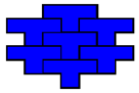
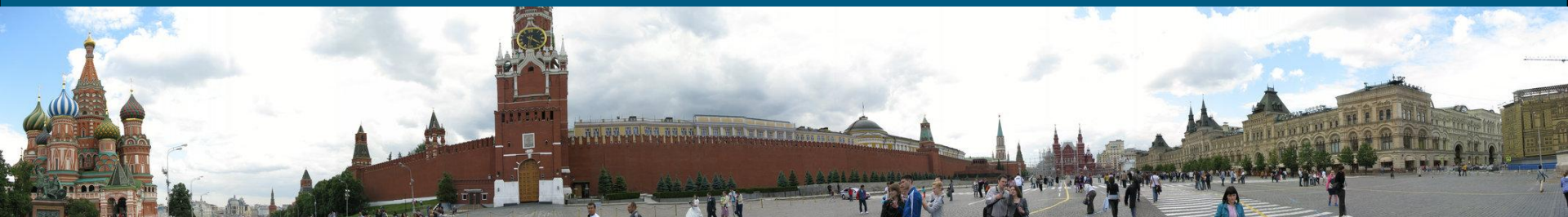






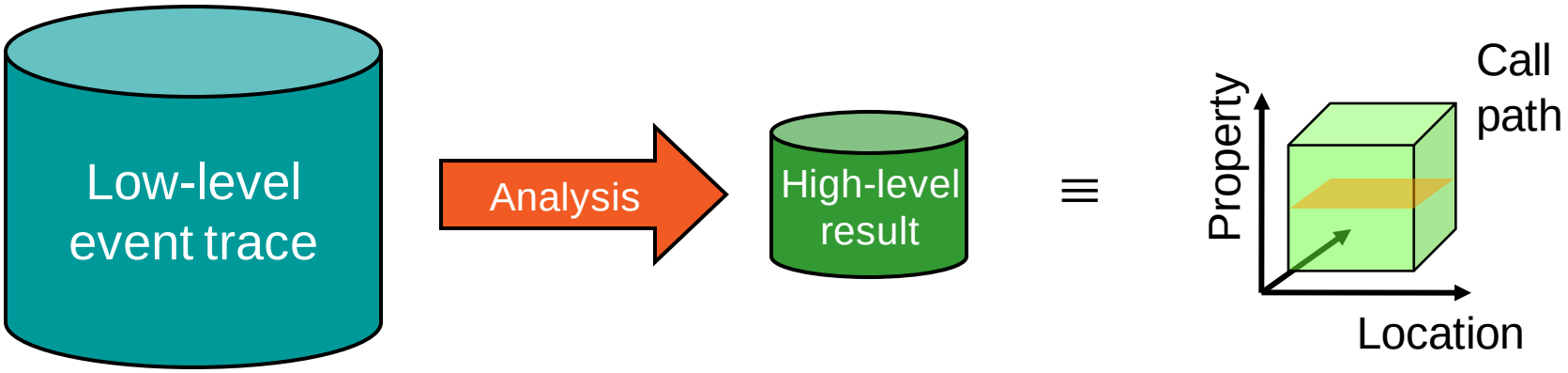
Automatic Trace Analysis with Scalasca

Bernd Mohr, Jülich Supercomputing Centre



Automatic Trace Analysis

- Idea
  - Automatic search for patterns of inefficient behavior
  - Classification of behavior & quantification of significance



  - Guaranteed to cover the entire event trace
  - Quicker than manual/visual trace analysis
  - Parallel replay analysis exploits memory & processors to deliver scalability

The Scalasca Project: Overview

- Project started in 2006
  - Initial funding by Helmholtz Initiative & Networking Fund
  - Many follow-up projects

- Follow-up to pioneering KOJAK project (started 1998)
  - Automatic pattern-based trace analysis

- Now joint development of
  - Jülich Supercomputing Centre

  - German Research School for Simulation Sciences

The Scalasca Project: Objective

- Development of a **scalable** performance analysis toolset
- Specifically targeting **large-scale** parallel applications
  - such as those running on IBM BlueGene or Cray XT with 10,000s to 100,000s of processes

- Latest release in July 2012: Scalasca v1.4.2
- Here: Scalasca v2.0α with Score-P support

  (no release date yet, available on request)

Scalasca 1.4 Features

- Open source, New BSD license
- Portable
  - BG/Q, BG/P, BG/L, IBM SP & blade clusters, Cray XT + XK, NEC SX, Solaris & Linux clusters, ...
- Supports parallel programming paradigms & languages
  - MPI, OpenMP & hybrid OpenMP/MPI
  - Fortran, C, C++
- Integrated measurement & analysis toolset
  - Runtime summarization (aka profiling)
  - Automatic event trace analysis

