Score-P – A Joint Performance Measurement Run-Time Infrastructure for Scalasca, TAU, and Vampir

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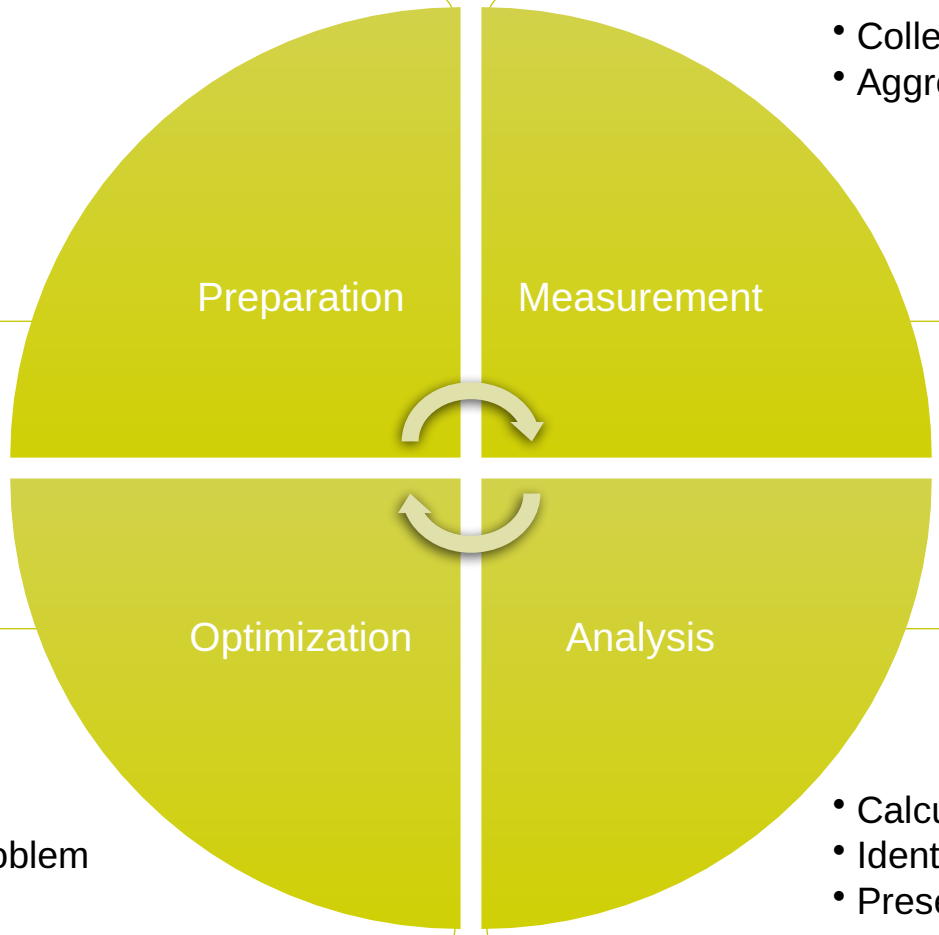
VI-HPS Team

Performance engineering workflow

- Prepare application with symbols
- Insert extra code (probes/hooks)



- Collection of performance data
- Aggregation of performance data

- Modifications intended to eliminate/reduce performance problem

- Calculation of metrics
- Identification of performance problems
- Presentation of results

