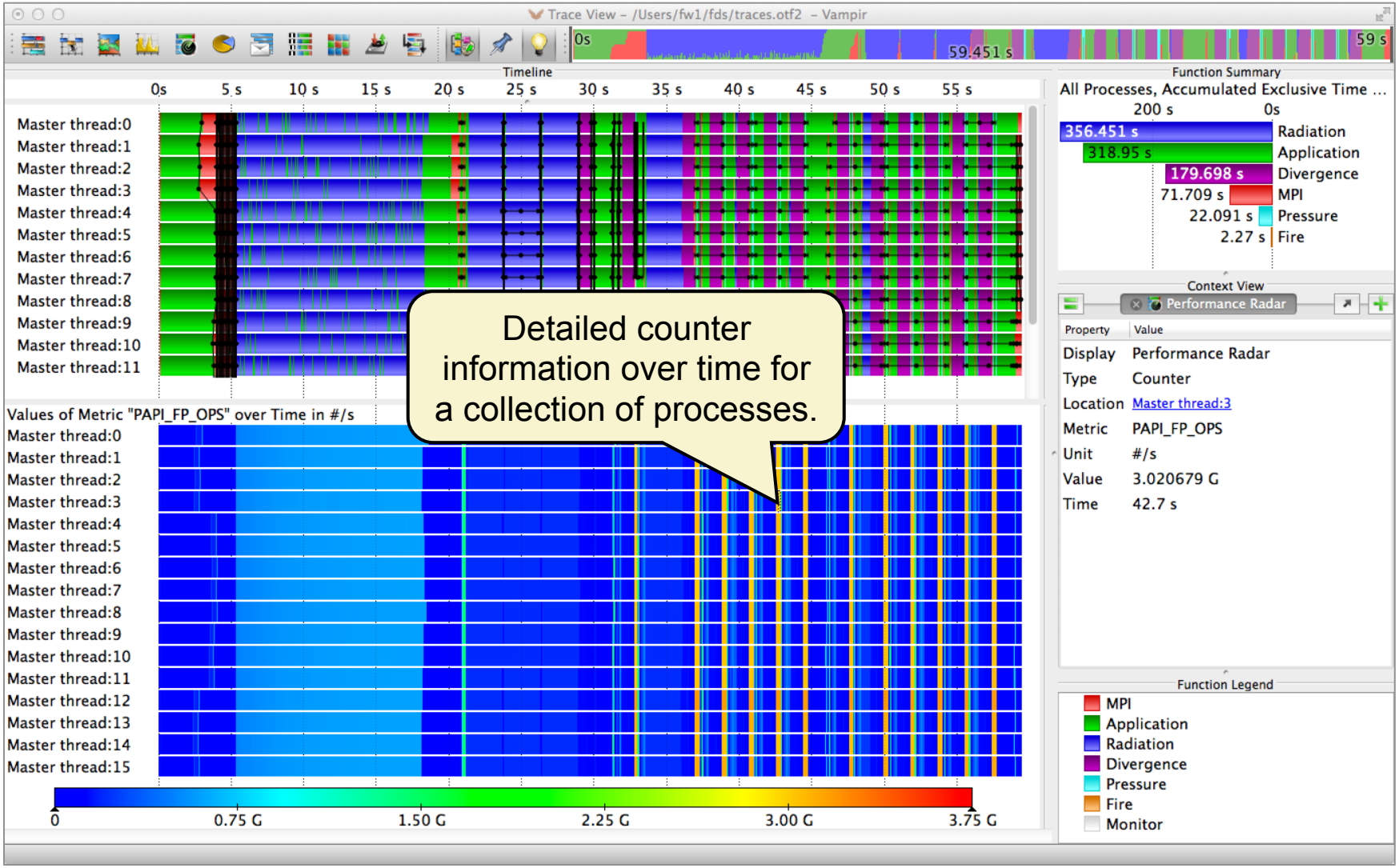
Vampir: Performance Charts

Counter Timeline



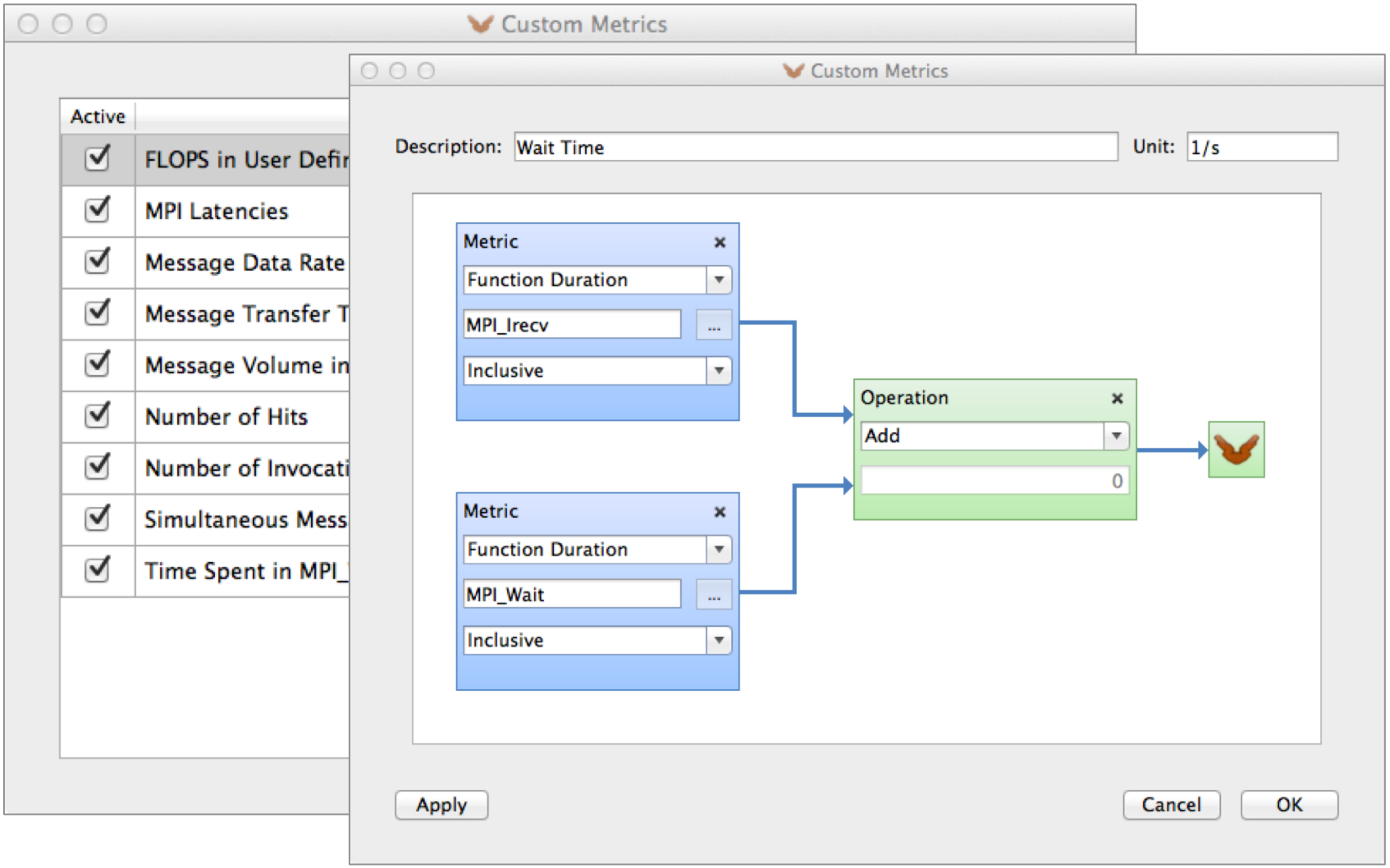
Vampir: Performance Charts

Performance Radar



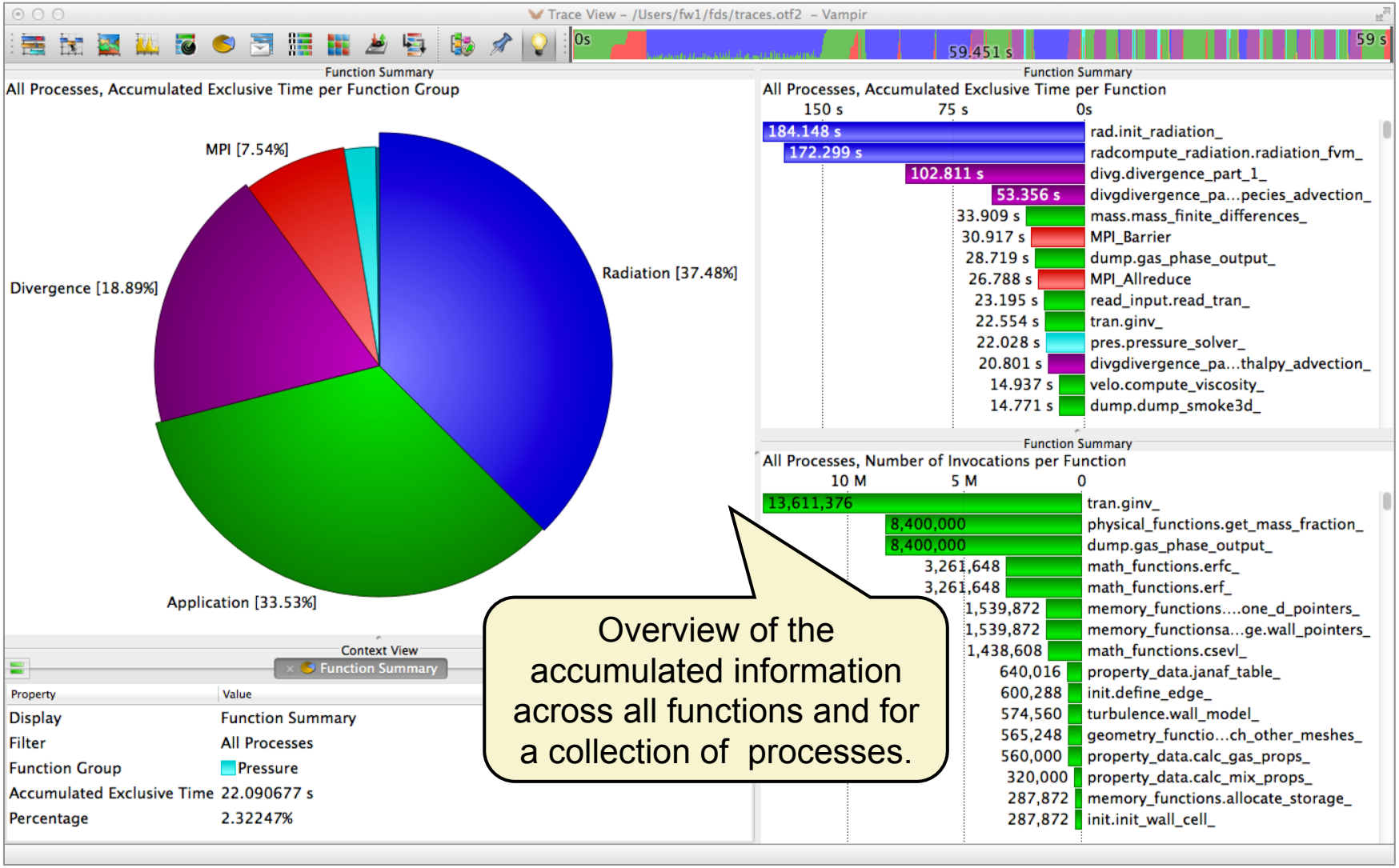
Vampir: Where Do the Metrics Come From?