- Uses Scalasca internal EPILOG trace and CUBE3 formats

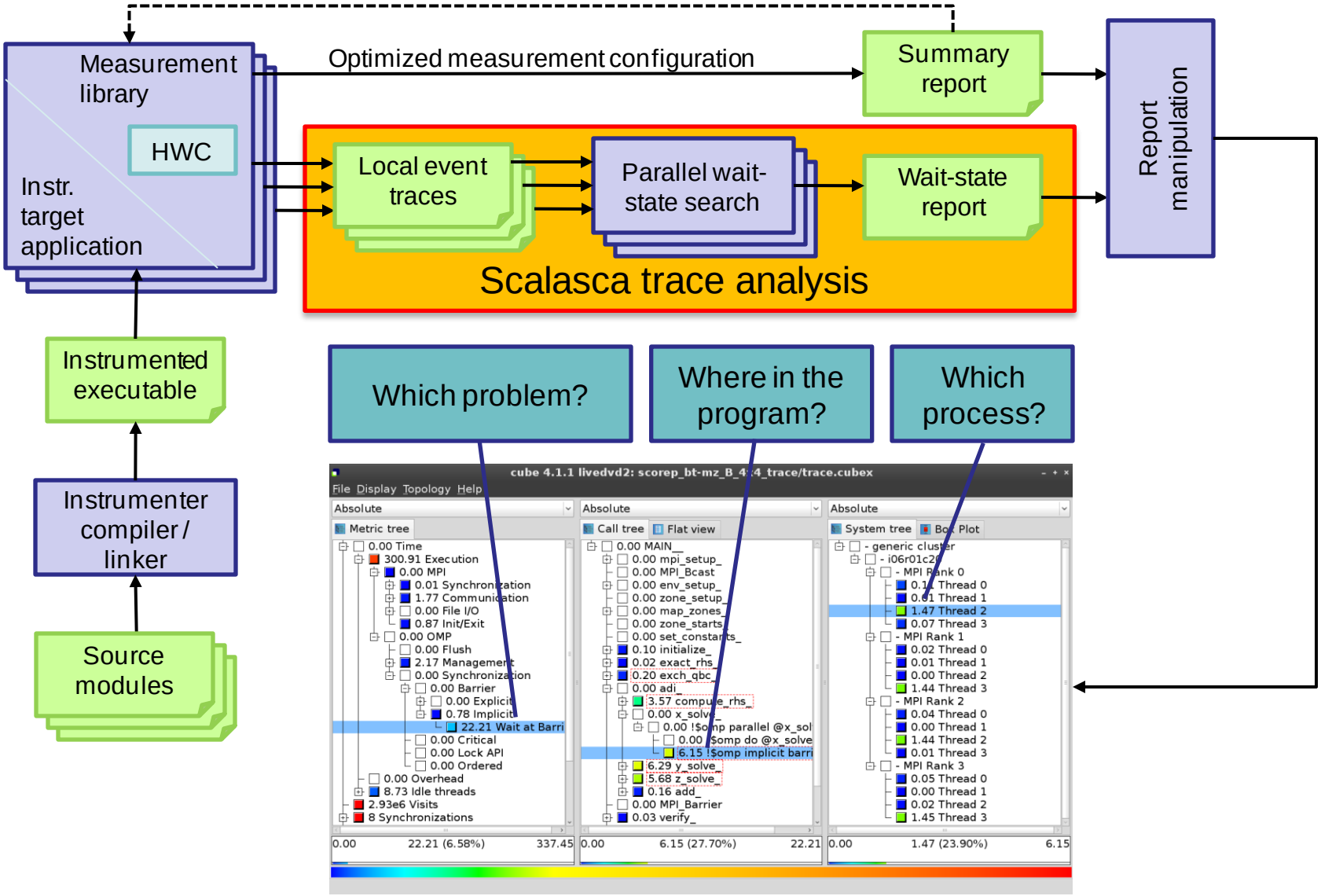
Scalasca 2.0α Features

- Open source, New BSD license
- Still aims to be portable
  - But not widely tested yet

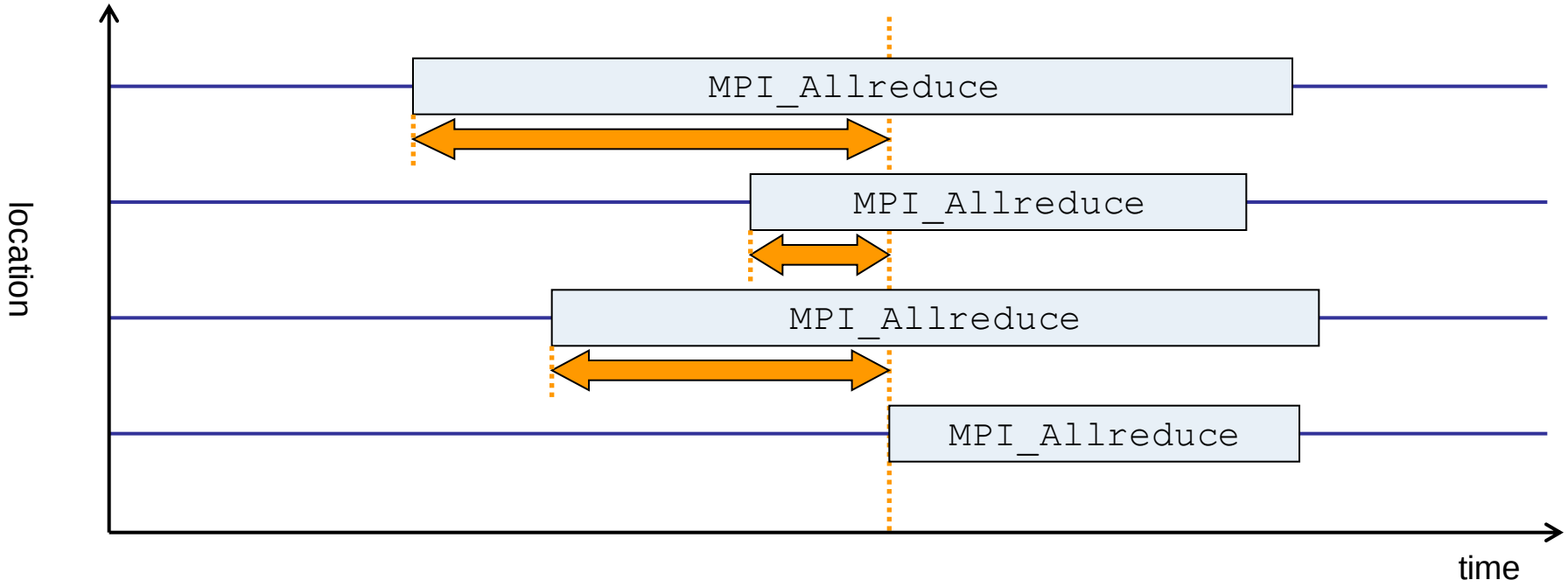
- Scalasca 1.4 measurement system superseded by Score-P
  - Scalasca 2.0 focuses on trace-based analyses only

- Supports common data formats
  - Reads event traces in OTF2 format
  - Writes analysis results in CUBE4 format