Score-P

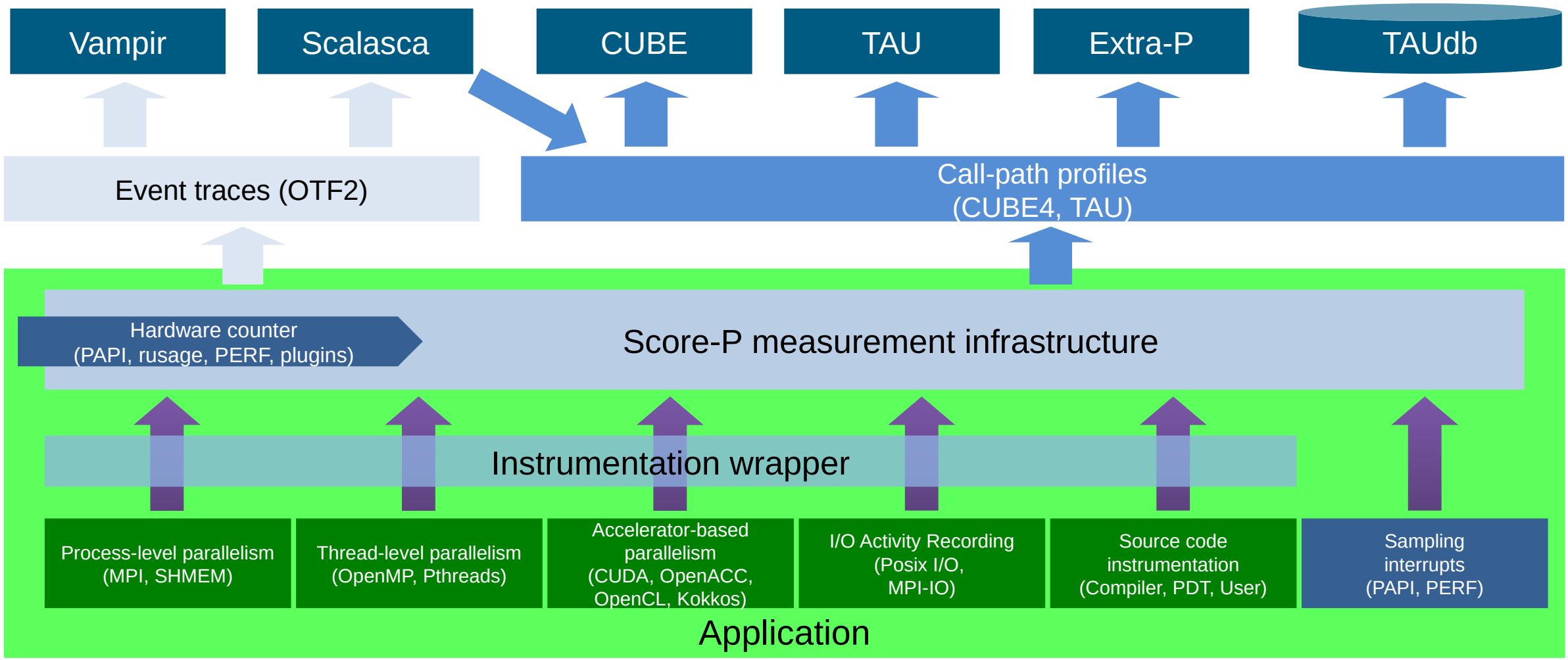
- Infrastructure for instrumentation and performance measurements
- Instrumented application can be used to produce several results:
  - Call-path profiling: CUBE4 data format used for data exchange
  - Event-based tracing: OTF2 data format used for data exchange

- Supported parallel paradigms:
  - Multi-process: MPI, SHMEM
  - Thread-parallel: OpenMP, Pthreads
  - Accelerator-based: CUDA, OpenCL, OpenACC, Kokkos

- Open Source; portable and scalable to all major HPC systems
- Initial project funded by BMBF
- Further developed in multiple 3rd-party funded projects

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Score-P overview



Partners

- Forschungszentrum Jülich, Germany
- Gesellschaft für numerische Simulation mbH Braunschweig, Germany
- RWTH Aachen, Germany
- Technische Universität Darmstadt, Germany
- Technische Universität Dresden, Germany
- Technische Universität München, Germany
- University of Oregon, Eugene, USA

Hands-on:
NPB-MZ-MPI / BT

Performance analysis steps

- 0.0 Reference preparation for validation

- 1.0 Program instrumentation
- 1.1 Summary measurement collection
- 1.2 Summary analysis report examination

- 2.0 Summary experiment scoring
- 2.1 Summary measurement collection with filtering
- 2.2 Filtered summary analysis report examination

- 3.0 Event trace collection
- 3.1 Event trace examination & analysis

Local installation (JUSUF)

- Load default environment (GCC + ParaStationMPI):

```
% module load Stages/2022 GCC ParaStationMPI
```

- Load the modules for the tool environment:

```
% module load Score-P CubeGUI
```

- Copy tutorial sources to your WORK directory (or your personal workspace)
  - Only required if not done already (for opening exercise)

```
% cd $SCRATCH_training2214/$USER
% tar zxvf  $PROJECT_training2214/NPB3.3-MZ-MPI.tar.gz
% cd NPB3.3-MZ-MPI
```