Custom Metrics Built-In Editor



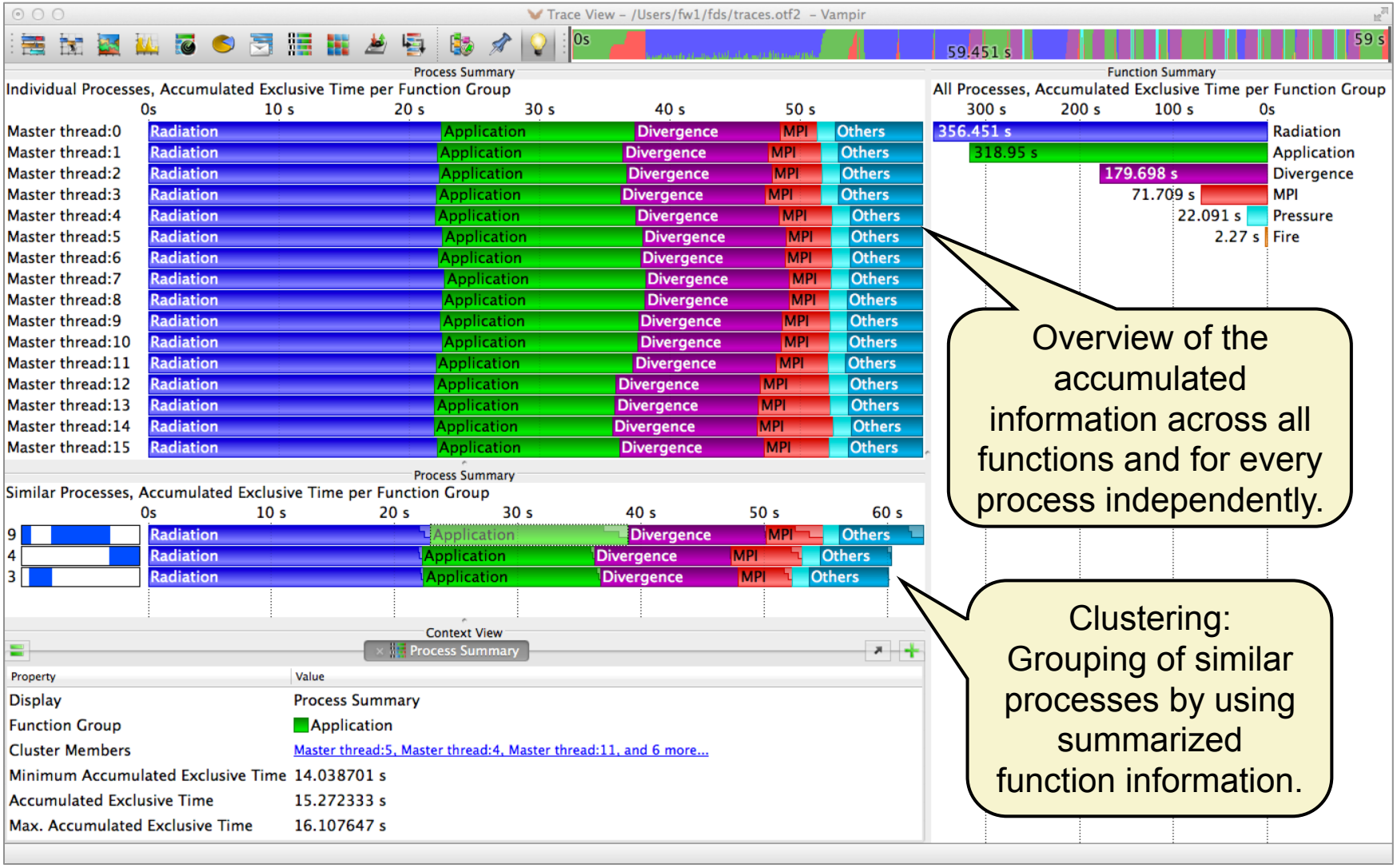
Vampir: Performance Charts

Function Summary



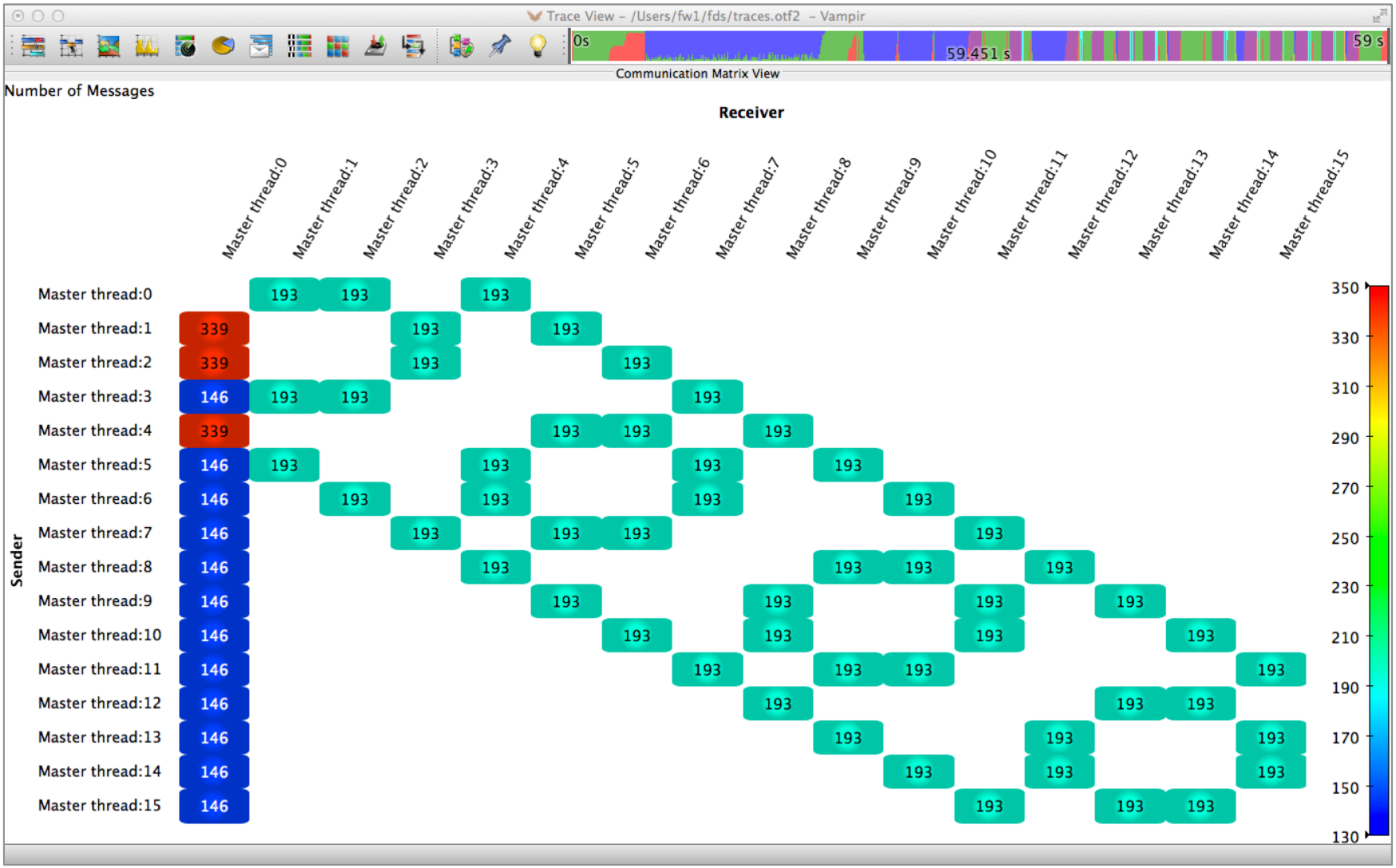
Vampir: Performance Charts

Process Summary



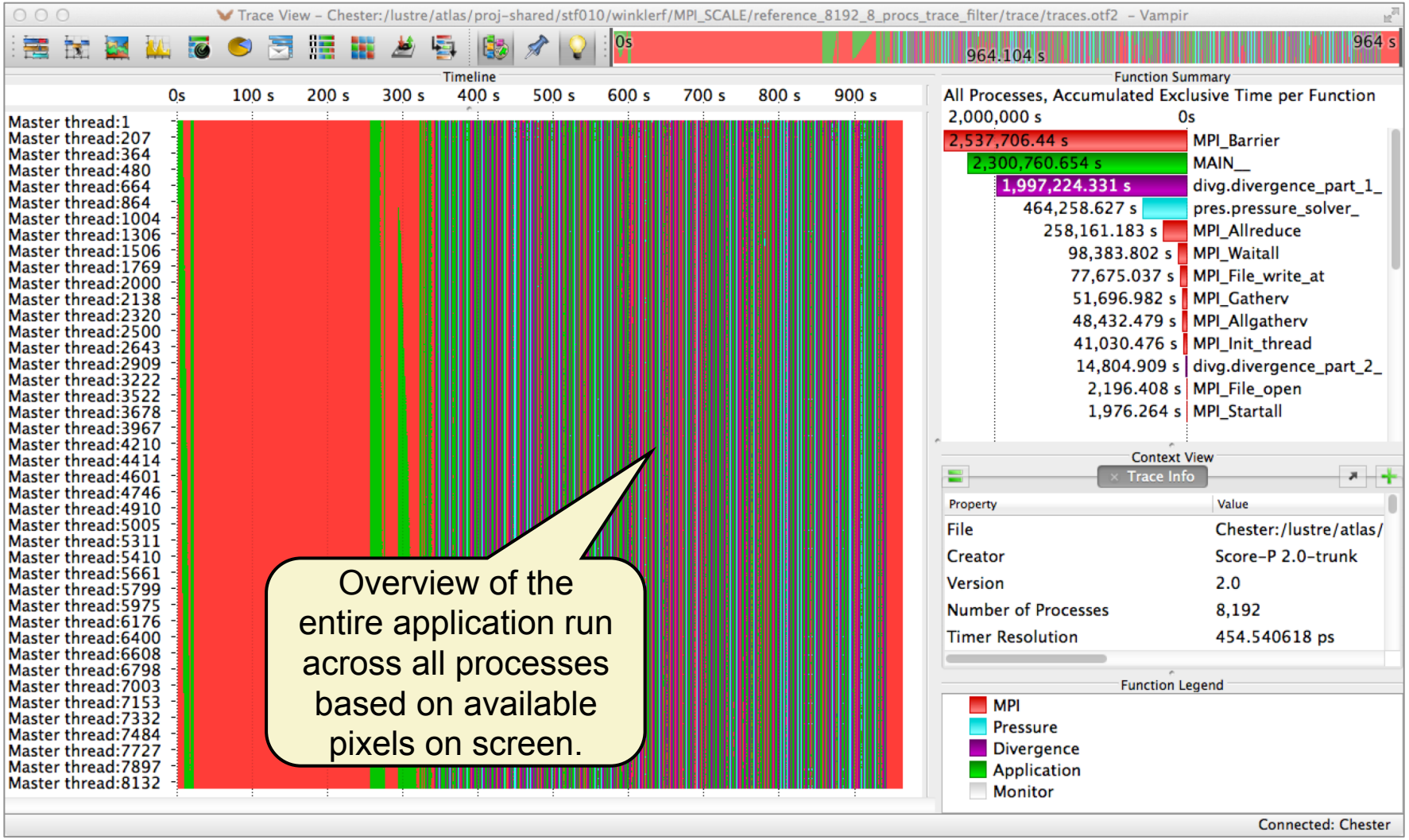
Vampir: Performance Charts

Communication Matrix View



Vampir at Scale: FDS with 8192 cores

Fit to chart height feature in Master Timeline



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Vampir & VampirServer

- Interactive trace visualization and analysis
- Intuitive browsing and zooming
- Scalable to large trace data sizes (20 TByte)
- Scalable to high parallelism (200000 processes)
- Vampir for Linux, Windows and Mac OS X