Scalasca Workflow

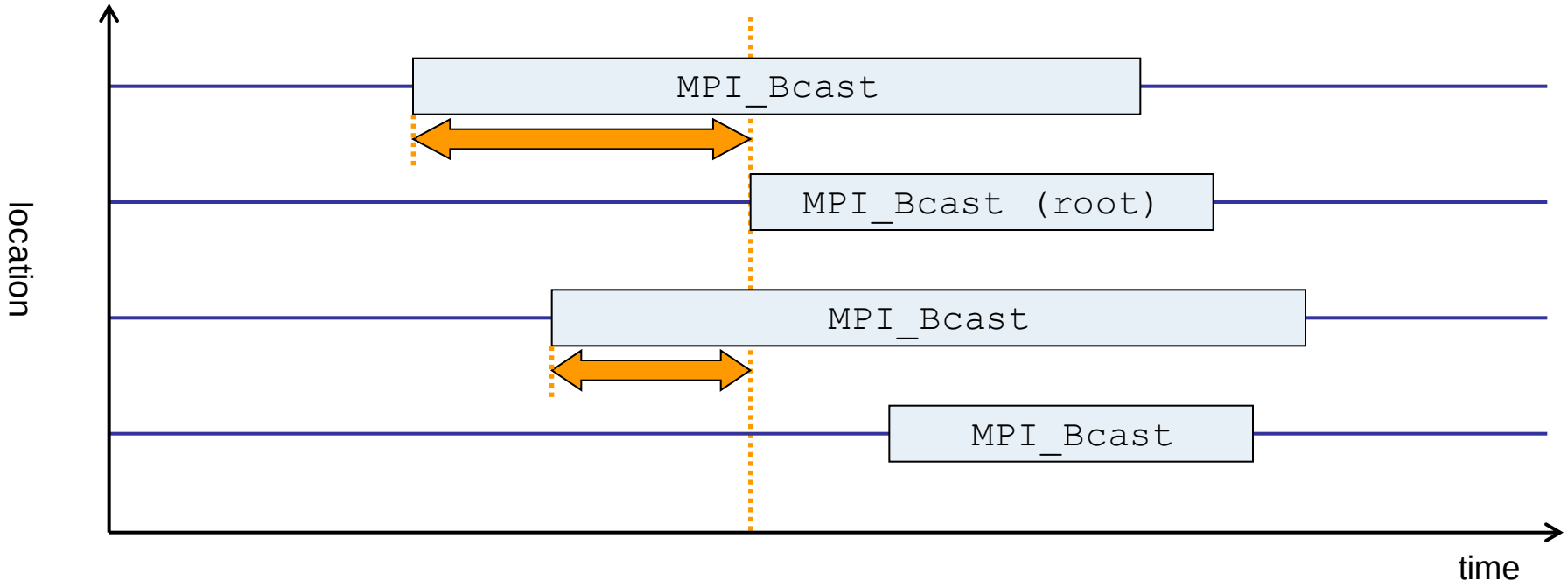


Example: Wait at NxN



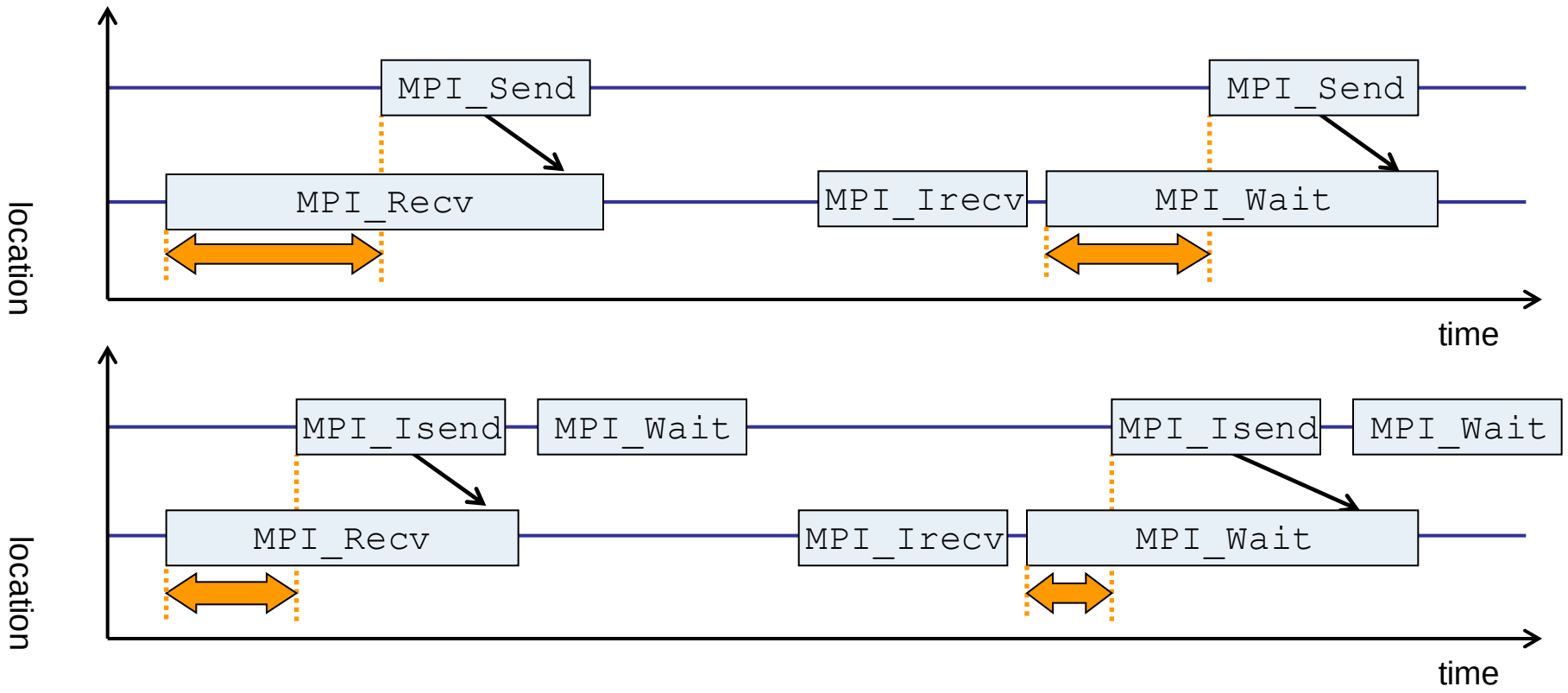
- Time spent waiting in front of synchronizing collective operation until the last process reaches the operation
- Applies to: MPI_Allgather, MPI_Allgatherv, MPI_Alltoall, MPI_Reduce_scatter, MPI_Reduce_scatter_block, MPI_Allreduce

Example: Late Broadcast



- Waiting times if the destination processes of a collective 1-to-N operation enter the operation earlier than the source process (root)
- Applies to: MPI_Bcast, MPI_Scatter, MPI_Scatterv

Example: Late Sender



- Waiting time caused by a blocking receive operation posted earlier than the corresponding send
- Applies to blocking as well as non-blocking communication

Hands-on: NPB-MZ-MPI / BT

scalasca

Scalasca Helper Commands

- Scalasca measurement collection & analysis nexus

```
% scan
Scalasca 2.0: measurement collection & analysis nexus
usage: scan {options} [launchcmd [launchargs]] target [targetargs]
      where {options} may include:
  -h    Help: show this brief usage message and exit.
  -v    Verbose: increase verbosity.
  -n    Preview: show command(s) to be launched but don't execute.
  -q    Quiescent: execution with neither summarization nor tracing.
  -s    Summary: enable runtime summarization. [Default]
  -t    Tracing: enable trace collection and analysis.
  -a    Analyze: skip measurement to (re-)analyze an existing trace.
  -e exptdir   : Experiment archive to generate and/or analyze.
                 (overrides default experiment archive title)
  -f filtfile  : File specifying measurement filter.
  -l lockfile  : File that blocks start of measurement.
  -m metrics   : Metric specification for measurement.
```

Scalasca Helper Commands (cont.)

