SCORE-P LICENSE AGREEMENT

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Chapter 1

Introduction

This document provides an introduction to Score-P: the Scalable Performance Measurement Infrastructure for Parallel Codes. It is a software system that provides a measurement infrastructure for profiling, event trace recording, and online analysis of High Performance Computing (HPC) applications. It has been developed within the framework of the Scalable Infrastructure for the Automated Performance Analysis of Parallel Codes (SILC) project funded by the German Federal Ministry of Education and Research (BMBF) under its HPC programme and the Performance Refactoring of Instrumentation, Measurement, and Analysis Technologies for Petascale Computing (PRIMA) project funded by the United States Department of Energy (DOE) with the goals of being highly scalable and easy to use.

The partners involved in the development of this system within the SILC and PRIMA projects were:

- Forschungszentrum Jülich,
- German Research School for Simulation Sciences,
- Gesellschaft für numerische Simulation mbH,
- Gesellschaft für Wissens- und Technologietransfer der TU Dresden (GWT-TUD GmbH),
- Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen,
- Technische Universität Dresden,
- Technische Universität München,
- and University of Oregon

The goal of Score-P is to simplify the analysis of the behavior of high performance computing software and to allow the developers of such software to find out where and why performance problems arise, where bottlenecks may be expected and where their codes offer room for further improvements with respect to the run time. A number of tools have been around to help in this respect, but typically each of these tools has only handled a certain subset of the questions of interest. A software developer who wanted to have a complete picture of his code therefore was required to use a multitude of programs to obtain the desired information. Most of these utilities work along similar principles. The first step is usually an instrumentation of the code to be investigated. Next, the instrumented programs are executed and write out (often very large amounts of) performance data. These data are then finally graphically displayed and analyzed after the end of the program run. In certain special cases, the visualization and analysis of the program behavior is also done while the program is running.

A crucial problem in the traditional approach used to be the fact that each analysis tool had its own instrumentation system, so the user was commonly forced to repeat the instrumentation procedure if more than one tool was to be employed. In this context, Score-P offers the user a maximum of convenience by providing the Opari2 instrumenter
as a common infrastructure for a number of analysis tools like Periscope, Scalasca, Vampir, and Tau that obviates the need for multiple repetitions of the instrumentation and thus substantially reduces the amount of work required. It is open for other tools as well. Moreover, Score-P provides the new Open Trace Format Version 2 (OTF2) for the tracing data and the new CUBE4 profiling data format which allow a better scaling of the tools with respect to both the run time of the process to be analyzed and the number of cores to be used.

Score-P supports the following parallel programming paradigms:

**Multi-process paradigms:**

- MPI
- SHMEM

**Thread-parallel paradigms:**

- OpenMP
- Pthreads

**Accelerator-based paradigms:**

- CUDA
- OpenCL
- OpenACC

And possible combinations from these including simple serial programs.

In addition, Score-P supports event recording for the following programming interfaces:

**Memory management interfaces:**

- C, up to C11 (i.e., malloc/free)
- C++, up to C++14 and old PGI/EDG (i.e., new/delete)
- High bandwidth memory API, from the memkind library (i.e., hbw_malloc/hbw_free)
- MPI
- SHMEM

**I/O interfaces:**

- POSIX I/O (i.e., open/close)
- POSIX asynchronous I/O (i.e., aio_read/aio_write)
- ISO C standard I/O (i.e., fopen/fclose)
- MPI I/O

### 1.1 About this Document

This document consists of three parts. This chapter is devoted to a basic introduction to performance analysis in general and the components of the Score-P system in particular. Chapter 'Getting Started' is a beginner’s guide to using the Score-P tool suite. It demonstrates the basic steps and commands required to initiate a performance analysis of a parallel application. In the Chapters 'Application Instrumentation', 'Application Sampling', and 'Application Measurement', the reader can find more detailed information about the components of Score-P. Chapter 'Performance Analysis Workflow Using Score-P' provides a typical workflow of performance analysis with Score-P and detailed instructions.
1.2 Getting Help and Support

The Score-P project uses various mailing lists to coordinate the development and to provide support to the user community. An overview of the available mailing lists can be found in the Table Score-P mailing lists.

You can subscribe to the news@score-p.org and support@score-p.org by ...

<table>
<thead>
<tr>
<th>List Address</th>
<th>Subscription</th>
<th>Posting</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="mailto:news@score-p.org">news@score-p.org</a></td>
<td>open</td>
<td>core team</td>
<td>Important news regarding the Score-P software, e.g., announcements of new releases.</td>
</tr>
<tr>
<td><a href="mailto:support@score-p.org">support@score-p.org</a></td>
<td>closed</td>
<td>anyone</td>
<td>Bug reports and general user support for the Score-P software.</td>
</tr>
</tbody>
</table>

Table 1.1 Score-P mailing lists

1.3 Basics of Performance Optimization

Performance optimization is a process that is usually executed in a work cycle consisting of a number of individual steps as indicated in Figure 1.1.

Thus, the process always begins with the original application in its unoptimized state. This application needs to be instrumented, i.e., it must be prepared in order to enable the measurement of the performance properties to take place. There are different ways to do this, including manual instrumentation of the source code by the

user, automatic instrumentation by the compiler, or linking against pre-instrumented libraries. All these options are available in Score-P.

When the instrumented application obtained in this way is executed, the additional commands introduced during the instrumentation phase collect the data required to evaluate the performance properties of the code. Depending on the user's requirements, Score-P allows to store these data either as a profile or as event traces. The user must keep in mind here that the execution of the additional instructions of course requires some run time and storage space. Thus the measurement itself has a certain influence on the performance of the instrumented code. Whether the perturbations introduced in this way have a significant effect on the behavior depends on the specific structure of the code to be investigated. In many cases the perturbations will be rather small so that the overall results can be considered to be a realistic approximation of the corresponding properties of the uninsstrumented code. However, certain constructions like regions with very small temporal extent that are executed frequently are likely to suffer from significant perturbations. It is therefore advisable not to measure such regions.

The next step is the analysis of the data obtained in the measurement phase. Traditionally this has mainly been done post mortem, i.e. after the execution of the instrumented application has ended. This is of course possible in Score-P too, but Score-P offers the additional option to go into the analysis in the so-called on-line mode, i.e. to investigate the performance data while the application is still running. If the collected data are event traces then a more detailed investigation is possible than in the case of profiles. In particular, one can then also look at more sophisticated dependencies between events happening on different processes.

The optimization cycle then continues with the presentation of the analysis results in a report. Here it is important to eliminate the part of the information that is irrelevant for the code optimization from the measured data. The reduction of the complexity achieved in this way will simplify the evaluation of the data for the user. However, care must be taken in order not to present the results in a too abstract fashion which would hide important facts from the user.

The performance report then allows the user to evaluate the performance of the code. One can then either conclude that the application behaves sufficiently well and exit the optimization cycle with the optimized version of the software being chosen as the final state, or one can proceed to identify weaknesses that need to be addressed and the potential for improvements of the code.

In the latter case, one then continues by changing the source code according to the outcome of the previous step and thus obtains an improved application that then can again be instrumented to become ready for a re-entry into the optimization cycle.

1.4 Score-P Software Architecture Overview

In order to allow the user to perform such an optimization of his code (typically written in Fortran, C, or C++ and implemented in a serial way or using a parallelization via an multi-process, thread-parallel, accelerator-based paradigm, or a combination thereof), the Score-P system provides a number of components that interact with each other and with external tools. A graphical overview of this structure is given in Fig. 1.2. We shall now briefly introduce the elements of this structure; more details will be given in the later chapters of this document.

In order to instrument an application, the user needs to recompile the application using the Score-P instrumentation command, which is added as a prefix to the original compile and link command lines. It automatically detects the programming paradigm by parsing the original build instructions and utilizes appropriate and configurable methods of instrumentation. These are currently:

- compiler instrumentation,
- MPI and SHMEM library interposition,
- source code instrumentation via the TAU instrumenter,
- OpenMP source code instrumentation using Opari2,
1.4 Score-P Software Architecture Overview

![Score-P Architecture Diagram](image)

**Figure 1.2 Overview of the Score-P measurement system architecture and the tools interface.**

- Pthread and OpenCL instrumentation via GNU ld library wrapping,
- CUDA instrumentation via the NVIDIA CUDA Profiling Tools Interface (CUPTI),
- OpenACC instrumentation using the OpenACC Profiling Interface,
- I/O library interposition.

While the first three of these methods are based on using tools provided externally, the Opari2 instrumenter for OpenMP programs is a part of the Score-P infrastructure itself. It is an extension of the well known and frequently used OpenMP Pragma And Region Instrumenter system (Opari) that has been successfully used in the past in combination with tools like Scalasca, VampirTrace and ompP. The fundamental concept of such a system is a source-to-source translation that automatically adds all necessary calls to a runtime measurement library allowing to collect runtime performance data of Fortran, C, or C++ OpenMP applications. This translation is based on the idea of OpenMP pragma/directive rewriting. The key innovation in Opari2, as compared to its predecessor, is the capability to support features introduced in version 3.0 of the OpenMP standard, in particular its new tasking functionality and OpenMP nesting. Opari used to work by automatically wrapping OpenMP constructs like parallel regions with calls to the portable OpenMP monitoring interface POMP. In order to reflect the above-mentioned extensions, this interface also had to be replaced by an enhanced version, POMP2.

Additionally, the user may instrument the code manually with convenient macros provided by Score-P. Score-P also supports sampling functionality that provides an alternative to direct instrumentation.

During measurement, the system records several performance metrics including execution time, communication metrics, and optionally hardware counters. Performance data is stored in appropriately sized chunks of a preallocated memory buffer that are assigned to threads on demand, efficiently utilizing the available memory and avoiding measurement perturbation by flushing the data to disk prematurely.

Without recompilation, measurement runs can switch between tracing and profiling mode. In tracing mode, the performance events are passed to the tracing back-end of Score-P and are written to files for subsequent post
mortem analysis using Scalasca or Vampir. This backend uses the newly developed Open Trace Format 2 (OTF2), the joint successor of the Open Trace Format used by Vampir and the Epilog format used by Scalasca. The Score-P system contains a new library with reading and writing routines for OTF2. Basically, OTF2 is a full merge of its two predecessors that retains all their features, and it is planned to become the default data source for future versions of both Vampir and Scalasca. In this way, the user is free to choose between these two complementary tools to investigate the trace files and may select the one that is more appropriate for the specific question at hand. As an alternative to writing the trace data to disk and evaluating them post mortem, it is also possible to directly hand over the data to on-line analysis tools like Periscope. The corresponding interface that allows this on-line access is also an integral part of Score-P.