Score-P

- Common instrumentation and measurement infrastructure for various analysis tools
- Hides away complicated details
- Provides many options and switches for experts

The people behind Vampir, Score-P, and OTF2:

Active

Dr. Holger Brunst
Jens Doleschal
Ronald Geisler
Tobias Hilbrich
Matthias Jurenz
Dr. Andreas Knüpfer
Dr. Hartmut Mix
Prof. Wolfgang E. Nagel
Ronny Tschüter
Michael Wagner
Matthias Weber
Bert Wesarg
Thomas William
Johannes Ziegenbalg

Retired

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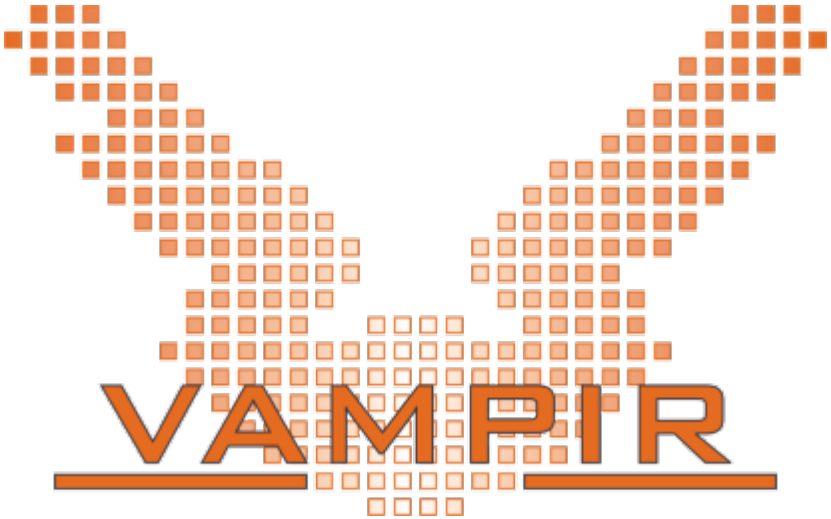


Vampir is available at http://www.vampir.eu

Vampir at Argonne NL: https://www.alcf.anl.gov/vampir

Get support via vampirsupport@zih.tu-dresden.de

Score-P: http://www.vi-hps.org/projects/score-p

Agenda

Welcome to the Vampir Tool Suite

- Parallel Performance Analysis Approaches
- Mission
- Event Trace Visualization

The Vampir Workflow

- Score-P: Instrumentation & Run-Time Measurement
- Vampir & VampirServer

Vampir Performance Charts

Vampir Demo

- Tracing and Visualizing NPB-MZ-MPI / BT → tonight

Conclusions

Vampir Demo: NPB-MZ-MPI / BT

- The NAS Parallel Benchmark suite (MPI+OpenMP version)
  - Available from: http://www.nas.nasa.gov/Software/NPB
  - 3 benchmarks in Fortran77 (bt-mz, lu-mz, sp-mz)
  - Configurable for various sizes & classes (S, W, A, B, C, D, E)
- Benchmark configuration for demo:
  - Benchmark name: **bt-mz**
  - Number of MPI processes: **NPROCS=4**
  - Benchmark class: **CLASS=W**
  - What does it do?
    - Solves a discretized version of unsteady, compressible Navier-Stokes equations in three spatial dimensions
    - Performs 200 time-steps on a regular 3-dimensional grid

NPB-MZ-MPI / BT Build

- Connect to Mira and add Vampir to the SoftEnv system

```
% vi .soft
  +vampir
% resoft
```

- Copy sources to working directory

```
% cp /projects/Tools/vampir/tutorial/NPB3.3-MZ-MPI.tar.gz .
% tar xzvf NPB3.3-MZ-MPI.tar.gz
% cd NPB3.3-MZ-MPI
```

- Compile the benchmark:

```
% make bt-mz CLASS=W NPROCS=4
cd BT-MZ; make CLASS=W NPROCS=4 VERSION=
make: Entering directory 'BT-MZ'
cd ../sys; cc  -o setparams setparams.c
../sys/setparams bt-mz 4 W
mpixlf77_r -c  -O3 -qsmp=omp -qextname=flush bt.f
 [...]
Built executable ../bin/bt-mz_W.4
make: Leaving directory 'BT-MZ'
```

NPB-MZ-MPI / BT Reference Execution

- Copy jobscript and launch as a hybrid MPI+OpenMP application

```
% cd bin
% cp ../jobscript/mira/run.sh .
% less run.sh
  export OMP_NUM_THREADS=4
  runjob -n 4 -p 4 --block $COBALT_PARTNAME --env-all : bt-mz_W.4
% qsub -A <projid> -t 10 -n 1 --mode script run.sh
% cat <jobid>.outpout
  NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark
  Number of zones:   4 x   4
  Iterations:  200   dt:   0.000800
  Number of active processes:     4
  Total number of threads:     16   (  4.0 threads/process)

  Time step    1
  Time step   20
   [...]
  Time step  200
  Verification Successful

  BT-MZ Benchmark Completed.
  Time in seconds = 2.27
```

Hint: save the benchmark output (or note the run time) to be able to refer to it later

NPB-MZ-MPI / BT Instrumentation

Edit config/make.def to adjust build configuration

- Modify specification of compiler/linker: MPIF77

```
#            SITE- AND/OR PLATFORM-SPECIFIC DEFINITIONS
#---------------------------------------------------------------------
# Items in this file may need to be changed for each platform.
#---------------------------------------------------------------------
...
#---------------------------------------------------------------------
# The Fortran compiler used for MPI programs
#---------------------------------------------------------------------
#MPIF77 = mpixlf77_r

# Alternative variants to perform instrumentation
...
MPIF77 = scorep mpixlf77_r

# This links MPI Fortran programs; usually the same as ${MPIF77}
FLINK   = $(MPIF77)
...
```

Uncomment the Score-P compiler wrapper specification

NPB-MZ-MPI / BT Instrumented Build

- Return to root directory and clean-up

```
% make clean
```

- Re-build executable using Score-P compiler wrapper

```
% make bt-mz CLASS=W NPROCS=4
cd BT-MZ; make CLASS=W NPROCS=4 VERSION=
make: Entering directory 'BT-MZ'
cd ../sys; cc  -o setparams setparams.c
../sys/setparams bt-mz 4 W
scorep mpixlf77_r -c  -O3 -qsmp=omp -qextname=flush bt.f
 [...]
cd ../common; scorep mpixlf77_r -c -O3 -qsmp=omp -qextname=flush timers.f
scorep mpixlf77_r -O3 -qsmp=omp -qextname=flush -o ../bin.scorep/bt-mz_W.4
bt.o initialize.o exact_solution.o exact_rhs.o set_constants.o \
adi.o rhs.o zone_setup.o x_solve.o y_solve.o exch_qbc.o \
solve_subs.o z_solve.o add.o error.o verify.o mpi_setup.o \
../common/print_results.o ../common/timers.o
Built executable ../bin.scorep/bt-mz_W.4
make: Leaving directory 'BT-MZ'
```

NPB-MZ-MPI / BT Summary Measurement Collection

- Change to the directory containing the new executable before running it and adjust configuration

```
% cd bin.scorep
% cp ../jobscript/mira/* .
% less run_profile.sh
  export SCOREP_ENABLE_TRACING=false
  export SCOREP_ENABLE_PROFLING=true
  export SCOREP_TOTAL_MEMORY=100M
  export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_W_4x4_sum
  export OMP_NUM_THREADS=4
  runjob -n 4 -p 4 --block $COBALT_PARTNAME --env-all : bt-mz_W.4
% qsub -A <projid> -t 10 -n 1 --mode script run_profile.sh
% cat <jobid>.outpout
  NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark
  Number of zones:   4 x   4
    [...]
  Time step  200
  Verification Successful

  BT-MZ Benchmark Completed.
  Time in seconds = 12.74
```