- Scalasca analysis report explorer

```
% square
Scalasca 2.0: analysis report explorer
usage: square [-v] [-s] [-f filtfile] [-F] <experiment archive
                                                | cube file>
   -F           : Force remapping of already existing reports
   -f filtfile  : Use specified filter file when doing scoring
   -s           : Skip display and output textual score report
   -v           : Enable verbose mode
```

Before Collecting a New Measurement…

- **scan** configures Score-P by setting some environment variables automatically
  - Precedence order:
    - Command-line arguments
    - Environment variables already set
    - Automatically determines values

- Also, **scan** prevents overwriting experiment directories

BT-MZ Summary Measurement

- Run the application using the Scalasca measurement collection & analysis nexus prefixed to launch command

```
% cd bin.scorep
% export OMP_NUM_THREADS=4
% scan -f ../config/scorep.filt  mpiexec -n 4 ./bt-mz_B.4
S=C=A=N: Scalasca 2.0 runtime summarization
S=C=A=N: ./scorep_bt-mz_B_4x4_sum experiment archive
S=C=A=N: Thu Sep 13 18:05:17 2012: Collect start
mpiexec -n 4 ./bt-mz_B.4

 NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark

 Number of zones:   8 x   8
 Iterations: 200    dt:   0.000300
 Number of active processes:     4

 [... More application output ...]

S=C=A=N: Thu Sep 13 18:05:39 2012: Collect done (status=0) 22s
S=C=A=N: ./scorep_bt-mz_B_4x4_sum complete.
```

- Creates experiment directory ./scorep_bt-mz_B_4x4_sum

BT-MZ Summary Analysis Report Examination

- Score summary analysis report

```
% square -s  scorep_bt-mz_B_4x4_sum
INFO: Post-processing runtime summarization result...
INFO: Score report written to ./scorep_bt-mz_B_4x4_sum/scorep.score
```

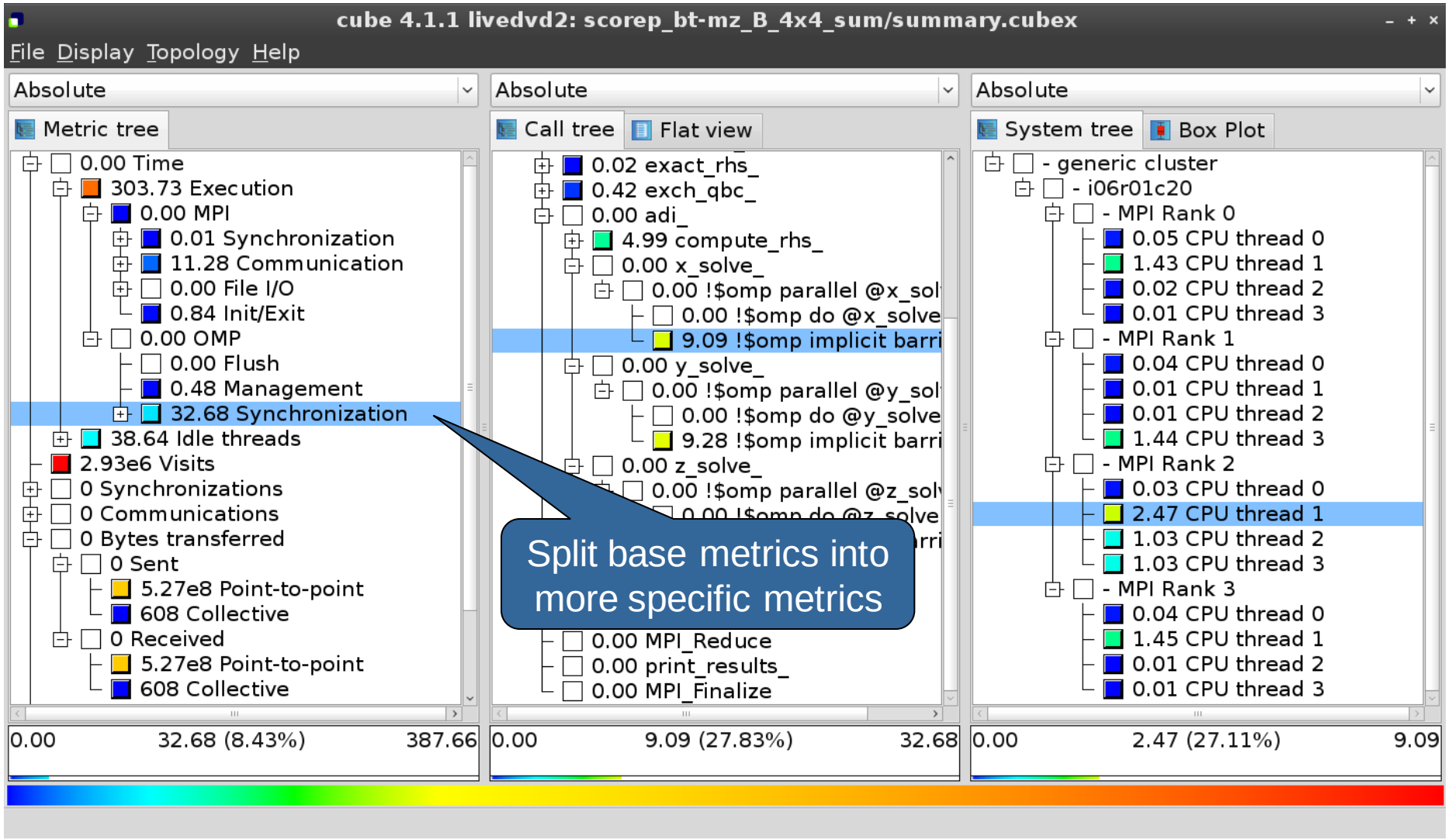
- Post-processing and interactive exploration with CUBE

```
% square  scorep_bt-mz_B_4x4_sum
INFO: Displaying ./scorep_bt-mz_B_4x4_sum/summary.cubex...

                [GUI showing summary analysis report]
```

- The post-processing generates a metric hierarchy, splitting some base metrics into more specific metrics

Post-Processed Summary Analysis Report



BT-MZ Trace Measurement Collection...

- To enable additional statistics and pattern instance tracking, set SCAN_ANALYZE_OPTS="-i"

```
% export SCAN_ANALYZE_OPTS="-i"
```

- Re-run the application using Scalasca nexus with "-t" flag

```
% export OMP_NUM_THREADS=4
% scan -f ../config/scorep.filt -t  mpiexec -n 4 ./bt-mz_B.4
S=C=A=N: Scalasca 2.0 trace collection and analysis
S=C=A=N: ./scorep_bt-mz_B_4x4_trace experiment archive
S=C=A=N: Thu Sep 13 18:05:39 2012: Collect start
mpiexec -n 4 ./bt-mz_B.4
 NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark

 Number of zones:   8 x   8
 Iterations: 200    dt:   0.000300
 Number of active processes:     4

 [... More application output ...]

S=C=A=N: Thu Sep 13 18:05:58 2012: Collect done (status=0) 19s
 [.. continued ...]
```