In profiling mode, the performance events are summarized at runtime separately for each call-path like in Scalasca. Additionally, support for phases, dynamic regions and parameter-based profiling has been integrated. The collected data is passed to the Score-P's profiling back-end CUBE4 for post mortem analysis using Scalasca or TAU or is used directly through the on-line access interface by Periscope. Also in profiling mode, Score-P supports the automatic detection of MPI wait states. Usually such inefficiencies are important bottlenecks and are thoroughly investigated by means of automatic trace analysis and subsequent visual analysis using a time-line representation. In the case of Score-P wait time profiling, inefficiencies are detected immediately when the respective MPI call is completed and stored as an additional metric in the call-path profile. In comparison to earlier versions of CUBE, this new one features a more powerful data model, more flexibility in the specification of system resource hierarchies and display parameters, and various techniques to enhance the efficiency that result in a much better scaling behavior of the analysis tool even in a range of tens of thousands of processes.

As a rough guideline for users who are uncertain which of these two modes to employ, we provide a brief comparison of their main advantages and disadvantages. Specifically, tracing mode allows to retain temporal and spatial connections, and it can reflect the dynamical behavior to an arbitrary precision. Moreover, statistical information and profiles may be derived from the program traces. On the other hand, the amount of data that is produced in the tracing mode can become prohibitively large; profiles tend to require much less storage space. In addition, the additional load that is imposed on the process, and hence the perturbations of the behavior of the code to be analyzed, are much smaller in profiling mode than in tracing mode. And finally we mention that the accurate synchronization of the clocks is an important aspect in tracing mode that may cause difficulties.

1.5 Acknowledgment

The development of Score-P was sponsored by a grant from the German Federal Ministry of Education and Research (Grant No. 01IH08006) within the framework of its High Performance Computing programme and with a grant from the US Department of Energy (Award No. DE-SC0001621). This support is gratefully acknowledged.
Chapter 2

Getting Started

In order to quickly introduce the user to the Score-P system, we explain how to build and install the tool and look at a simple example. We go through the example in full detail.

As mentioned above, the three core steps of a typical work cycle in the investigation of the behavior of a software package can be described as follows:

- **Instrumentation of user code**: Calls to the measurement system are inserted into the application. This can be done either fully automatically or with a certain amount of control handed to the software developer.
- **Measurement and analysis**: The instrumented application is executed under the control of the measurement system and the information gathered during the run time of this process is stored and analyzed.
- **Examination of results**: The information about the behavior of the code at run time is visualized and the user gets the opportunity to examine the reported results.

After building and installing the tool, we shall go through these three steps one after the other in the next sections. This will be followed by a full workflow example. For getting detailed presentations of available features, see Section 'Application Instrumentation' for the instrumentation step and Section 'Application Measurement' for the measurement.

2.1 Score-P Quick Installation

The Score-P performance analysis tool uses the GNU Autotools (Autoconf, Automake, Libtool and M4) build system. The use of Autotools allows Score-P to be build in many different systems with varying combinations of compilers, libraries and MPI implementations.

Autotools based projects are build as follows:

1. The available compilers and tools available are detected from the environment by the configure script.
2. Makefiles are generated based on the detected compilers and tools.
3. The generated Makefile project is then built and installed.

Score-P will have features enabled or disabled, based on the detection made by the Autotools generated configure script. The following 2 sub-sections cover mandatory prerequisites as well as optional features that are enabled based on what is available in the configured platform.
2.1.1 Prerequisites

To build Score-P, C, C++ and Fortran compilers and related tools are required. These can be available as modules (typically on super-computer environments) or as packages (on most Linux or BSD distributions).

For Debian based Linux systems using the APT package manager, the following command (as root) is sufficient to build Score-P with minimal features enabled:

```
apt-get install gcc g++ gfortran mpich2
```

On Red-Hat and derivative Linux systems running the YUM package manager, in a similar way:

```
yum install gcc g++ gfortran mpich2
```

For users of the SuperMUC, it is recommended to load the following modules:

```
module load ccomp/intel/12.1 fortran/intel/12.1 mpi.ibm/5.2_PMR-fixes papi/4.9
```

2.1.2 General Autotools Build Options

System administrators can build Score-P with the familiar:

```
mkdir _build
cd _build
../configure && make && make install
```

The previous sequence of commands will detect compilers, libraries and headers, and then build and install Score-P in the following system directories:

```
/opt/scorep/bin
/opt/scorep/lib
/opt/scorep/include
/opt/scorep/share
```

Users that are not administrators on the target machine may need to install the tool in a different location (due to permissions). The prefix flag should be specified with the target directory:

```
../configure --prefix=<installation directory>
```

For example, in the `install/scorep` directory on his/her home folder:

```
../configure --prefix=$HOME/install/scorep
```

In this case, the user's PATH variable needs to be updated to include the `bin` directory of Score-P, and the appropriate library and include folders specified (with `-L` and `-I`) when instrumenting and building applications.

Users of the SuperMUC (after loading the required modules mentioned previously), can issue the following command to configure Score-P:

```
../configure --prefix=$HOME/install/scorep --enable-static --disable-shared --with-nocross-compiler-suite=intel --with-mpi=openmpi --with-papi-header=$PAPI_BASE/include --with-papi-lib=$PAPI_BASE/lib
```
2.2 Instrumentation

2.1.3 Score-P Specific Build Options

In addition to general options available in all Autotools based build systems, there are Score-P configuration flags. These can be printed out by passing the `--help` flag to the configure script.

They are usually self explanatory. Here is a list of them with a short explanation:

- `--with-nocross-compiler-suite=(gcc|ibm|intel|pgi|studio|clang)`
  Specifies the compiler suite to use when not cross-compiling. Selecting one of the options sets all relevant variables to their expected names. These are CC, FC, F77, as well as the linker, preprocessor, etc.

- `--with-frontend-compiler-suite=(gcc|ibm|intel|pgi|studio|clang)`
  Similar to the previous configuration flag, but for cross-compiling environments.

- `--with-mpi=(mpich2|impi|openmpi)`
  The MPI compiler and runtime suite to use. Currently there are entries for MPICH2, Intel MPI and Open MPI.

- `--with-shmem=(openshmem|openmpi|sgimpt)`
  The SHMEM compiler suite to build this package in non cross-compiling mode. Usually autodetected. Needs to be in $PATH.

- `--with-otf2=(yes|<otf2-bindir>)`
  An already install OTF2 can be specified with this flag. This is usually not necessary since OTF2 is built together with Score-P. Specify yes if the tool is in your $PATH, otherwise specify the full path.

- `--with-opari2=(yes|<opari2-bindir>)`
  Similar to the previous configuration flag, but for OPARI2.

- `--with-cube=(yes|<cube-bindir>)`
  Similar to the previous two configuration flags, but for CUBE.

2.2 Instrumentation

Various analysis tools are supported by the Score-P infrastructure. Most of these tools are focused on certain special aspects that are significant in the code optimization process, but none of them provides the full picture. In the traditional workflow, each tool used to have its own measurement system, and hence its own instrumenter, so the user was forced to instrument his code more than once if more than one class of features of the application was to be investigated. One of the key advantages of Score-P is that it provides an instrumentation system that can be used for all the performance measurement and analysis tools, so that the instrumentation work only needs to be done once.

Internally, the instrumentation itself will insert special measurement calls into the application code at specific important points (events). This can be done in an almost automatic way using corresponding features of typical compilers, but also semi-automatically or in a fully manual way, thus giving the user complete control of the process. In general, an automatic instrumentation is most convenient for the user. However, this approach may lead to too many and/or too disruptive measurements, and for such cases it is then advisable to use selective manual instrumentation and measurement instead. For the moment, we shall however start the procedure in an automatic way to keep things simple for novice users.

To this end, we need to ask the Score-P instrumenter to take care of all the necessary instrumentation of user and MPI functions. This is done by using the `scorep` command that needs to be prefixed to all the compile and link commands usually employed to build the application. Thus, an application executable `app` that is normally generated from the two source files `app1.f90` and `app2.f90` via the command:

```bash
mpif90 app1.f90 app2.f90 -o app
```
will now be built by:

```
scorep mpiF90 app1.f90 app2.f90 -o app
```

to

```
scorep mpiF90 app1.f90 app2.f90 -o app
```

using the Score-P instrumenter.

In practice one will usually perform compilation and linking in separate steps, and it is not necessary to compile all source files at the same time (e.g., if makefiles are used). It is possible to use the Score-P instrumenter in such a case too, and this actually gives more flexibility to the user. Specifically, it is often sufficient to use the instrumenter not in all compilations but only in those that deal with source files containing MPI code. However, when invoking the linker, the instrumenter must *always* be used.

When makefiles are employed to build the application, it is convenient to define a placeholder variable to indicate whether a "preparation" step like an instrumentation is desired or only the pure compilation and linking. For example, if this variable is called `PREP` then the lines defining the C compiler in the makefile can be changed from:

```
MPICC = mpicc
```

(and analogously for linkers and other compilers). One can then use the same makefile to either build an instrumented version with the

```
make PREP="scorep"
```

command or a fully optimized and not instrumented default build by simply using:

```
make
```

in the standard way, i.e. without specifying `PREP` on the command line. Of course it is also possible to define the same compiler twice in the makefile, once with and once without the `PREP` variable, as in:

```
MPICC = $(PREP) mpicc
MPICC_NO_INSTR = mpicc
```

and to assign the former to those source files that must be instrumented and the latter to those files that do not need this.
2.3 Measurement and Analysis

Once the code has been instrumented, the user can initiate a measurement run using this executable. To this end, it is sufficient to simply execute the target application in the usual way, i.e.:

```
mpiexec $MPIFLAGS app [app_args]
```

in the case of an MPI or hybrid code, or simply:

```
app [app_args]
```

for a serial or pure OpenMP program. Depending on the details of the local MPI installation, in the former case the `mpiexec` command may have to be substituted by an appropriate replacement.