NPB-MZ-MPI / BT Summary Analysis Report Examination

- Creates experiment directory ./scorep_bt-mz_W_4x4_sum containing
  - A record of the measurement configuration (scorep.cfg)
  - The analysis report that was collated after measurement (profile.cubex)

```
% ls
...  scorep_bt-mz_W_4x4_sum
% ls scorep_bt-mz_W_4x4_sum
profile.cubex  scorep.cfg
```

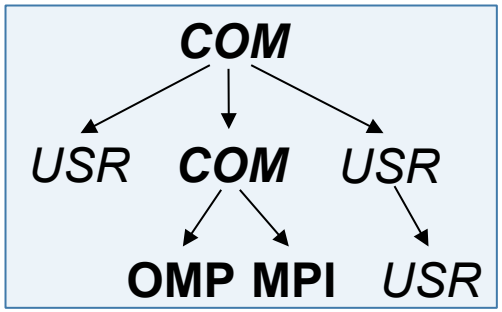
NPB-MZ-MPI / BT Summary Analysis Result Scoring

- Report scoring as textual output

```
% scorep-score scorep_bt-mz_W_4x4_sum/profile.cubex
Estimated aggregate size of event trace:                   909683062 bytes
Estimated requirements for largest trace buffer (max_tbc): 235123428 bytes
(hint: When tracing set SCOREP_TOTAL_MEMORY > max_tbc to avoid intermediate flushes
 or reduce requirements using file listing names of USR regions to be filtered.)

flt type         max_tbc         time      % region
     ALL       235123428       419.92  100.0 ALL
     USR       232516724        78.19   18.6 USR
     OMP         5973040       121.45   28.9 OMP
     COM          314710         1.38    0.3 COM
     MPI           88898       218.90   52.1 MPI
```

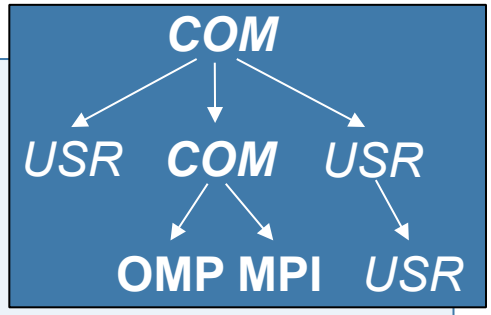
868 MB total memory
224 MB per rank!

- Region/callpath classification
  - MPI (pure MPI library functions)
  - OMP (pure OpenMP functions/regions)
  - USR (user-level source local computation)
  - COM (“combined” USR + OpenMP/MPI)
  - ANY/ALL (aggregate of all region types)



NPB-MZ-MPI / BT Summary Analysis Report Breakdown

- Score report breakdown by region




```
% scorep-score -r scorep_bt-mz_W_4x4_sum/profile.cubex
 [...]
flt type          max_tbc         time      % region
                 35123428       419.92   100.0 ALL
                  2516724        78.19    18.6 USR
                  5973040       121.45    28.9 OMP
                   314710         1.38     0.3 COM
                    18898       218.90    52.1 MPI

     USR         72578286        18.80     4.5 matmul_sub
     USR         72578286        20.41     4.9 matvec_sub
     USR         72578286        33.47     8.0 binvcrhs
     USR          6747972         2.91     0.7 lhsinit
     USR          6747972         1.88     0.4 binvrhs
     USR          2939464         0.71     0.2 exact_solution
     OMP           369840         0.14     0.0 !$omp parallel @exch_qbc…
     OMP           369840         0.13     0.0 !$omp parallel @exch_qbc…
     OMP           369840         0.13     0.0 !$omp parallel @exch_qbc…
 [...]
```

More than 223 MB just for these 6 regions

NPB-MZ-MPI / BT Summary Analysis Report Filtering

- Report scoring with prospective filter listing 6 USR regions

```
% cat ../config/scorep.filt
SCOREP_REGION_NAMES_BEGIN EXCLUDE
binvcrhs*
matmul_sub*
matvec_sub*
exact_solution*
binvrhs*
lhs*init*
timer_*

% scorep-score -f ../config/scorep.filt scorep_bt-mz_W_4x4_sum/profile.cubex

Estimated aggregate size of event trace:                   20482398 bytes
Estimated requirements for largest trace buffer (max_tbc): 6377242 bytes
(hint: When tracing set SCOREP_TOTAL_MEMORY > max_tbc to avoid intermediate flushes
 or reduce requirements using file listing names of USR regions to be filte
```

20 MB of memory in total,
6 MB per rank!

Advanced Measurement Configuration: Metrics

- Available PAPI metrics
  - Preset events: common set of events deemed relevant and useful for application performance tuning
    - Abstraction from specific hardware performance counters, mapping onto available events done by PAPI internally

```
% qsub -A <projid> -n 1 --mode c1 --proccount 1 -t 10 \
  /soft/perftools/papi/bin/papi_avail
% cat <jobid>.outpout
```

  - Native events: set of all events that are available on the CPU (**platform dependent**)

```
% qsub -A <projid> -n 1 --mode c1 --proccount 1 -t 10 \
  /soft/perftools/papi/bin/papi_native_avail
% cat <jobid>.outpout
```

Note:
Due to hardware restrictions
- number of concurrently recorded events is limited
- there may be invalid combinations of concurrently recorded events

NPB-MZ-MPI / BT Trace Measurement Collection...

- Re-run the application using the tracing mode of Score-P

```
% cd bin.scorep
% less run_trace.sh
  export SCOREP_ENABLE_TRACING=true
  export SCOREP_ENABLE_PROFLING=false
  export SCOREP_FILTERING_FILE=../config/scorep.filt
  export SCOREP_TOTAL_MEMORY=100M
  export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_W_4x4_trace
  export SCOREP_METRIC_PAPI=PAPI_FP_OPS,PAPI_L1_DCM
  export OMP_NUM_THREADS=4
  runjob -n 4 -p 4 --block $COBALT_PARTNAME --env-all : bt-mz_W.4
% qsub -A <projid> -t 10 -n 1 --mode script run_trace.sh
% cat <jobid>.outpout
  NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark
  Number of zones:   4 x   4
    [...]
  Time step  200
  Verification Successful

  BT-MZ Benchmark Completed.
  Time in seconds = 3.49
```