... and Analysis

- Continues with automatic (parallel) analysis of trace files

```
S=C=A=N: Thu Sep 13 18:05:58 2012: Analyze start
mpiexec -n 4 scout.hyb -i ./scorep_bt-mz_B_4x4_trace/traces.otf2
SCOUT   Copyright (c) 1998-2012 Forschungszentrum Juelich GmbH
        Copyright (c) 2009-2012 German Research School for Simulation
                                Sciences GmbH

Analyzing experiment archive ./scorep_bt-mz_B_4x4_trace/traces.otf2

Opening experiment archive ... done (0.002s).
Reading definition data    ... done (0.004s).
Reading event trace data   ... done (0.669s).
Preprocessing              ... done (0.975s).
Analyzing trace data       ... done (0.675s).
Writing analysis report    ... done (0.112s).

Max. memory usage         : 145.078MB

Total processing time     : 2.785s
S=C=A=N: Thu Sep 13 18:06:02 2012: Analyze done (status=0) 4s
```

… on Graphit

- Run the application using the tracing mode of Score-P

```
% vim run.sh
% export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_B_4x4_trace
% export SCOREP_FILTERING_FILE=../config/scorep.filt
% export SCOREP_ENABLE_TRACING=true
% export SCOREP_ENABLE_PROFILING=false
% export SCOREP_TOTAL_MEMORY=100M

% cleo-submit -np 4 ./run.sh

 NAS Parallel Benchmarks (NPB3.3-MZ-MPI) - BT-MZ MPI+OpenMP Benchmark
 [... More application output ...]
```

- Manually execute the scalasca trace analyzer:
  - `scout.mpi` or `scout.hby`

```
% cleo-submit -np 4 `which scout.hyb` -i -s -v \
  scorep_bt-mz_B_4x4_trace/traces.otf2
SCOUT   Copyright (c) 1998-2012 Forschungszentrum Juelich GmbH
        Copyright (c) 2009-2012 German Research School for Simulation
                                Sciences GmbH
Analyzing experiment archive ./scorep_bt-mz_B_4x4_trace/traces.otf2
...
```

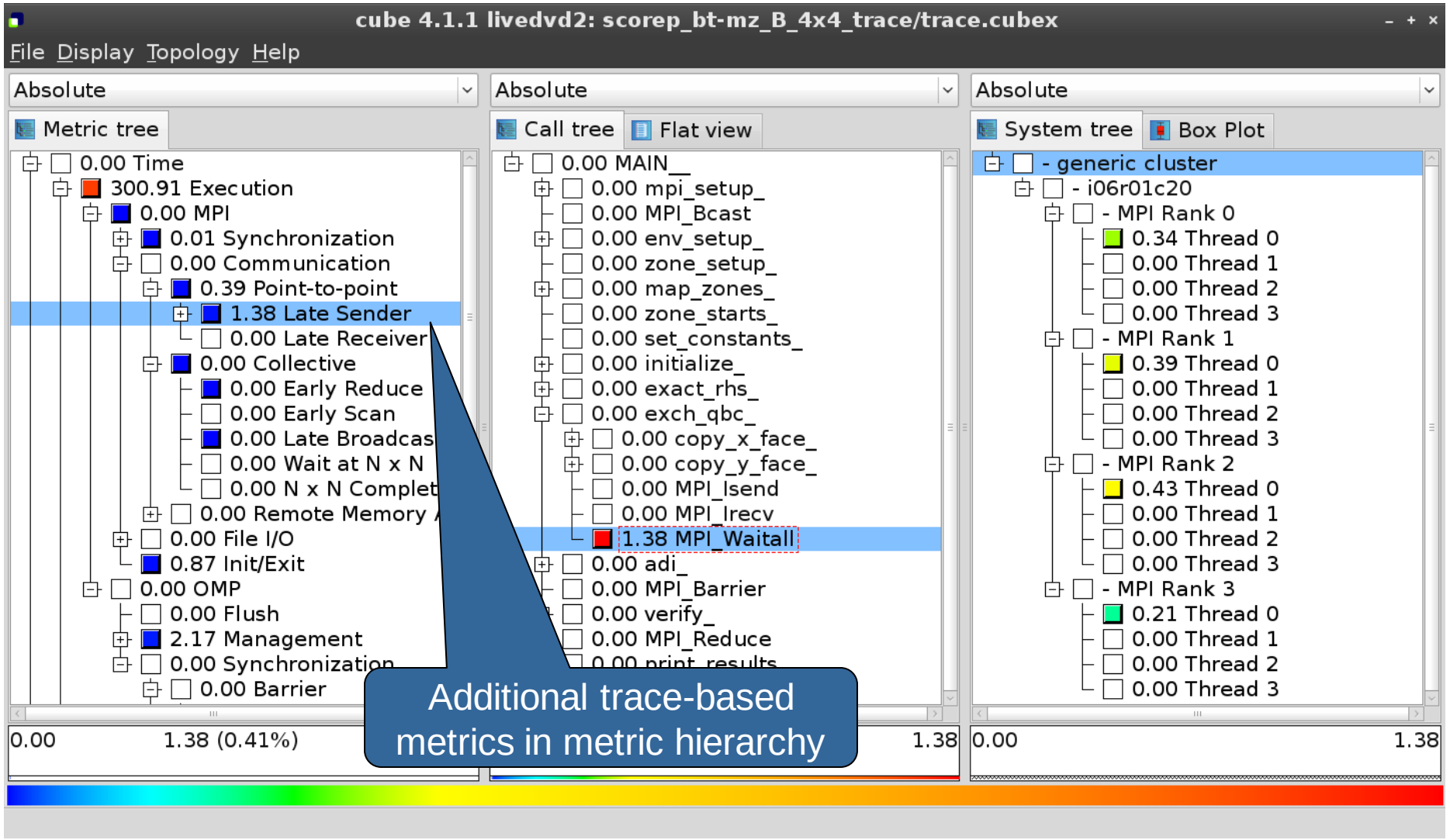
BT-MZ Trace Analysis Report Exploration

- Produces trace analysis report in experiment directory containing trace-based wait-state metrics