When running the instrumented executable, the measurement system will create a directory called `scorep-YYYYMMDD_HHMM_XXXXXXXX` where its measurement data will be stored. Here `YYYYMMDD` and `HHMM` are the date (in year-month-day format) and time, respectively, when the measurement run was started, whereas `XXXXXXXX` is an additional identification number. Thus, repeated measurements, as required by the optimization work cycle, can easily be performed without the danger of accidentally overwriting results of earlier measurements. The environment variables `SCOREP_ENABLE_TRACING` and `SCOREP_ENABLE_PROFILING` control whether event trace data or profiles are stored in this directory. By setting either variable to `true`, the corresponding data will be written to the directory. The default values are `true` for `SCOREP_ENABLE_PROFILING` and `false` for `SCOREP_ENABLE_TRACING`.

2.4 Report Examination

After the completion of the execution of the instrumented code, the requested data (traces or profiles) is available in the indicated locations. Appropriate tools can then be used to visualize this information and to generate reports, and thus to identify weaknesses of the code that need to be modified in order to obtain programs with a better performance. A number of tools are already available for this purpose. This includes, in particular, the CUBE4 Performance report explorer for viewing and analyzing profile data, Vampir for the investigation of trace information, and the corresponding components of the TAU toolsuite.

Alternatively, the Periscope system may be used to analyze the behaviour of the code on-line during its run time, i.e. (in contrast to the approaches mentioned above) before the end of the program run.

2.5 Simple Example

As a specific example, we look at a short C code for the solution of a Poisson equation in a hybrid (MPI and OpenMP) environment. The corresponding source code comes as part of the Score-P distribution under the `scorep/test/jacobi/` folder. Various other versions are also available - not only hybrid but also for a pure MPI parallelization, a pure OpenMP approach, and in a non-parallel way; and, in each case, not only in C but also in C++ and Fortran.

As indicated above, the standard call sequence:

```
mpicc -std=c99 -g -O2 -fopenmp -c jacobi.c
mpicc -std=c99 -g -O2 -fopenmp -c main.c
mpicc -std=c99 -g -O2 -fopenmp -o jacobi jacobi.o main.o -lm
```
that would first compile the two C source files and then link everything to form the final executable needs to be modified by prepending `scorep` to each of the three commands, i.e. we now have to write:

```bash
scorep mpicc -std=c99 -g -O2 -fopenmp -c jacobi.c
scorep mpicc -std=c99 -g -O2 -fopenmp -c main.c
scorep mpicc -std=c99 -g -O2 -fopenmp -o jacobi jacobi.o main.o -lm
```

This call sequence will create a number of auxiliary C source files containing the original source code and a number of commands introduced by the measurement system in order to enable the latter to create the required measurements when the code is actually run. These modified source files are then compiled and linked, thus producing the desired executable named `jacobi`.

The actual measurement process is then initiated, e.g., by the call:

```bash
mpiexec -n 2 ./jacobi
```

The output data of this process will be stored in a newly created experiment directory `scorep-YYYYMMDD_HHMM_XXXXXXXX` whose name is built up from the date and time when the measurement was started and an identification number.

As we had not explicitly set any Score-P related environment variables, the profiling mode was active by default. We obtain a file called `profile.cubex` containing profiling data in the experiment directory as the result of the measurement run. This file can be visually analyzed with the help of CUBE.

If we had set the variable `SCOREP_ENABLE_TRACING` to `true`, we would additionally have obtained trace data, namely the so called anchor file `traces.otf2` and the global definitions `traces.def` as well as a subdirectory `traces` that contains the actual trace data. This trace data is written in Open Trace Format 2 (OTF2) format. OTF2 is the joint successor of the classical formats OTF (used, e.g., by Vampir) and Epilog (used by Scalasca). A tool like Vampir can then be used to give a visual representation of the information contained in these files.
Chapter 3

Application Instrumentation

Score-P provides several possibilities to instrument user application code. Besides the automatic compiler-based instrumentation (Section 'Automatic Compiler Instrumentation'), it provides manual instrumentation using the Score-P User API (Section 'Manual Region Instrumentation'), semi-automatic instrumentation using POMP2 directives (Section 'Semi-Automatic Instrumentation of POMP2 User Regions') and, if configured, automatic source-code instrumentation using the PDToolkit-based instrumenter (Section 'Source-Code Instrumentation Using PDT').

As well as user routines and specified source regions, Score-P currently supports the following kinds of events:

**MPI library calls:** Instrumentation is accomplished using the standard MPI profiling interface PMPI. To enable it, the application program has to be linked against the Score-P MPI (or hybrid) measurement library plus MPI-specific libraries. Note that the Score-P libraries must be linked **before** the MPI library to ensure interposition will be effective.

**SHMEM library calls:** Instrumentation is accomplished using the SHMEM profiling interface or the GNU linker for library wrapping. To enable it, the application program has to be linked against the Score-P SHMEM (or hybrid) measurement library plus SHMEM-specific libraries. Note that the Score-P libraries must be linked **before** the SHMEM library to ensure interposition will be effective.

**OpenMP directives & API calls:** The Score-P measurement system uses the OPARI2 tool for instrumentation of OpenMP constructs. See the OPARI2 documentation on how to instrument OpenMP source code. In addition, the application must be linked with the Score-P OpenMP (or hybrid) measurement library.

**Pthread library calls:** The Score-P measurement system uses GNU linker for instrumentation of Pthreads library calls. At the moment only a few library calls are supported.

**I/O library calls:** The Score-P measurement system supports instrumentation of calls to POSIX I/O and MPI I/O routines.

The Score-P instrumenter command `scorep` automatically takes care of compilation and linking to produce an instrumented executable. For manual builds or build-systems based on plain Makefiles it is usually sufficient to prefix the compiler or compiler definitions like `CC` or `MPICC` (and equivalents) with the `scorep` instrumenter command, see below.

More complex build-systems that consist of a configuration-step and a make-step, like autotools and CMake, need to be handled differently. We need to take care that `scorep` is invoked during the make-step only to not confuse the configuration-step by additional Score-P output. To address this issue we provide so called Score-P compiler wrappers. Section 'Score-P Compiler Wrapper Usage' explains their usage in detail and provides CMake and autotools examples.

Usually the Score-P instrumenter `scorep` is able to automatically detect the programming paradigm from the set of compile and link options given to the compiler. In some cases however, when the compiler or compiler wrapper
enables specific programming paradigm by default (e.g., Pthreads on Cray and Blue Gene/Q systems) or using non-standard ways of activating features (e.g., providing the OpenMP runtime via \texttt{-lgomp} instead of \texttt{-fopenmp} as seen with CMake), \texttt{scorep} needs to be made aware of the programming paradigm in order to do the correct instrumentation. Please see \texttt{scorep --help} for the available options.

When using Makefiles, it is often convenient to define a "preparation preposition" placeholder (e.g., \texttt{PREP}) which can be prefixed to (selected) compile and link commands:

\begin{verbatim}
MPICC = $(PREP) mpicc
MPICXX = $(PREP) mpicxx
MPIF90 = $(PREP) mpif90
\end{verbatim}

These can make it easier to prepare an instrumented version of the program with

\begin{verbatim}
make PREP="scorep"
\end{verbatim}

while default builds (without specifying \texttt{PREP} on the command line) remain fully optimized and without instrumentation.

In order to instrument applications which employ GNU Autotools for building, following instrumentation procedure has to be used:

1. Configure application as usual, but provide additional argument:

   \begin{verbatim}
   --disable-dependency-tracking
   \end{verbatim}

2. Build application using \texttt{make} command with compiler specification variables set as follows:

\begin{verbatim}
make CC="scorep <your-cc-compiler>" \\
CXX="scorep <your-cxx-compiler>" \\
FC="scorep <your-fc-compiler>" ...
\end{verbatim}

When compiling without the Score-P instrumenter, the \texttt{scorep-config} command can be used to simplify determining the appropriate linker flags and libraries, or include paths:

\begin{verbatim}
scorep-config [--mpp=none|--mpp=mpi|--mpp=shmem] \\
[--thread=none|--thread=omp|--thread=pthread] --libs
\end{verbatim}

The \texttt{--mpp=<paradigm>} switch selects which message passing paradigm is used. Currently, Score-P supports applications using MPI (\texttt{--mpp=mpi}) or SHMEM (\texttt{--mpp=shmem}) and applications without any message passing paradigm. It is not possible to specify two message passing systems for the same application. The \texttt{--thread=<paradigm>} switch selects which threading system is used in Score-P. You may use OpenMP (\texttt{--thread=omp}), no threading system (\texttt{--thread=none}) or POSIX threading system (\texttt{--thread=pthread}). It is not possible to specify two threading systems for the same application. However, you may combine a message passing system with a threading system.
A particular installation of Score-P may not offer all measurement configurations!

The scorep-config command can also be used to determine the right compiler flags for specifying the include directory of the scorep/SCOREP_User.h or scorep/SCOREP_User.inc header files. When compiling without using the Score-P instrumenter, necessary defines and compiler instrumentation flags can be obtained by calling one of the following, depending on the language:

```
scorep-config --cflags [options]
scorep-config --cxxflags [options]
scorep-config --fflags [options]
```

If you compile a C file, you should use --cflags. If you use a C++ program, you should use --cxxflags. And if you compile a Fortran source file, you should use --flags.

With the additional options it is possible to select the used adapter, the threading system and the message passing system. For each adapter, we provides a pair of flags of the form --adapter, and --noadapter (please replace adapter by the name of the adapter). This allows to get options for non-default instrumentation possibilities. E.g., --user enables the manual instrumentation with the Score-P user API, the --nocompiler option disables compiler instrumentation.

Note

Disabling OpenMP measurements with the --noopenmp flag, disables all except parallel regions. Internally Score-P needs to track events on a per-thread basis and thus needs to be aware of the creation and destruction of OpenMP threads. Accordingly these regions will also show up in the measurements.

Score-P supports a variety of instrumentation types for user-level source routines and arbitrary regions, in addition to fully-automatic MPI and OpenMP instrumentation, as summarized in Table Score-P instrumenter option overview.

When the instrumenter determines that MPI or OpenMP are being used, it automatically enables MPI library instrumentation or OPARI2-based OpenMP instrumentation, respectively. The default set of instrumented MPI library functions is specified when Score-P is installed. All OpenMP parallel constructs and API calls are instrumented by default.

Note

To fine-tune instrumentation of OpenMP regions, use the --opari=<parameter-list> option. For available parameters please refer to the OPARI2 manual.

Note

Since Score-P version 1.3 there were two variants of internal OpenMP data handling, namely --thread=omp:pomp_tpd and --thread=omp:ancestry, depending on the functionality available on the target system. From Score-P version 4 on, due to internal refactorings, we replace the two OpenMP threading variants by only one: --thread=omp. The possible options are detected at configure time. If both are available, the ancestry mechanism will be used by default.