NPB-MZ-MPI / BT Interactive Trace Analysis with Vampir

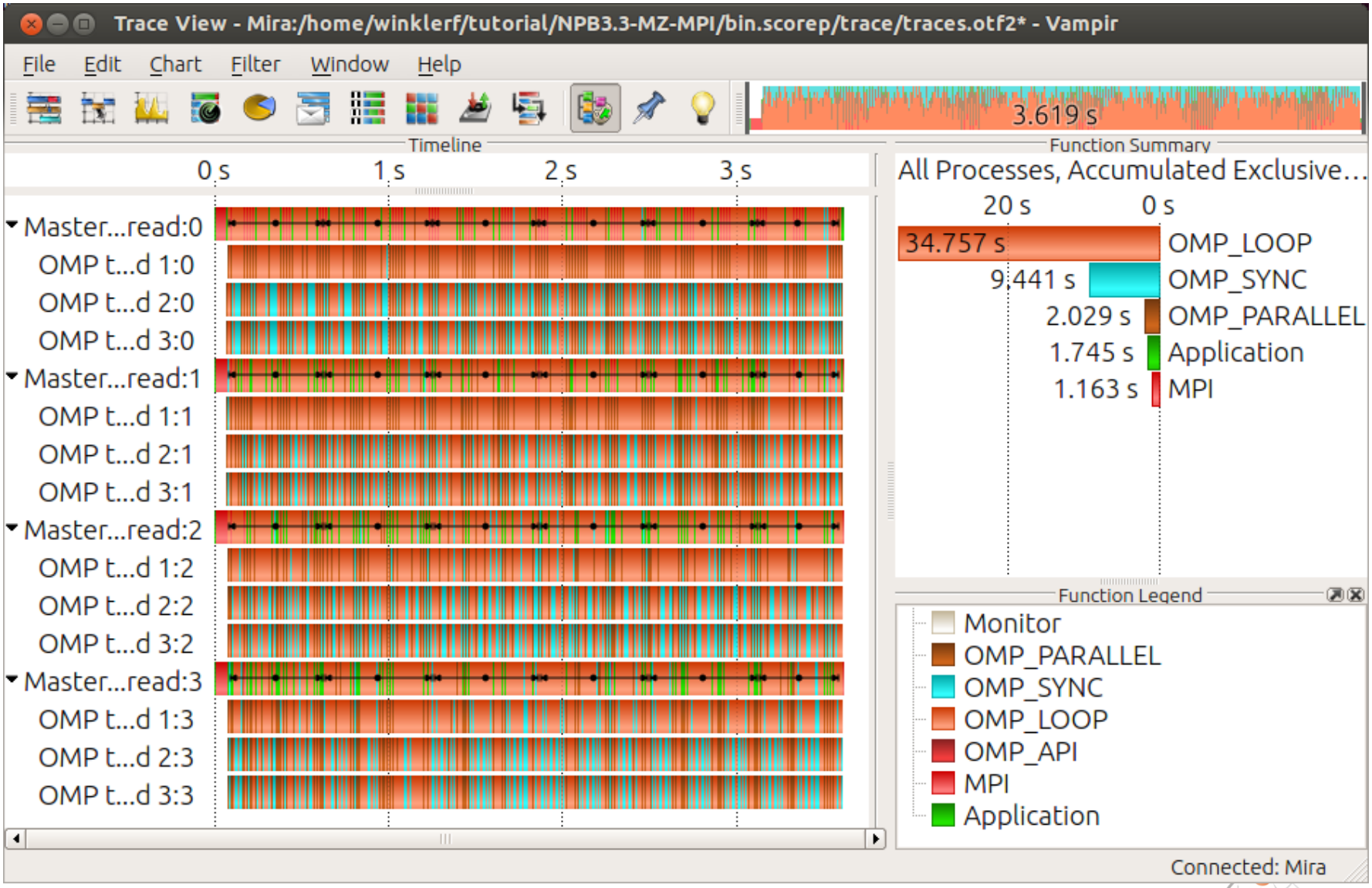
- Download and install VampirClient for target platform

```
# Linux 64bit
$ scp <user>@mira.alcf.anl.gov:/projects/Tools/vampir/vampir-gui/vampir-*-x86_64.bin .
$ scp <user>@mira.alcf.anl.gov:/projects/Tools/vampir/vampir-gui/vampir-remote.license .
$ bash ./vampir-*.bin
```

- Start VampirServer and follow output instructions

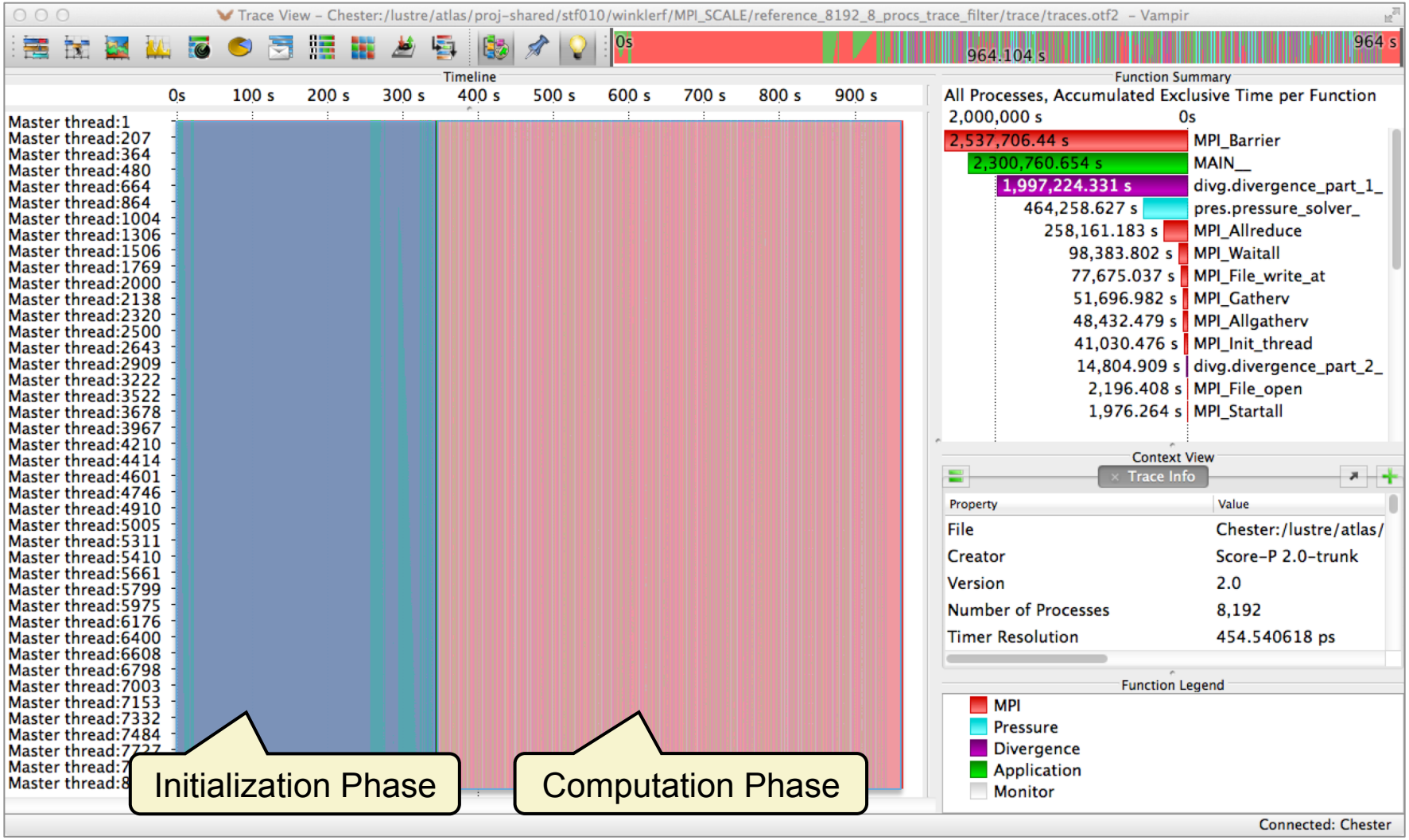
```
$ vampirserver start -a <projid> -n 16
Launching VampirServer...
Submitting PBS batch job (this might take a while)...
** Project 'tools'; job rerouted to queue 'prod-short'
VampirServer 8.2.1  (r8876)
Licensed to Mira Performance Boot Camp 2014
Running 15 analysis processes... (abort with vampirserver stop 28448)
VampirServer <28448> listens on: Q2G-I5-J01.mira.i2b:30066

Please run:
    ssh -L 30001:Q2G-I5-J01.mira.i2b:30066 <user>@mira.alcf.anl.gov
on your desktop to create ssh tunnel to VampirServer.

Start vampir on your desktop and choose 'Open Other -> Remote File'
    Description: mira,   Server: localhost,   Port: 30001
    Authentication: None
    Connection type: Socket
    Ignore "More Options"
```