NPB-MZ-MPI / BT instrumentation

```
#---------------------------------------------------------------------
# The Fortran compiler used for MPI programs
#---------------------------------------------------------------------
#MPIF77 = mpif77

# Alternative variants to perform instrumentation
...
MPIF77 = scorep mpif77

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

- Edit config/make.def to adjust build configuration
  - Modify specification of compiler/linker: MPIF77

Uncomment the Score-P compiler wrapper specification

NPB-MZ-MPI / BT instrumented build

```
% make clean

% make bt-mz CLASS=C NPROCS=8
cd BT-MZ; make CLASS=C NPROCS=8 VERSION=
make: Entering directory 'BT-MZ'
cd ../sys; cc  -o setparams setparams.c -lm
../sys/setparams bt-mz 8 B
scorep --user mpif77 -g -c  -O3 -qopenmp bt.f
 [...]
cd ../common;  scorep --user mpif77 -g -c  -O3 -qopenmp timers.f
 [...]
scorep --user mpif77 -g –O3 -qopenmp -o ../bin.scorep/bt-mz_C.8 \
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_C.8
make: Leaving directory 'BT-MZ‘
```

- Return to root directory and clean-up
- Re-build executable using Score-P compiler wrapper

Measurement configuration: scorep-info

```
% scorep-info config-vars --full
SCOREP_ENABLE_PROFILING
  Description: Enable profiling
          [...]
SCOREP_ENABLE_TRACING
  Description: Enable tracing
          [...]
SCOREP_TOTAL_MEMORY
  Description: Total memory in bytes for the measurement system
          [...]
SCOREP_EXPERIMENT_DIRECTORY
  Description: Name of the experiment directory
          [...]
SCOREP_FILTERING_FILE
  Description: A file name which contain the filter rules
          [...]
SCOREP_METRIC_PAPI
  Description: PAPI metric names to measure
          [...]
SCOREP_METRIC_RUSAGE
  Description: Resource usage metric names to measure
          [... More configuration variables ...]
```

- Score-P measurements are configured via environmental variables

Summary measurement collection

```
% cd bin.scorep
% cp ../jobscript/jusuf/scorep.sbatch .
% cat scorep.sbatch
...
# Score-P measurement configuration
export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_sum
#export SCOREP_FILTERING_FILE=../config/scorep.filt
#export SCOREP_METRIC_PAPI=PAPI_TOT_INS,PAPI_TOT_CYC,…
#export SCOREP_METRIC_PAPI_PER_PROCESS=PAPI_L2_TCM
#export SCOREP_METRIC_RUSAGE=ru_stime
#export SCOREP_METRIC_RUSAGE_PER_PROCESS=ru_maxrss
#export SCOREP_TIMER=gettimeofday

# Run the application
export OMP_NUM_THREADS=${SLURM_CPUS_PER_TASK}
srun ./bt-mz_$CLASS.$PROCS

% sbatch scorep.sbatch
```

- Change to the directory containing the new executable before running it with the desired configuration
- Check settings

Leave these lines commented out for the moment

- Submit job

Summary measurement collection

```
% less npb_btmz.o<job_id>

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

 Number of zones:  16 x  16
 Iterations: 200    dt:   0.000100
 Number of active processes:     8
 Use the default load factors with threads
 Total number of threads:    48  (  6.0 threads/process)

 Calculated speedup = 47.97

 Time step    1

        [... More application output ...]
```

- Check the output of the application run

BT-MZ summary analysis report examination

```
% ls
bt-mz_C.8 bt-mz.o<job_id> scorep_bt-mz_sum/
% ls scorep_bt-mz_sum
MANIFEST.md profile.cubex  scorep.cfg




% cube scorep_bt-mz_sum/profile.cubex

      [CUBE GUI showing summary analysis report]
```

- Creates experiment directory including
  - A brief content overview (MANIFEST.md)
  - A record of the measurement configuration (scorep.cfg)
  - The analysis report that was collated after measurement (profile.cubex)
- Interactive exploration with Cube

Hint:
Copy ‘profile.cubex’ to local system (laptop) using ‘scp’ to improve responsiveness of GUI

Reference results available:
`/p/project/training2214/reference_results`

Further information

- Community instrumentation & measurement infrastructure
  - Instrumentation (various methods)
  - Basic and advanced profile generation
  - Event trace recording
- Available under 3-clause BSD open-source license
- Documentation & Sources:
  - http://www.score-p.org
- User guide also part of installation:
  - <prefix>/share/doc/scorep/{pdf,html}/
- Support and feedback: support@score-p.org
- Subscribe to news@score-p.org, to be up to date