By default, automatic instrumentation of user-level source routines by the compiler is enabled (equivalent to specifying --compiler). The compiler instrumentation can be disabled with --nocompiler when desired, such as when using PDTToolkit, or POMP2 or Score-P user API manual source annotations, are enabled with --pdt, --pomp and --user, respectively. Compiler, PDToolkit, POMP2 and Score-P user API instrumentation can all be used simultaneously, or in arbitrary combinations, however, it is generally desirable to avoid instrumentation duplication (which would result if all are used to instrument the same routines). Note that enabling PDToolkit instrumentation automatically enables Score-P user instrumentation, because it inserts Score-P user macros into the source code.

Sometimes it is desirable to explicitly direct the Score-P instrumenter to do nothing except execute the associated compile/link command. For such cases it is possible to disable default instrumentation with --nocompiler, --thread=none, and/or --mpp=none. Although no instrumentation is performed, this can help verify that the Score-P instrumenter correctly handles the compile/link commands.

Note

Disabling OpenMP in the instrumenter for OpenMP applications will cause errors during program execution if any event occurs inside of a parallel region.
### Table 3.1 Score-P instrumenter option overview

<table>
<thead>
<tr>
<th>Type of instrumentation</th>
<th>Instrumenter switch</th>
<th>Default value</th>
<th>Instrumented routines</th>
<th>Runtime measurement control</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPI</td>
<td>--mpp=mpi/</td>
<td>(auto)</td>
<td>configured by install</td>
<td>'Selection of MPI Groups'</td>
</tr>
<tr>
<td></td>
<td>--mpp=none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHMEM</td>
<td>--mpp=shmemp/</td>
<td>(auto)</td>
<td>configured by install</td>
<td></td>
</tr>
<tr>
<td></td>
<td>--mpp=none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUDA</td>
<td>--[no]cuda</td>
<td>enabled</td>
<td>all</td>
<td>'CUDA Performance Measurement'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OpenCL</td>
<td>--[no]opencl</td>
<td>enabled</td>
<td>configured by install</td>
<td>'OpenCL Performance Measurement'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OpenACC</td>
<td>--[no]openacc</td>
<td>enabled</td>
<td>configured by install</td>
<td>'OpenACC Performance Measurement'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OpenMP</td>
<td>--thread=omp/</td>
<td>(auto)</td>
<td>all parallel constructs, see Note below</td>
<td></td>
</tr>
<tr>
<td></td>
<td>--[no]openmp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pthread</td>
<td>--thread=pthread</td>
<td>(auto)</td>
<td>Basic Pthread library calls</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Automatic Compiler Instrumentation'</td>
<td>--[no]compiler</td>
<td>enabled</td>
<td>all</td>
<td>'Filtering'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Recording of I/O activities'</td>
<td>--[no]io=...</td>
<td>disabled</td>
<td>configured by install</td>
<td>'Recording of I/O activities'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Source-Code Instrumentation Using PDT'</td>
<td>--[no]pdt</td>
<td>disabled</td>
<td>all</td>
<td>'Filtering'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Semi-Automatic Instrumentation of POMP2 User Regions'</td>
<td>--[no]pomp</td>
<td>disabled</td>
<td>manually annotated</td>
<td>'Filtering'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Manual Region Instrumentation'</td>
<td>--[no]user</td>
<td>disabled</td>
<td>manually annotated</td>
<td>'Filtering' and 'Selective Recording'</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Score-P User Library Wrapping'</td>
<td>--libwrap=[...]</td>
<td>disabled</td>
<td>all by library wrapper</td>
<td>'Filtering'</td>
</tr>
</tbody>
</table>

#### 3.1 Automatic Compiler Instrumentation

Most current compilers support automatic insertion of instrumentation calls at routine entry and exit(s), and Score-P can use this capability to determine which routines are included in an instrumented measurement.

Compiler instrumentation of all routines in the specified source file(s) is enabled by default by Score-P, or can be explicitly requested with --compiler. Compiler instrumentation is disabled with --nocompiler.

**Note**

Depending on the compiler, and how it performs instrumentation, insertion of instrumentation may disable in-lining and other significant optimizations, or in-lined routines may not be instrumented at all (and therefore "invisible").

Automatic compiler-based instrumentation has been tested with a number of different compilers:
3.2 Manual Region Instrumentation

- GCC (UNIX-like operating systems, not tested with Windows)
- Clang/LLVM (UNIX-like operating systems, not tested with Windows)
- IBM xlc, xIC (version 7 or later, IBM Blue Gene)
- IBM xlf (version 9.1 or later, IBM Blue Gene)
- PGI (on Linux)
- Intel compilers (version 10 or later, Linux)
- SUN Studio compilers (Linux, Fortran only)

In all cases, Score-P supports automatic instrumentation of C, C++ and Fortran codes, except for the SUN Studio compilers which only provide appropriate support in their Fortran compiler and the Clang compiler which provides support for instrumentation of C/C++ codes.

Note

The automatic compiler instrumentation might create a significant relative measurement overhead on short function calls. This can impact the overall application performance during measurement. C++ applications are especially prone to suffer from this, depending on application design and whether C++ STL functions are also instrumented by the compiler. Currently, it is not possible to prevent the instrumentation of specific functions on all platforms when using automatic compiler instrumentation.

Note

As an exception, instrumentation via the GCC plug-in or Intel compilers support all filtering features when using the Score-P option --instrument-filter=<file>. This option may require an absolute file path. Note that the GCC plug-in instrumentation by default does not instrument functions declared as inline. By providing a filter that matches inline functions in an explicit INCLUDE rule, the default behavior can be overridden. This INCLUDE is not allowed to be the match-all rule INCLUDE * (see Sec. 'Filtering').

Note

CMake marks headers from imported targets as system headers, which consequently marks functions contained in these headers uninstrumentable by the GCC compiler instrumentation. The CMake option -DCMAKE_NO_SYSTEM_FROM_IMPORTED can be used to circumvent this marking, thus ensuring full instrumentation coverage of these targets, if this is desired (see previous note).

Names provided for instrumented routines depend on the compiler, which may add underscores and other decorations to Fortran and C++ routine names, and whether name “demangling” has been enabled when Score-P was installed and could be applied successfully.

3.2 Manual Region Instrumentation

In addition to the automatic compiler-based instrumentation (see Section 'Automatic Compiler Instrumentation'), instrumentation can be done manually. Manual instrumentation can also be used to augment automatic instrumentation with region or phase annotations, which can improve the structure of analysis reports. Furthermore, it offers the possibility to record additional, user defined metrics. Generally, the main program routine should be instrumented, so that the entire execution is measured and included in the analysis.

Instrumentation can be performed in the following ways, depending on the programming language used.

Fortran:
CHAPTER 3. APPLICATION INSTRUMENTATION

```c
#include "scorep/SCOREP_User.inc"

subroutine foo
    SCOREP_USER_REGION_DEFINE( my_region_handle )
    ! more declarations
    SCOREP_USER_REGION_BEGIN( my_region_handle, "foo",
        SCOREP_USER_REGION_TYPE_COMMON )
    ! do something
    SCOREP_USER_REGION_END( my_region_handle )
end subroutine foo

C/C++:

#include <scorep/SCOREP_User.h>

void foo()
{
    SCOREP_USER_REGION_DEFINE( my_region_handle )
    // more declarations
    SCOREP_USER_REGION_BEGIN( my_region_handle, "foo",
        SCOREP_USER_REGION_TYPE_COMMON )
    // do something
    SCOREP_USER_REGION_END( my_region_handle )
}

C++ only:

#include <scorep/SCOREP_User.h>

void foo()
{
    SCOREP_USER_REGION( "foo", SCOREP_USER_REGION_TYPE_FUNCTION
        )
    // do something
}

Note

When using Fortran, make sure the C preprocessor expands the macros. In most cases, the fortran compiler invoke the C preprocessor if the source file suffix is in capital letters. However, some compilers provide extra flags to tell the compiler to use a C preprocessor. Furthermore, it is important to use the C-like #include with the leading '#' character to include the SCOREP_User.inc header file. Otherwise, the inclusion may happen after the C preprocessor ran. As result the fortran compiler complains about unknown preprocessing directives.

Region handles (my_region_handle) should be registered in each annotated function/subroutine prologue before use within the associated body, and should not already be declared in the same program scope.

For every region, the region type can be indicated via the region type flag. Possible region types are:

- **SCOREP_USER_REGION_TYPE_COMMON** Indicates regions without a special region type.
- **SCOREP_USER_REGION_TYPE_FUNCTION** Indicates that the region is a function or subroutine
- **SCOREP_USER_REGION_TYPE_LOOP** Indicates that the region is the body of a loop, with the same number of iterations in all locations.
- **SCOREP_USER_REGION_TYPE_DYNAMIC** Set this type to create a separate branch in the call-tree for every execution of the region. See Section 'Dynamic Region Profiling'.
3.2 Manual Region Instrumentation

**SCOREP_USER_REGION_TYPE_PHASE** Indicates that this region belongs to a special phase. See Section ‘Phase Profiling’.

To create a region of combined region types you can connect two or more types with the binary OR-operator, e.g.:

```c
SCOREP_USER_REGION_BEGIN( handle, "foo",
    SCOREP_USER_REGION_TYPE_LOOP |
    SCOREP_USER_REGION_TYPE_PHASE |
    SCOREP_USER_REGION_TYPE_DYNAMIC )
```

For function instrumentation in C and C++, Score-P provides macros, which automatically pass the name and function type to Score-P measurement system. The **SCOREP_USER_FUNC_BEGIN** macro contains a variable definition. Thus, compilers that require strict separation of declaration and execution part, may not work with this macro.

C/C++:

```c
#include <scorep/SCOREP_User.h>

void foo()
{
    SCOREP_USER_FUNC_BEGIN()
    // do something
    SCOREP_USER_FUNC_END()
}
```

In some cases, it might be useful to have the possibility to define region handles with a global scope. In C/C++, a region handle can be defined at a global scope with **SCOREP_USER_GLOBAL_REGION_DEFINE**. In this case, the **SCOREP_USER_REGION_DEFINE** must be omitted. The **SCOREP_USER_GLOBAL_REGION_DEFINE** must only appear in one file. To use the same global variable in other files, too, declare the global region in other files with **SCOREP_USER_GLOBAL_REGION_EXTERNAL**.

File 1:

```c
SCOREP_USER_GLOBAL_REGION_DEFINE( global_handle )

foo()
{
    SCOREP_USER_REGION_BEGIN( global_handle, "phase 1",
        SCOREP_USER_REGION_TYPE_PHASE)
    // do something
    SCOREP_USER_REGION_END( global_handle )
}
```

File 2:

```c
SCOREP_USER_GLOBAL_REGION_EXTERNAL( global_handle )

bar()
{
    SCOREP_USER_REGION_BEGIN( global_handle, "phase 1",
        SCOREP_USER_REGION_TYPE_PHASE)
    // do something
    SCOREP_USER_REGION_END( global_handle )
}
```
Note

These macros are not available in Fortran.

In addition, the macros `SCOREP_USER_REGION_BY_NAME_BEGIN(name, type)` and `SCOREP_USER_REGION_BY_NAME_END(name)` are available. These macros might introduce more overhead than the standard macros but can annotate user regions without the need to take care about the handle struct. This might be useful for automatically generating instrumented code or to avoid global declaration of this variable.

C/C++:

```c
#include <scorep/SCOREP_User.h>

/* Application functions are already instrumented with these two calls. */
void instrument_begin(const char* regionname)
{
    /* code added for Score-P instrumentation */
    SCOREP_USER_REGION_BY_NAME_BEGIN( regionname, SCOREP_USER_REGION_TYPE_COMMON )
}

void instrument_end(const char* regionname)
{
    SCOREP_USER_REGION_BY_NAME_END( regionname )
}
```

Fortran:

```fortran
#include "scorep/SCOREP_User.inc"

subroutine instrument_begin(regionname)
    character(len=*) :: regionname
    SCOREP_USER_REGION_BY_NAME_BEGIN( regionname, SCOREP_USER_REGION_TYPE_COMMON )
end subroutine instrument_begin

subroutine instrument_end(regionname)
    character(len=*) :: regionname
    SCOREP_USER_REGION_BY_NAME_END( regionname )
end subroutine instrument_end
```

Note

When using the "BY_NAME" macros in Fortran, be aware of section 12.4.1.1 of the F90/95/2003 standard. If you pass `name` through a dummy argument of a subroutine the length `len` of the character array `name` must be exactly the size of the actual string passed. In the Fortran examples above this is assured by `len=*`.

Note

To ensure correct nesting, avoid automatic compiler instrumentation for these helper functions.

The source files instrumented with Score-P user macros have to be compiled with `-DScoreP_USER_ENABLE` otherwise Score-P calls expand to nothing and are ignored. If the Score-P instrumenter --user flag is used, the `SCOREP_USER_ENABLE` symbol will be defined automatically. Also note, that Fortran source files instrumented this way have to be preprocessed with the C preprocessor (CPP).

Manual routine instrumentation in combination with automatic source-code instrumentation by the compiler or PDT leads to double instrumentation of user routines, i.e., usually only user region instrumentation is desired in this case.
3.3 Instrumentation for Parameter-Based Profiling

The Score-P user API provides also macros for parameter-based profiling. In parameter-based profiling, the parameters of a function are used to split up the call-path for executions of different parameter values. In Score-P parameter-based profiling is supported for integer and string parameters. To associate a parameter value to a region entry, insert a call to `SCOREP_USER_PARAMETER_INT64` for signed integer parameters, `SCOREP_USER_PARAMETER_UINT64` for unsigned integer parameters, or `SCOREP_USER_PARAMETER_STRING` for string parameters after the region entry (e.g., after `SCOREP_USER_REGION_BEGIN` or `SCOREP_USER_FUNCTION_REGION_BEGIN`).

Fortran:

```fortran
#include "scorep/SCOREP_User.inc"

subroutine foo(i, s)
  integer :: i
  character (*) :: s
  SCOREP_USER_REGION_DEFINE( my_region_handle )
  SCOREP_USER_PARAMETER_DEFINE( int_param )
  SCOREP_USER_PARAMETER_DEFINE( string_param )
  SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region", SCOREP_USER_REGION_TYPE_COMMON )
  SCOREP_USER_PARAMETER_INT64(int_param, "myint",i)
  SCOREP_USER_PARAMETER_UINT64(uint_param, "myuint",i)
  SCOREP_USER_PARAMETER_STRING(string_param, "mystring",s)
  // do something
  SCOREP_USER_REGION_END( my_region_handle )
end subroutine foo
```

C/C++:

```c
#include <scorep/SCOREP_User.h>

void foo(int64_t myint, uint64_t myuint, char *mystring)
{
  SCOREP_USER_REGION_DEFINE( my_region_handle )
  SCOREP_USER_REGION_DEFINE( int_param )
  SCOREP_USER_REGION_BEGIN( my_region_handle, "foo", SCOREP_USER_REGION_TYPE_COMMON )
  SCOREP_USER_PARAMETER_INT64("myint",myint)
  SCOREP_USER_PARAMETER_UINT64("myuint",myuint)
  SCOREP_USER_PARAMETER_STRING("mystring",mystring)
  // do something
  SCOREP_USER_REGION_END( my_region_handle )
}
```

In C/C++, only a name for the parameter and the value needs to be provided. In Fortran, the handle must be defined first with `SCOREP_USER_PARAMETER_DEFINE`. The defined handle name must be unique in the current scope. The macro `SCOREP_USER_PARAMETER_INT64` as well as the macro `SCOREP_USER_PARAMETER_STRING` need the handle as the first argument, followed by the name and the value.

**Note**

If a region that has parameters triggers a user metric, the metric must be triggered after the parameters are provided.

**Note**

The order of the parameters is important. If the region will have different orders for the same parameters, than only one will survive in the measurement data. Also in Cube, parameters are grouped into numeric and string types, thus the order will may be different than the instrumentation.
3.4 Measurement Control Instrumentation

The Score-P user API also provides several macros for measurement control that can be incorporated in source files and activated during instrumentation. The macro SCOREP_RECORDING_OFF can be used to (temporarily) pause recording until a subsequent SCOREP_RECORDING_ON. Just like the already covered user-defined annotated regions, SCOREP_RECORDING_ON and the corresponding SCOREP_RECORDING_OFF must be correctly nested with other enter/exit events. Please beware that if program start is recorded, i.e., main or MAIN_ are instrumented and not filtered, the recording needs to be switched on before program end in order to get valid measurements. Finally, with SCOREP_RECORDING_IS_ON you can test whether recording is switched on.

Events are not recorded when recording is switched off (though associated definitions are), resulting in smaller measurement overhead. In particular, traces can be much smaller and can target specific application phases (e.g., excluding initialization and/or finalization) or specific iterations. Since the recording switch is process-local, and effects all threads on the process, it can only be initiated outside of OpenMP parallel regions. Switching recording on/off is done independently on each MPI process without synchronization.

Note

Switching recording on/off may result in inconsistent traces or profiles, if not applied with care. In particular, if communication is recorded incomplete (e.g., if the send is missing but the corresponding receive event is recorded) it may result in errors during execution or analysis. Furthermore, it is not possible to switch recording on/off from within parallel OpenMP regions. We recommend to use the selective recording interface, instead of the manual on/off switch whenever possible. Special care is required in combination with selective recording (see Section 'Selective Recording', which also switches recording on/off.

3.5 Source-Code Instrumentation Enabling Online Access

The Online Access interface to the measurement system of Score-P allows remote control of measurement and access to the profile data. The online access interface may not be available on all platforms. To use the Online Access interface, Score-P must have been built with Online Access (OA) support.

The Online Access module requires the user to specify at least one online access phase. The online access phase does not show the behavior of a region of type phase as defined in Section 'Manual Region Instrumentation'. However, the way to specify an online access phase is similar to manual region instrumentation. The start and end of the online access phase defines the interaction points, where new measurement control commands are applied and data requests are answered.

To insert an online access phase into the code, the user has to insert the macros SCOREP_USER_OA_PHASE_BEGIN and the corresponding SCOREP_USER_OA_PHASE_END at appropriate locations. These macros must be

• correctly nested with all regions and
• must be potential global synchronization points.

Common practice is to mark the body of the application's main loop as online access phase, in order to utilize the main loop iterations for iterative online analysis. Only the measurements collected inside the OA phase could be configured and retrieved.

Instrumentation can be performed in the following ways, depending on the programming language used.

Fortran:
3.6 Semi-Automatic Instrumentation of POMP2 User Regions

Note
Since Score-P version 1.4, OpenMP instrumentation using OPARI2 no longer activates POMP2 instrumentation implicitly. You need to explicitly add the `--pomp` option to the Score-P instrumenter.

If you manually instrument the desired user functions and regions of your application source files using the POMP2 \texttt{INST} directives described below, the Score-P instrumenter `--pomp` flag will generate instrumentation for them. POMP2 instrumentation directives are supported for Fortran and C/C++. The main advantages are that

- being directives, the instrumentation is ignored during "normal" compilation and
- this semi-automatic instrumentation procedure can be used when fully automatic compiler instrumentation is not supported.

The \texttt{INST BEGIN/END} directives can be used to mark any user-defined sequence of statements. If this block has several exit points (as is often the case for functions), all but the last have to be instrumented by \texttt{INST ALTEND}.

Fortran:

```fortran
subroutine foo(...) !declarations
  !POMP$ INST BEGIN(foo)
  ...
  if (<condition>) then
    !POMP$ INST ALTEND(foo)
    return
  end if
  !POMP$ INST END(foo)
end subroutine foo
```
C/C++:

```c
void foo(...) {
    /* declarations */
    #pragma pomp inst begin(foo)
    ...
    if (<condition>)
    {
        #pragma pomp inst altend(foo)
        return;
    }
    ...
    #pragma pomp inst end(foo)
}
```

At least the main program function has to be instrumented in this way, and additionally, one of the following should be inserted as the first executable statement of the main program:

Fortran:

```fortran
program main
    ! declarations
    !POMP$ INST INIT
    ...
end program main
```

C/C++:

```c
int main(int argc, char** argv)
{
    /* declarations */
    #pragma pomp inst init
    ...
}
```

By default, the source code is preprocessed before POMP2 instrumentation happens. For more information on the preprocessing, see Section 'Preprocessing before POMP2 and OpenMP instrumentation'.

### 3.7 Preprocessing before POMP2 and OpenMP Instrumentation

By default, source files are preprocessed before the semi-automatic POMP2 instrumentation or the OpenMP construct instrumentation with OPARI2 happens. This ensures, that all constructs and regions that might be contained in header files, templates, or macros are properly instrumented. Furthermore, conditional compilation directives take effect, too. The necessary steps are performed by the Score-P instrumenter tool.

Some Fortran compilers do not regard information about the original source location that the preprocessing leaves in the preprocessed code. This causes wrong source code information for regions from compiler instrumentation, and manual source code instrumentation. However, these compilers also disregard the source code information left by OPARI2. Thus, for these compilers the source location information is incorrect anyway.

If the preprocessing is not desired, you can disable it with the `--nopreprocess` flag. In this case the instrumentation is performed before the preprocessing happens. In this case constructs and regions in header files, macros, or templates are not instrumented. Conditional compilation directives around constructs may also lead to broken instrumentation.

**Note**

If a parallel region is not instrumented, the application will crash during runtime.

The preprocessing does not work in combination with PDT source code instrumentation. Thus, if PDT instrumentation is enabled, it changes the default to not preprocess a source file. If you manually specify preprocessing and PDT source code instrumentation, the instrumenter will abort with an error.
3.8 Source-Code Instrumentation Using PDT

3.8 Source-Code Instrumentation Using PDT

If Score-P has been configured with PDTToolkit support, automatic source-code instrumentation can be used as an alternative instrumentation method. In this case, the source code of the target application is pre-processed before compilation, and appropriate Score-P user API calls will be inserted automatically. However, please note that this feature is still somewhat experimental and has a number of limitations (see Section 'Limitations').

To enable PDT-based source-code instrumentation, call scorep with the --pdt option, e.g.,

   scorep --pdt mpicc -c foo.c

This will by default instrument all routines found in foo.c. (To avoid double instrumentation, automatic compiler instrumentation is disabled when using Source-Code Instrumentation with PDT. However, if you can enforce additional compiler instrumentation with --compiler.) The underlying PDT instrumentor supports a set a instrumentation options, which can be set like

   scorep --pdt="-f <inclusion/exclusion file>" mpicc -c foo.c

This particular option for example can be used to manually include/exclude specific functions from the instrumentation process. The respective file format is described here. Please check the documentation about the tau_← instrumentor for more valid options.

3.8.1 Limitations

Currently the support for the PDT-based source-code instrumenter still has a number of limitations:

- When instrumenting Fortran 77 applications, the inserted instrumentation code snippets do not yet adhere to the Fortran 77 line length limit. Typically, it is possible to work around this issue by supplying extra command line flags (e.g., -ffixed-line-length-132 or -qfixed=132) to the compiler.

- Code in C/C++ header files as well as included code in Fortran (either using the C preprocessor or the include keyword) will currently not be instrumented.

- Support for C++ templates and classes is currently only partially implemented.

- Advanced TAU instrumentation features such as static/dynamic timers, loop, I/O and memory instrumentation are not yet supported. Respective entries in the selective instrumentation file will be ignored.

3.9 User Library Wrapping

User library wrapping enables you to install library wrappers for any C/C++ library you want.

Without this mechanism, in order to intercept calls to a library, you would need to either build this library with Score-P or add manual instrumentation to the application using the library. Another advantage of user library wrapping is you don't need access to the source code of the to-be-wrapped library. Headers and library files suffice.

This feature requires Score-P to be configured with libclang. You can find out whether user library wrapping is enabled via scorep-info config-summary in Section "Score-P (libwrap)".

This section covers how to use already installed wrappers. Appendix 'Score-P User Library Wrapping' explains how to create user library wrappers, and provides additional details.

To find out which user library wrappers are installed call
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$ scorep-info libwrap-summary

It lists all found wrappers, either installed into Score-P's installation directory or found via the SOCP_LIBWRAP environment variable. Optionally you can run

$ scorep-info libwrap-summary <wrappername>

to show the configuration of a specific wrapper.

You can then use Score-P to link your application in the usual way and additionally provide --libwrap=[<wrapmode>:]<wrappername> to enable library wrapping for the target library.

Example with only relinking the application:

$ scorep --libwrap=fftw3 gcc -o main main.o -L$FFTW_LIB -lfftw3

Example with both recompiling and linking the application:

$ scorep --libwrap=fftw3 --nocompiler gcc -o main -I$FFTW_INC main.c \
   -L$FFTW_LIB -lfftw3

3.9.1 Runtime vs Linktime Wrapping

There exist two ways to wrap calls to the to-be-wrapped (or target-) library. The main difference lies in when the actual wrapping takes place - at linktime or runtime. While they are in essence the same, they differ in which function calls can be intercepted. Specifically:

**linktime**: Wraps calls originating from object files that are part of the linker command line. In addition, calls originating from static libraries are wrapped as well. The actual technique used is the `--wrap` linker flag.

**runtime**: Wraps all calls that linktime wrapping would, plus those which originate from already linked shared objects. The actual technique used is replacing the original function of the target library and using `dlopen` and `dlsym` in the wrapper to open the target library plus finding and calling the original function.

You can choose linktime or runtime wrapping manually via the `--libwrap` flag by prefixing the wrapper name with either `linktime:` or `runtime:`.

3.10 Recording of I/O activities

Score-P checks for availability of several I/O paradigm at configure time. Please have a look at the configure summary to get an overview of the detected I/O routines. You can provide multiple options to the scorep instrumenter to record I/O routines of multiple paradigms at a time. In the following example Score-P will instrument calls to POSIX I/O routines.

    scorep --io=posix mpicc foo.c -o foo

In addition calls to MPI I/O routines are automatically instrumented if the MPI programming paradigm is detected by the scorep instrumenter.
3.11 Enforce Linking of Static/Shared Score-P Libraries

If the Score-P was build with shared libraries and with static libraries, the instrumenter uses the compiler defaults for linking. E.g., if the compiler chooses shared libraries by default, the instrumenter will link your application with the shared Score-P libraries. Furthermore, the linking is affected by parameters in the original link command. E.g., if your link command contains a `-Bstatic` flag, afterwards appended Score-P libraries are also linked statically.

If you want to override the default and enforce linking of static or dynamic Score-P libraries, you can add the flag `--static` or `--dynamic` for the instrumenter. E.g., a command to enforce static linking can look like:

```
scorep --static mpicc foo.c -o foo
```

In this case, the linking against the static version of the Score-P libraries is enforced.

If enforcing static or dynamic linking is not possible on your system, e.g., because no static/dynamic Score-P libraries are installed, the instrumenter will abort with an error. You can determine whether `--static` or `--dynamic` is available from the output of `scorep --help`. If the `--static` or `--dynamic` flags are not shown, then they are not available.
Chapter 4

Application Sampling

This document describes how to use the sampling options within Score-P.

4.1 Introduction

Score-P supports sampling that can be used concurrently to instrumentation to generate profiles and traces. In the following, we will describe how sampling differs from instrumentation. Reading this text will help you to interpret resulting performance data. However, if you are aware of how sampling works, you can skip the preface.

In our context, we understand sampling as a technique to capture the behavior and performance of programs. We interrupt the running programs at a specified interval (the sampling period) and capture the current state of the program (i.e., the current stack) and performance metrics (e.g., PAPI). The obtained data is then further stored as a trace or a profile and can be used to analyze the behavior of the sampled program.

Before version 2.0 of Score-P, only instrumentation-based performance analysis had been possible. Such an instrumentation relies on callbacks to the measurement environment (instrumentation points), e.g., a function enter or exit. The resulting trace or profile presented the exact runtimes of the functions, augmented with performance data and communication information. However, instrumentation introduces a constant overhead for each of the instrumentation points. For small instrumented functions, this constant overhead can be overwhelming.

Sampling provides the opportunity to prevent this overwhelming overhead, and even more, the overhead introduced by sampling is controllable by setting the sampling rate. However, the resulting performance data is more "fuzzy". Not every function call is captured and thus the resulting data should be analyzed carefully. Based on the duration of a function and the sampling period, a function call might or might not be included in the gathered performance data. However, statistically, the profile information is correct. Additionally, the sampling rate allows to regulate the trade-off between overhead and correctness, which is not possible for instrumentation.

In Score-P we support both instrumentation and sampling. This allows you for example to get a statistical overview of your program as well as analyzing the communication behavior. If a sample hits a function that is known to the measurement environment via instrumentation (e.g., by OPARI2), the sample will show the same function in the trace and the profile.
4.2 Prerequisites

This version of Score-P provides support for sampling. To enable sampling, several prerequisites have to be met.

- **libunwind**: 
  Additionally to the usual configuration process of Score-P, libunwind is needed. libunwind can be installed using a standard package manager or by downloading the latest version from [http://download.savannah.gnu.org/releases/libunwind/](http://download.savannah.gnu.org/releases/libunwind/). This library must be available at your system to enable sampling. In our tests, we used the most current stable version (1.1) as previous versions might result in segmentation faults.

- **Sampling Sources**: 
  Sampling sources generate interrupts that trigger a sample. We interface three different interrupt generators, which can be chosen at runtime.

  1. **Interval timer**: 
     Interval timers are POSIX compliant but provide a major drawback: They cannot be used for multi-threaded programs, but only for single-threaded ones. We check for `setitimer` that is provided by `sys/time.h`.

  2. **PAPI**: 
     We interface the PAPI library, if it is found in the configure phase. The PAPI interrupt source uses overflowing performance counters to interrupt the program. This source can be used in multi-threaded programs. Due to limitations from the PAPI library, PAPI counters will not be available if PAPI sampling is enabled. However, you can use `perf` metrics, e.g.,
     
     ```
     export SCOREP_METRIC_PERF=instructions:page-faults
     ```

  3. **perf**: 
     perf is comparable to PAPI but much more low-level. We directly use the system call. This source can be used in multi-threaded programs. PAPI counters are available if `perf` is used as an interrupt source. Currently we only provide a cycle based overflow counter via `perf`.

     We recommend using PAPI or `perf` as interrupt sources. However, these also pose a specific disadvantage when power saving techniques such as DVFS or idle states are active on a system. In this case, a constant sampling interval cannot be guaranteed. If, for example, an application calls a sleep routine, then the cycle counter might not increase as the CPU might switch to an idle state. This can also influence the result data. Such idling times can also be introduced by OpenMP runtimes and can be avoided by setting the block times accordingly or setting the environment variable `OMP_WAIT_POLICY` to `ACTIVE`.

4.3 Configure Options

4.3.1 libunwind

If libunwind is not installed in a standard directory, you can provide the following flags in the configure step:

```bash
--with-libunwind=(yes|no|<Path to libunwind installation>)
```

If you want to build scorep with libunwind but do not have a libunwind in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-libunwind is a shorthand for --with-libunwind-include=<Path/include> and --with-libunwind-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.