NPB-MZ-MPI / BT Trace Analysis with Vampir



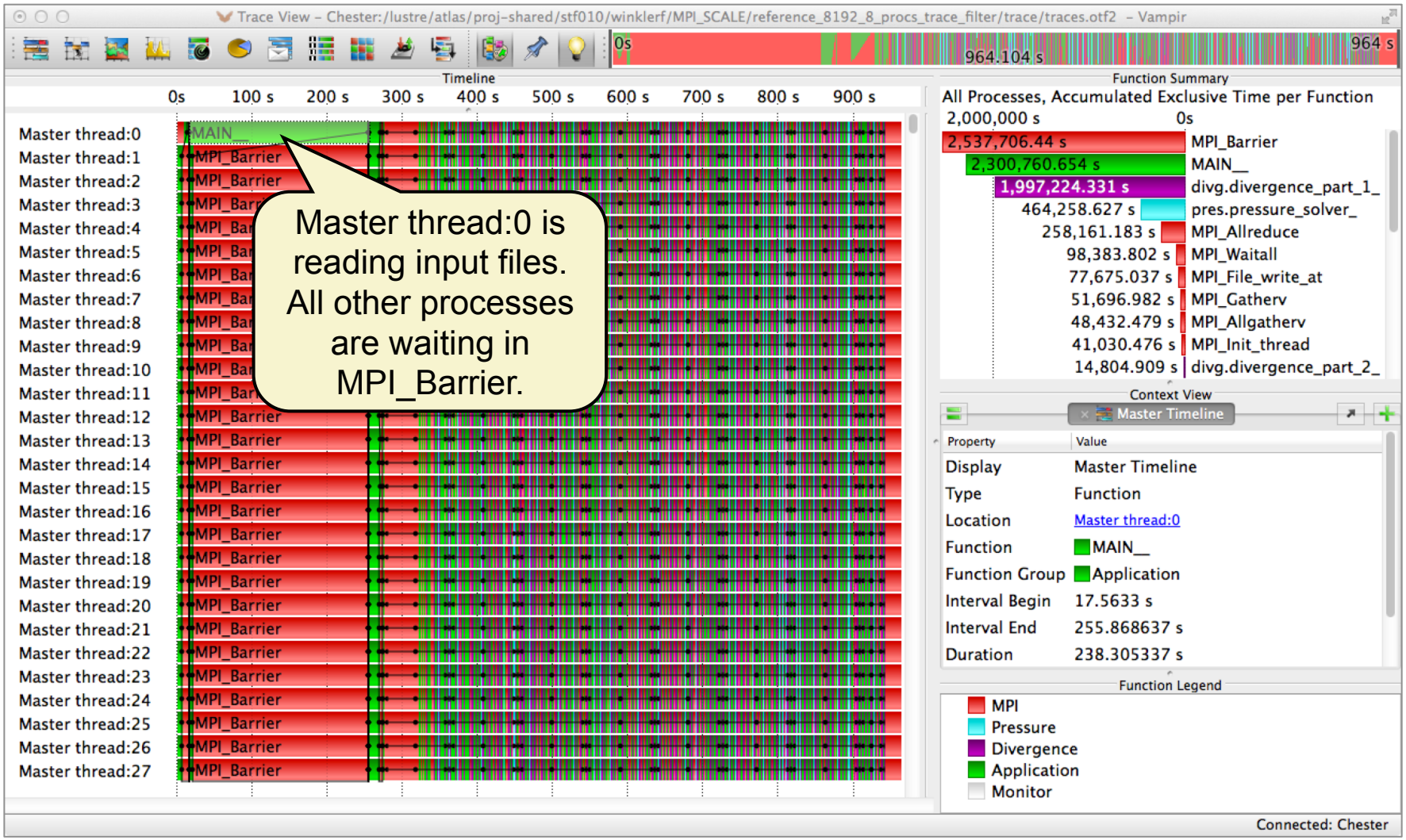
Vampir Bonus: Case Study of FDS

- Indentification of program phases



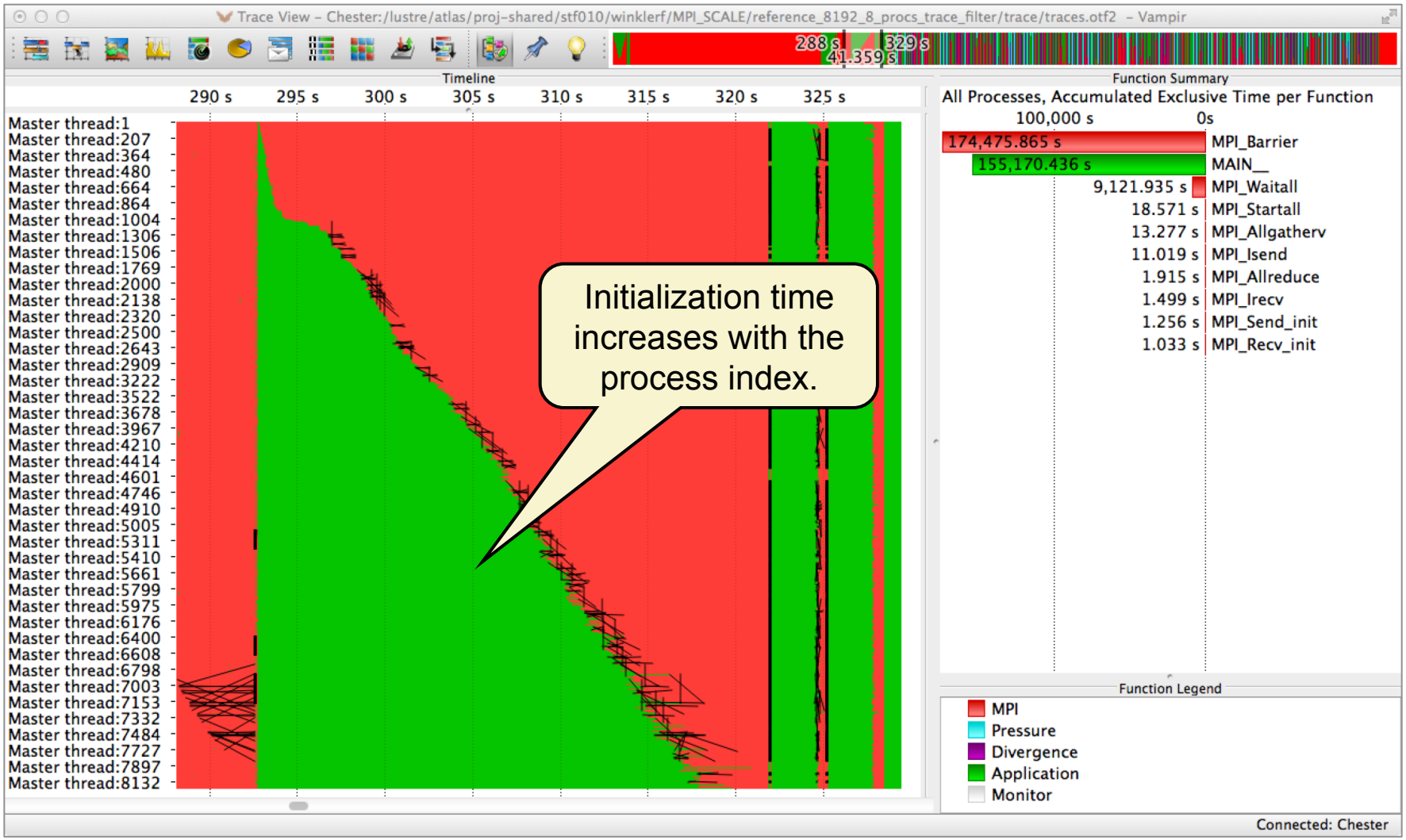
Vampir Bonus: Case Study of FDS

- Load imbalance in initialization phase



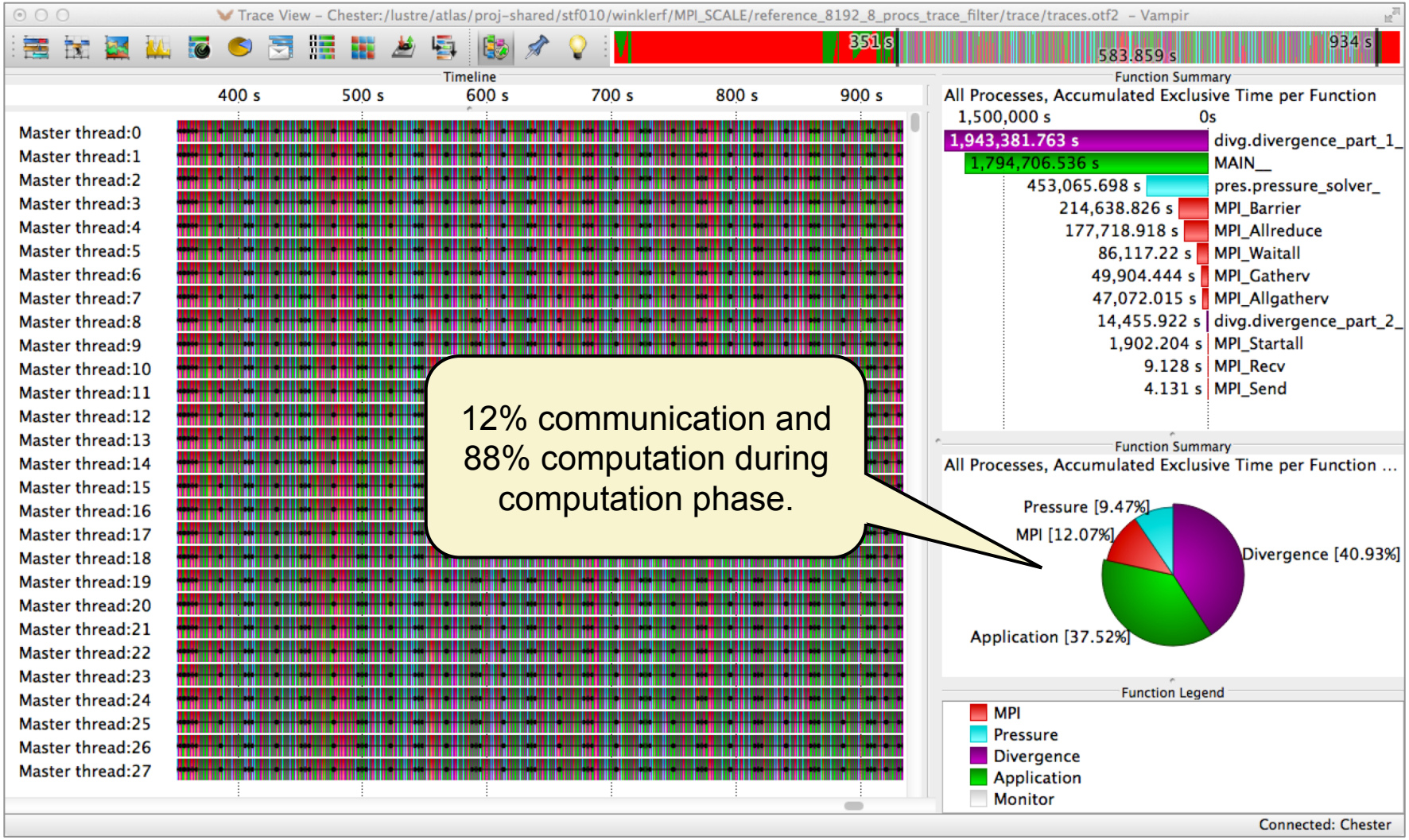