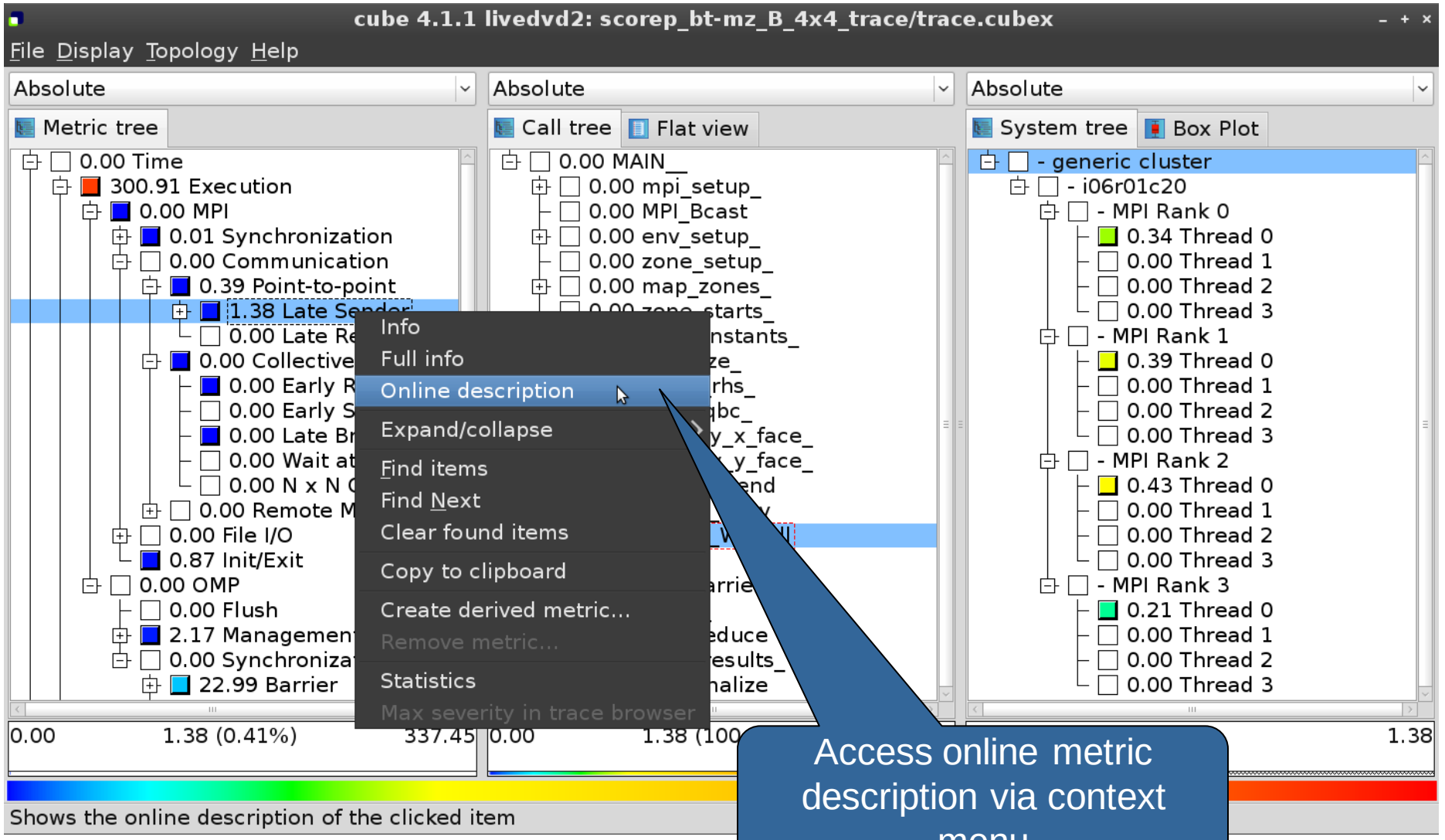
```
% square scorep_bt-mz_B_4x4_trace
INFO: Post-processing runtime summarization result...
INFO: Post-processing trace analysis report...
INFO: Displaying ./scorep_bt-mz_B_4x4_sum/trace.cubex...

                [GUI showing trace analysis report]
```

Post-Processed Trace Analysis Report



Online Metric Description



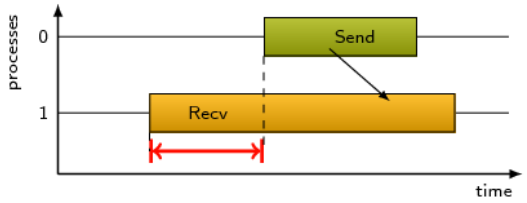
Online Metric Description

Performance properties

Late Sender Time

Description:

Refers to the time lost waiting caused by a blocking receive operation (e.g., `MPI_Recv` or `MPI_Wait`) that is posted earlier than the corresponding send operation.



If the receiving process is waiting for multiple messages to arrive (e.g., in an call to `MPI_Waitall`), the maximum waiting time is accounted, i.e., the waiting time due to the latest sender.

Unit:

Seconds

Diagnosis:

Try to replace `MPI_Recv` with a non-blocking receive `MPI_Irecv` that can be posted earlier, proceed concurrently with computation, and complete with a wait operation after the message is expected to have been sent. Try to post sends earlier, such that they are available when receivers need them. Note that outstanding messages (i.e., sent before the receiver is ready) will occupy internal message buffers, and that large numbers of posted receive buffers will also introduce message management overhead, therefore moderation is advisable.

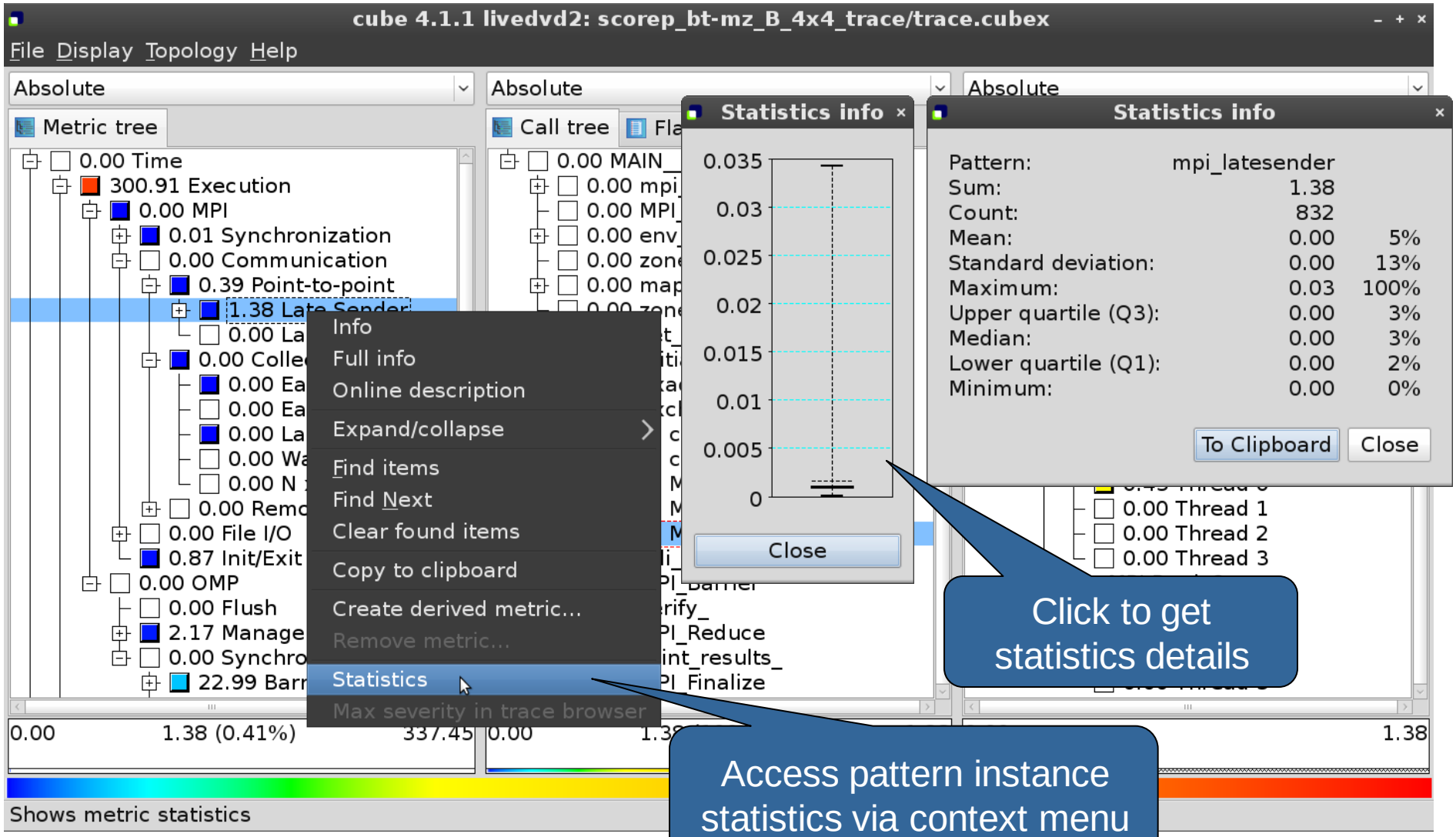
Parent:

MPI Point-to-point Communication Time

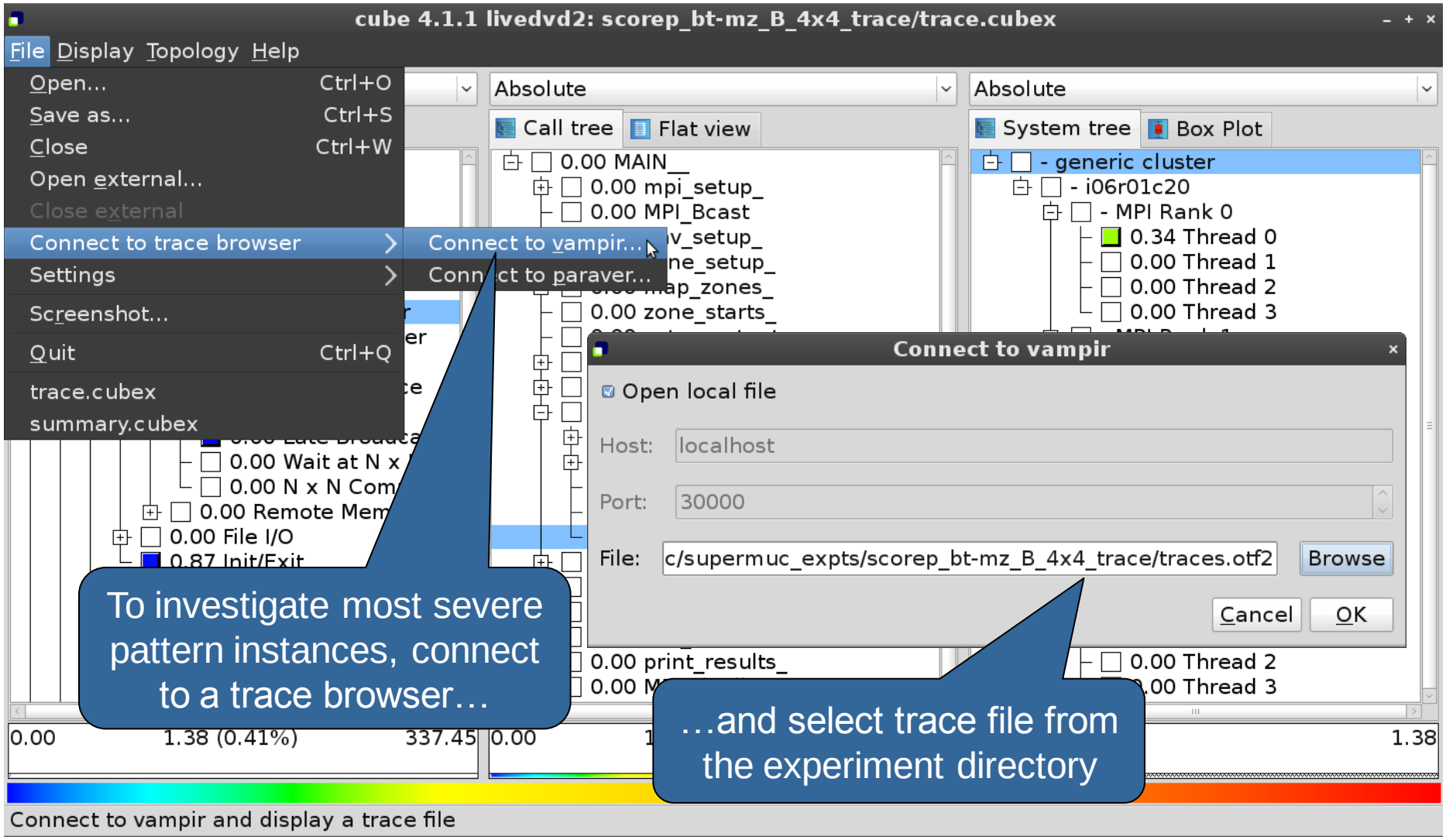
Children:

Close

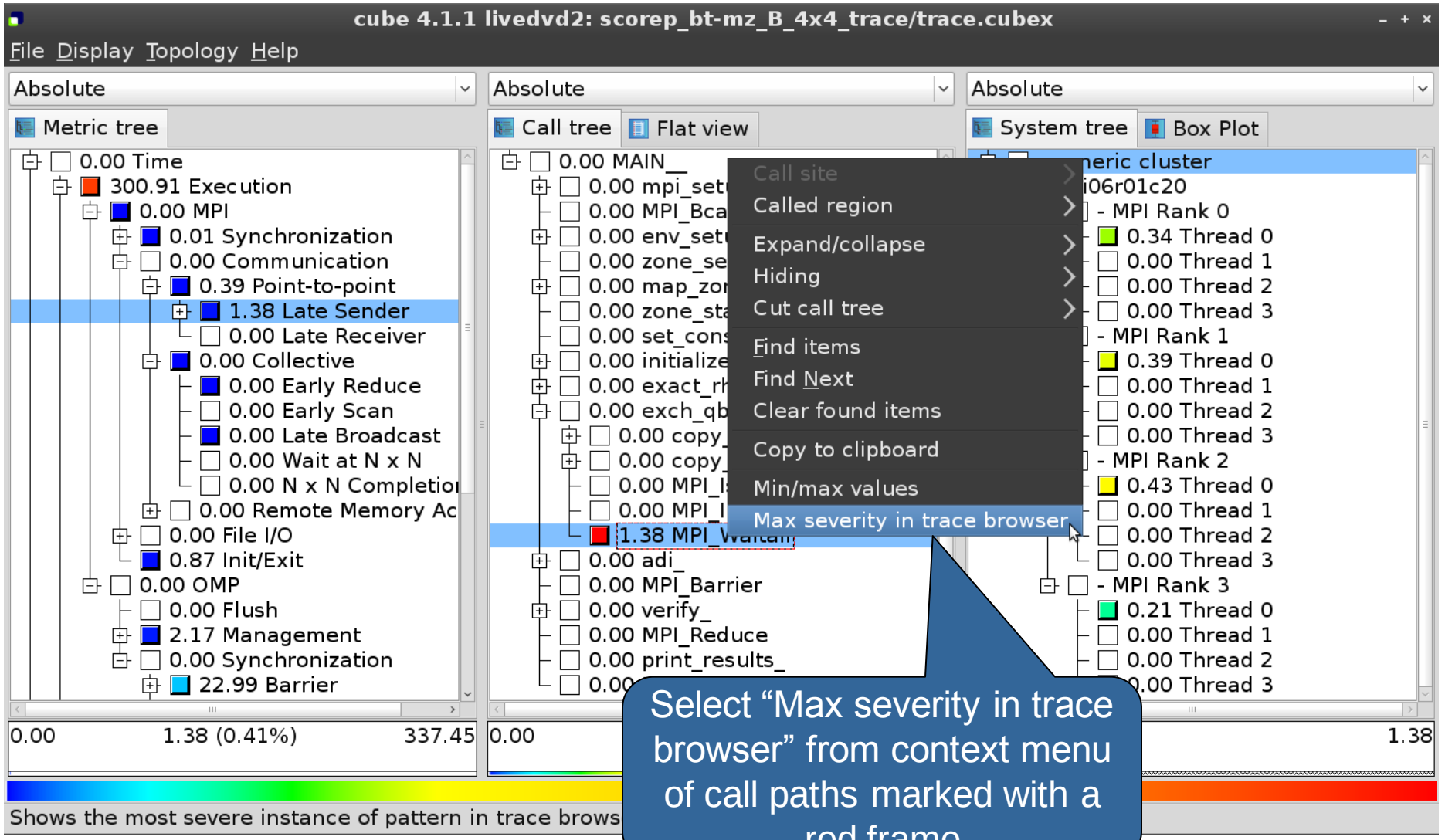
Pattern Instance Statistics



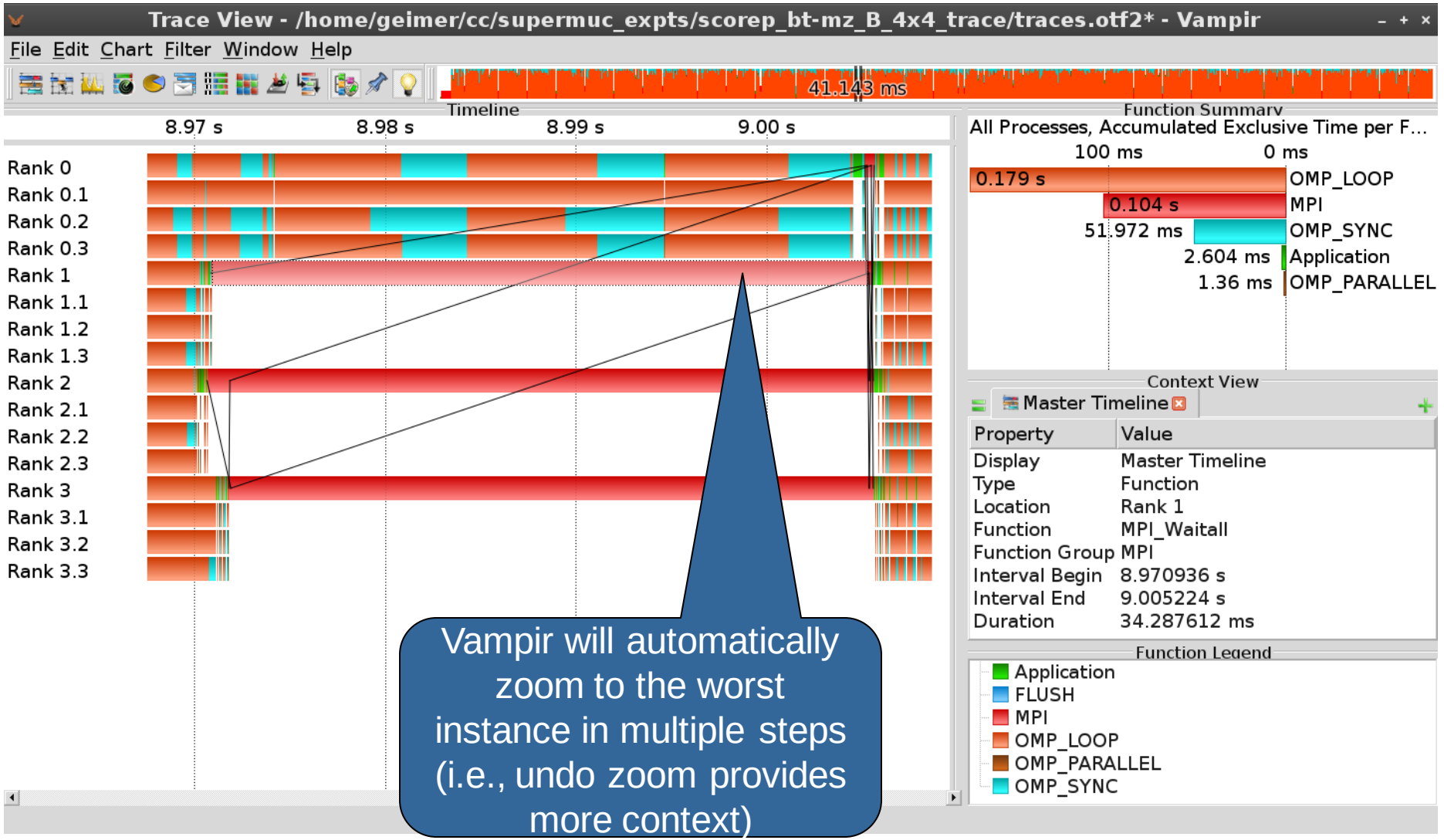
Connect to Vampir Trace Browser



Show Most Severe Pattern Instances



Investigate Most Severe Instance in Vampir



Further Information

Scalable performance **a**nalysis of **la**rge-**sc**ale parallel **a**pplications

- toolset for scalable performance measurement & analysis of MPI, OpenMP & hybrid parallel applications
- supporting most popular HPC computer systems
- available under New BSD open-source license
- sources, documentation & publications:
  - **http://www.scalasca.org**
  - mailto: **scalasca@fz-juelich.de**

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Questions?