Vampir Bonus: Case Study of FDS

- Load imbalance in initialization phase (2)



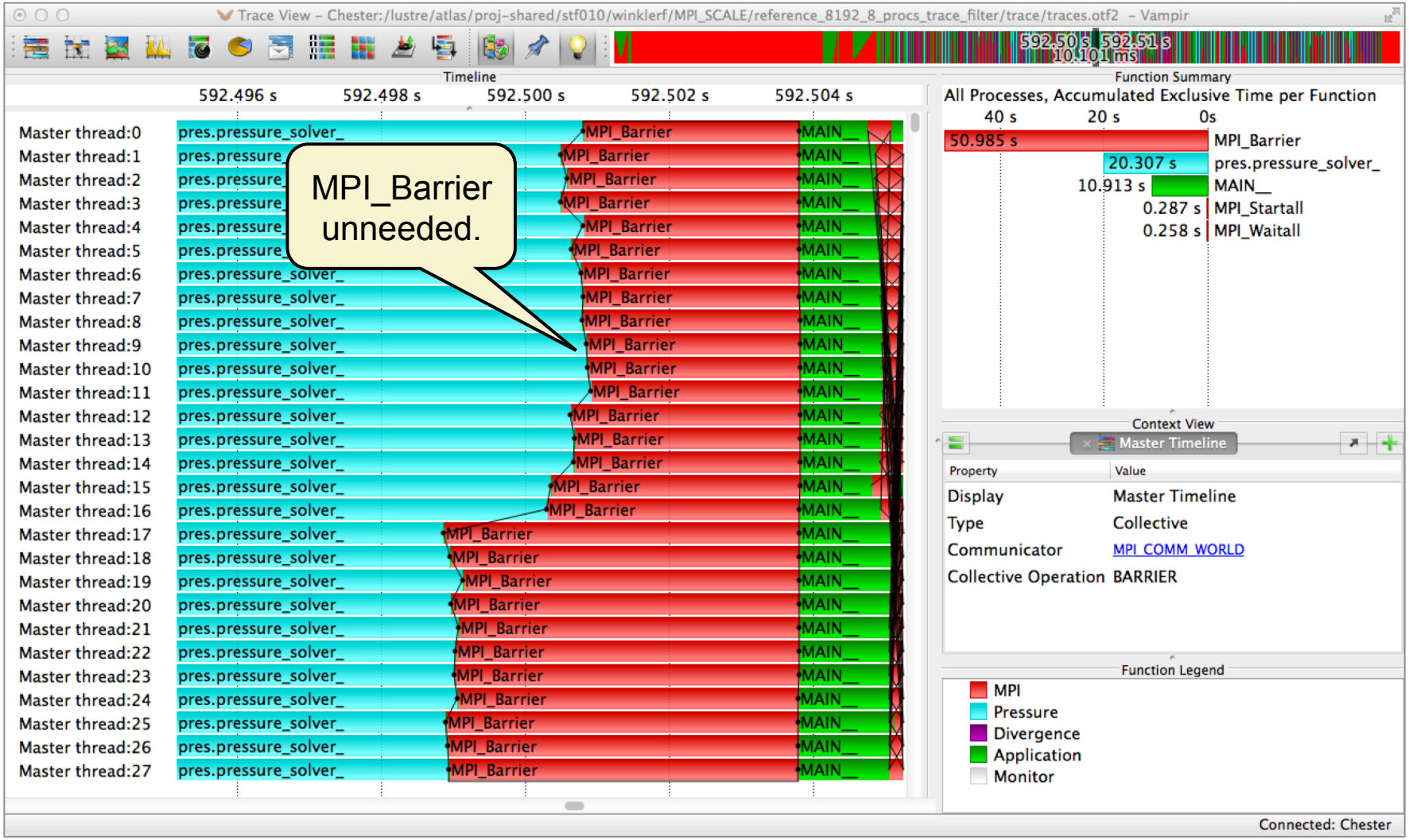
Vampir Bonus: Case Study of FDS

- Computation phase



Vampir Bonus: Case Study of FDS

- Unnecessary synchronization in computation phase



Vampir Bonus: Case Study of FDS

- Inefficient cache usage in computation phase