```bash
--with-libunwind-include=<Path to libunwind headers>
--with-libunwind-lib=<Path to libunwind libraries>
```
4.4 Sampling Related Score-P Measurement Configuration Variables

The following lists the Score-P measurement configuration variables which are related to sampling. Please refer to the individual variables for a more detailed description.

- **SCOREP_ENABLE_UNWINDING**
- **SCOREP_SAMPLING_EVENTS**
- **SCOREP_SAMPLING_SEP**
- **SCOREP_TRACING_CONVERT_CALLING_CONTEXT_EVENTS**

4.5 Use Cases

4.5.1 Enable unwinding in instrumented programs

Additionally to the instrumentation, you now see where the instrumented region has been called. A pure MPI instrumentation for example does not tell you which functions have been issuing communications. With unwinding enabled, this is revealed and stored in the trace or profile.

Instrument your program, e.g., with MPI instrumentation enabled.

```
scorep mpicc my_mpi_code.c -o my_mpi_application
```

Set the following environment variables:

```
export SCOREP_ENABLE_UNWINDING=true
export SCOREP_SAMPLING_EVENTS=
```

Run your program

```
mpirun -np 16 ./my_mpi_application
```

4.5.2 Instrument a hybrid parallel program and enable sampling

In this example you get rid of a possible enormous compiler instrumentation overhead but you are still able to see statistical occurrences of small code regions. The NAS Parallel Benchmark BT-MZ for example uses small sub functions within OpenMP parallel functions that increase the measurement overhead significantly when compiler instrumentation is enabled.

Instrument your program, e.g., with MPI and OpenMP instrumentation enabled.

```
scorep mpicc -fopenmp my_hybrid_code.c -o my_hybrid_application
```

Note: If you use the GNU compiler and shared libraries of Score-P you might get errors due to undefined references depending on your gcc version. Please add `--no-as-needed` to your scorep command line. This flag will add a GNU ld linker flag to fix undefined references when using shared Score-P libraries. This happens on systems using `--as-needed` as linker default. It will be handled transparently in future releases of Score-P.

Set the following environment variables:

```
export SCOREP_ENABLE_UNWINDING=true
```

If you want to use a sampling event and period differing from the default settings you additionally set:

```
export SCOREP_SAMPLING_EVENTS=PAPI_TOT_CYC@1000000
```

Run your program

```
mpirun -np 16 ./my_mpi_application
```
4.6 Test Environment

Example

4.6.1 Instrument NAS BT-MZ code

```
cd <NAS_BT_MZ_SRC_DIR>
vim config/make.def
```

Set add the Score-P wrapper to your MPI Fortran compiler.

```
MPIF77 = scorep mpif77
```

Recompile the NAS BT-MZ code.

```
make clean
make bt-mz CLASS=C NPROCS=128
```

4.6.2 Run instrumented binary

```
cd bin
sbatch run.slurm
```

Batch script example:

```
#!/bin/bash
#SBATCH --nodes=32
#SBATCH --tasks-per-node=4
#SBATCH --cpus-per-task=2
#SBATCH --time=00:30:00
export OMP_NUM_THREADS=2
export NPB_MZ_BLOAD=0
export SCOREP_ENABLE_TRACING=true
export SCOREP_ENABLE_PROFILING=false
export SCOREP_ENABLE_UNWINDING=true
export SCOREP_TOTAL_MEMORY=200M
export SCOREP_SAMPLING_EVENTS=perf_cycles@2000000
export SCOREP_EXPERIMENT_DIRECTORY='bt-mz_C.128x2_trace_unwinding'
srun ./bt-mz_C.128
```
Chapter 5

Application Measurement

If an application was instrumented with Score-P, you will get an executable, which you can execute like the uninstrumented application. After the application run, you will find an experiment directory as child of the current working directory, which contains all recorded data (note that there will be no directory if no substrate requested one). The experiment directory has the format `scorep-YYYYMMDD_HHMM_XXXXXXXX`, where `YYYYMMDD` and `HHMM` encodes the date followed by a series of random numbers. You may specify the name of the experiment directory by setting the environment variable `SCOREP_EXPERIMENT_DIRECTORY` to the desired name of the directory. Note that this directory will also be created directly under the current working directory. No parent directories will be created. If the directory already exists, the existing directory will be renamed by appending a date like above by default. You can let Score-P abort the measurement immediately by setting `SCOREP_OVERWRITE_EXPERIMENT_DIRECTORY` to `false` if the experiment directory already exists. This has only an effect if `SCOREP_EXPERIMENT_DIRECTORY` was set too.

In general, you can record a profile and/or a event trace. Whether a profile and/or a trace is recorded, is specified by the environment variables `SCOREP_ENABLE_PROFILING` and `SCOREP_ENABLE_TRACING`. If the value of this variables is zero or `false`, profiling/tracing is disabled. Otherwise Score-P will record a profile and/or trace. By default, profiling is enabled and tracing is disabled.

You may start with a profiling run, because of its lower space requirements. According to profiling results, you may configure the trace buffer limits, filtering or selective recording for recording traces.

Score-P allows to configure several parameters via environment variables. See Appendix 'Score-P Measurement Configuration' for a detailed description of how to configure the measurement.

5.1 Profiling

Score-P implements a call-tree based profiling system. Every node in the call tree represent a recorded region. The edges of the tree represent the caller-callee relationship: The children of a node are those regions, that are entered/exited within a region. The path from the root to an arbitrary node, represents a call-path. Thus, every node in the tree identifies also the call-path from the root to itself.

Together with a node, the statistics for the call-path are stored. By default, the runtime and the number of visits are recorded. Additionally, hardware counters can be configured and are stored for every call-path. User defined metrics are only stored in those nodes, where the metric was triggered.

For enabling profiling, set the `SCOREP_ENABLE_PROFILING` environment variable to 1 or `true`. After the execution of your application you will then find a file, named `profile.cubex` in your measurement directory, which you can display with the CUBE4 with `cube-qt profile.cubex`. The name of the profile can be changed
through the environment variable \texttt{SCOREP\_PROFILE\_BASE\_NAME}. The extension \texttt{.cubex} will be appended to the base name you specify in the environment variable \texttt{SCOREP\_PROFILE\_BASE\_NAME}.

By default, Score-P writes the profile in CUBE4 base format. Hereby, for every metric contains one value, usually only the sum. However, Score-P allows to store the profile in other formats. To change the default format, set the environment variable \texttt{SCOREP\_PROFILE\_FORMAT}. Please refer to the description of this variable for possible values.

Score-P records a call tree profile. The maximum call-path depth that is recorded is limited to 30, by default. This avoids extremely large profiles for recursive calls. However, this limit can be changed with the environment variable \texttt{SCOREP\_PROFILE\_MAX\_CALLPATH\_DEPTH}.

5.1.1 Parameter-Based Profiling

Parameter-based profiling allows to separate the recoded statistics for a region, depending on the values of one or multiple parameters. In the resulting call-tree, each occurred parameter-value will create a sub-node of the region. Every parameter has a parameter name. Thus, if multiple parameters are used, they can be distinguished and split the call-tree in the order of the parameter events. In the final call-tree it looks like every parameter-name/parameter-value pair is a separate region.

Currently, the only source for parameter events is manual instrumentation (see Section 'Instrumentation for Parameter-Based Profiling').

5.1.2 Phase Profiling

Phase-profiling allows, to group the execution of the application into logical phases. Score-P records a separate call-tree for every phase in the application. A phase starts when a region of type \texttt{SCOREP\_USER\_REGION\_TYPE\_PHASE} (see Section 'Manual Region Instrumentation') is entered. If the region is exited, the phase is left. If two phases are nested, then the outer phase is left, when the inner phase is entered. If the inner phase is exited, the outer phase is re-entered. Figure 5.1 shows the difference in the call-tree if the regions with the names phase1 and phase2 are not of type \texttt{SCOREP\_USER\_REGION\_TYPE\_PHASE} on the left side and the forest if they are of type \texttt{SCOREP\_USER\_REGION\_TYPE\_PHASE} on the right side.

If the phase consists of multiple partitions, and thus cannot be enclosed by a single code region, all code-regions that form the phase must have the same region handle. The possibility to define global region handles in C/C++ might be useful for the definition of phases that are have multiple partitions (see Section 'Manual Region Instrumentation').

5.1.3 Dynamic Region Profiling

When profiling, multiple visits of a call-path are summarized. However, e.g, for investigations in time-dependent behavior of an application, each iteration of a main loop (or some other region) should create a separate profile sub-tree. For such cases, Score-P allows to define regions to by of type dynamic. For dynamic regions, each entry of the region will create a separate path. For this cause, the Score-P profiling system creates an extra parameter, named \texttt{instance}. On each visit to a dynamic region, the instance parameter for this call-path is increased and triggered automatically. Thus, the every visit to a dynamic region generates a separate subtree in the profile.

As an example, let us assume that an application contains the regions \texttt{foo} and \texttt{main}, where \texttt{main} calls \texttt{foo} three times. A regular profile would show two call-paths:

- \texttt{main}
- \texttt{main/foo}
5.1 Profiling

Figure 5.1 Call-tree changes when using phases. The left side shows the calltree if no region is of type phase. The right side shows the call-tree forest with phases.

If foo is a dynamic region, the profile would contain additional sub-nodes for each visit of foo. The resulting profile would contain the following call-paths:

- main
- main/foo
- main/foo/instance=0
- main/foo/instance=1
- main/foo/instance=2

In this case main/foo contains the summarized statistics for all 3 visits, while main/foo/instance=0 contains the statistics for the first visits of the call-path.

Note

The enumeration of the instance is per call-path and not per dynamic region. In particular, if a dynamic region foo appears in 2 call-paths, it has 2 instance number 0, one in both call-paths. It is not a global enumeration of the visits to foo but enumerates the visits of foo in a particular call-path from 0 to N.

Currently, the only possibility to define dynamic regions is via the manual region instrumentation, described in Section 'Manual Region Instrumentation'.

Note

Using dynamic regions can easily create very large profiles. Thus, use this feature with care. If you are only interested in some parts of the application, selective recording (see Section 'Selective Recording') might be a memory space save alternative. Furthermore, you can use clustering (see Section 'Clustering') to reduce the memory requirements.
5.1.4 Clustering

Clustering allows to reduce the memory requirements of a dynamic region, by clustering similar sub-trees into one cluster. A visualization tool (like CUBE 4) might expand the clusters back to single iterations transparently. You can enable/disable clustering via the environment variable \texttt{SCOREP_PROFILING_ENABLE_CLUSTERING}. By default, clustering is enabled.

Currently, clustering is limited to the instances of one node in the call-tree. If a dynamic region appears on several call-paths, Score-P will only cluster one, and generate separate sub-trees for every iterations in all other call-paths. By default, Score-P will cluster the instances of that dynamic region call-path that it enters first. If you have only one call-path where a dynamic region occurs (e.g., if the body of the main loop is the only dynamic region), this region will be clustered automatically. Otherwise, we recommend to specify the region you want to cluster in the environment variable \texttt{SCOREP_PROFILING_CLUSTERED_REGION}.

\textbf{Note}

If the selected region appears on multiple call-paths, only one of them is clustered. Score-P chooses the call-path of that regions that it enters first. In particular, if the selected dynamic region is nested into itself, the outermost occurrence is clustered.

Furthermore, the clustered region must not be inside of a parallel region, but must be at a sequential part of the program. However, the clustered region may contain parallel regions.

Clustering is a lossy compression mechanism. The accuracy increases if more clusters are available. On the downside, more clusters require more memory. You can specify the number of clusters you want by setting the environment variable \texttt{SCOREP_PROFILING_CLUSTER_COUNT} to the number of clusters you want to have. The default cluster number is 64.

Furthermore, you can enforce a minimal structural similarity of instances of a cluster. Clusters that fit the minimal structural similarity requirements belong to the same equivalence class. Only instances of the same equivalence class will be clustered together. If you have more equivalence classes than the number of clusters you specified in \texttt{SCOREP_PROFILING_CLUSTER_COUNT}, the maximal number of clusters is increased. Thus, you might get more clusters than you specified.

The minimal structural similarity is defined by the clustering mode which can be set via the environment variable \texttt{SCOREP_PROFILING_CLUSTERING_MODE}. Please refer to the description of this variable for possible values.

5.1.5 Enabling additional debug output on inconsistent profiles

If the Score-P profiling system detects inconsistencies during measurement, it stops recording the profile and prints an error message. Examples for reasons of an inconsistent profile are, if the nesting order of function entries and exits is broken, or events appear for an uninitialized thread. This might indicate an bug of the profile, but typically the cause is an erroneous instrumentation. E.g., if manual instrumentation is applied, but not all possible exit points of a function are instrumented.

In order to support debugging of manual instrumentation, or during the development of own automatic instrumentation techniques, the profile can write additional information about its current state in a textual form into a file. This output may contain the following information:

- The current call stack of the failing thread
- The profile structure of the failing thread
- The complete profile structure

None of the three entries is guaranteed to appear in the output, it depends on the current state of the profile. It might not be possible to provide any output at all. Furthermore, the online representation of the profile structure may differ from the final profile structure.

You can enable this additional output by setting the environment variable \texttt{SCOREP_PROFILING_ENABLE_CORE_FILES} to true. Then, if the profile detects an inconsistency, it will write a core file into your measurement directory. If an inconstant profiles is detected on multiple locations, every location where an inconsistency is detected will write a core file. Thus, it is not recommended, to enable this feature for large scale runs.
5.2 Tracing

Score-P can write events to OTF2 traces. By setting the environment variable `SCOREP_ENABLE_TRACING`, you can control whether a trace is recorded. If the value is 0 or false, no trace is recorded. If the value is non-zero or true, a trace is recorded. If the variable is not specified, Score-P records traces on default. After trace recording you will find the OTF2 anchor file, named `trace.otf2` in the experiment directory, along with the trace data.

5.3 Filtering

When automatic compiler instrumentation or automated source code instrumentation with PDT has been used to instrument user-level source-program routines, there are cases where measurement and associated analysis are degraded, e.g., by frequently-executed, small and/or generally uninteresting functions, methods and subroutines.

A measurement filtering capability is therefore only supported for compiler instrumented regions, regions instrumented with the user API from Score-P (see section 'Manual Region Instrumentation'), regions instrumented with the user API from OPARI2 (see section 'Semi-Automatic Instrumentation of POMP2 User Regions'), CUDA device and host activities (see Section 'CUDA Performance Measurement'), and Kokkos activities (see Section 'Kokkos Performance Measurement'). See section 'Selection of MPI Groups' to restrict the recording of MPI features and the OPARI2 documentation of `--disable` to restrict instrumentation of OpenMP directives. This `--disable` flag can then be passed on to the OPARI2 invocation with the `--opari=<parameter-list>` flag of the Score-P instrumenter. Because PDT instrumentation (Section 'Source-Code Instrumentation Using PDT') inserts Score-P user API instrumentation those regions can be filtered, too. Regions can be filtered based on their region name (e.g., their function name) or based on the source file, in which they are defined.

A file that contains the filter definition can be specified via the environment variable `SCOREP_FILTERING_FILE`. If no filter definition file is specified, all instrumented regions are recorded. For filtered regions, the enter/exit events are not recorded in trace and profile.

The filter definition file can contain two blocks:

- One block defines filter rules for filtering regions based on the source files they are defined in.
- One filter block defined rules for region names.

When the filter rules are applied, the source file name filter is evaluated first. If a region is filtered because it appears in a filtered source file, it cannot be included by the function name filter. If a region was defined in a not-filtered source file, the region name filter is evaluated. This means, events for a region are not recorded if they are filtered by the source file filter or the region name filter. Events for a region are recorded if the region is neither filtered by the source file filter nor by the region name filter. If one of the both filter blocks is not specified, it is equivalent to an empty filter block.

Aside from the two filter blocks, you may use comments in the filter definition file. Comments start with the character `'#'` and is terminated by a new line. You may use comments also inside the filter blocks. If a region name or source file name contains `'#'`, you must escape it with a backslash.
5.3.1 Source File Name Filter Block

The filter block for source file names, must be enclosed by `SCOREP_FILE_NAMES_BEGIN` and `SCOREP_FILE_NAMES_END`. In between you can specify an arbitrary number of include and exclude rules which are evaluated in sequential order. At the beginning all source files are included. Source files that are excluded after all rules are evaluated, are filtered.

An exclude rule starts with the keyword `EXCLUDE` followed by one or multiple white-space separated source file names. Respectively, include rules start with `INCLUDE` followed by one or multiple white-space separated file names. For the specification of file names, bash-like wild-cards are supported. In particular, the `*` wild-card matches an string of arbitrary length, the `?` matches exactly one arbitrary character, or within `[]` you may specify multiple options.

**Note**

Unlike bash, a `*` may match a string that contains slashes. E.g., you may use the `*` wild-card for path prefixes.

An example source file filter block could look like this:

```bash
SCOREP_FILE_NAMES_BEGIN # This is a comment
  EXCLUDE */filtering/filter*
  INCLUDE */filter_test.c
SCOREP_FILE_NAMES_END
```

**Note**

The keywords (`SCOREP_FILE_NAMES_BEGIN`, `SCOREP_FILE_NAMES_END`, `EXCLUDE`, and `INCLUDE`) are case-sensitive.

The filtering is based on the filenames as seen by the measurement system. Depending on instrumentation method and compiler the actual filename may contain the absolute path, a relative path or no path at all. The instrumentation tool tries to create as much absolute paths as possible. Paths are simplified before comparison to a rule. E.g., it removes `path/..`, `./` and multiple slashes. You may look up the actual filename in the resulting output of the measurement.

5.3.2 Region Name Filter Block

The filter block for the region names, must be enclosed by `SCOREP_REGION_NAMES_BEGIN` and `SCOREP_REGION_NAMES_END`. In between you can specify an arbitrary number of include and exclude rules which are evaluated in sequential order. At the beginning, all regions are included. Regions that are excluded after all rules are evaluated, are filtered.

**Note**

Regions that are defined in source files that are filtered, are excluded due to the source file filter. They cannot be included anymore by an include rule in the region filter block.

An exclude rule starts with the keyword `EXCLUDE` followed by one or multiple white-space separated region names. Respectively, include rules start with `INCLUDE` followed by one or multiple white-space separated expressions. For the specification of region names, bash-like wild-cards are supported. In particular, the `*` wild card matches an string of arbitrary length, the `?` matches exactly one arbitrary character, or within `[]` you may specify multiple options.

An example region filter block could look like this:
5.4 Selective Recording

SCOREP_REGION NAMES BEGIN
   EXCLUDE *
   INCLUDE bar foo baz main
SCOREP_REGION NAMES END

In this example, all but the functions bar, foo, baz and main are filtered.

The filtering is based on the region names as seen by the measurement system. Depending on instrumentation method and compiler the actual region name may be mangled, or decorated. Thus, you may want to inspect the profile to determine the name of a region inside the measurement system.

In some cases, the instrumentation provides mangled names, which are demangled by Score-P. In this cases, Score-P uses the demangled form for display in profile and trace definitions, and thus, the demangled form should be used in the filter file. However, The MANGLED keyword marks a filter rule to be applied on the mangled name, if a different mangled name is available. If no mangled name is available, the rule is applied on the displayed name instead. The MANGLED keyword must appear inside of an include rule or exclude rule. All patterns of the rule that follow the MANGLED keyword, are applied to the mangled name, if the mangled name is available.

In the following example, foo and baz are applied to the mangled name, while bar and main are applied on the displayed name.

SCOREP_REGION NAMES BEGIN
   EXCLUDE *
   INCLUDE bar MANGLED foo baz main
SCOREP_REGION NAMES END

The displayed name may also be mangled if no demangled form is available. It is not necessary to prepend rules with the MANGLED keyword if the displayed name is mangled, but only if a mangled name is available that differs from the displayed name.

Note

The keywords (e.g., EXCLUDE, INCLUDE, SCOREP_REGION NAMES BEGIN, SCOREP_REGION NAMES END, and MANGLED) are case-sensitive.

Instrumentation via the GCC plug-in or Intel compilers support all above mentioned filtering features when using the --instrument-filter=<file> flag to the Score-P instrumenter (see Sec. ‘Automatic Compiler Instrumentation’). The filter file is then used during compilation time but the use of such a filter file during runtime is still possible. The usage of the filter during compilation time removes the overhead of runtime filtering.

5.4 Selective Recording

Score-P experiments record by default all events during the whole execution run. If tracing is enabled the event data will be collected in buffers on each process that must be adequately sized to store events from the entire execution.

Instrumented routines which are executed frequently, while only performing a small amount of work each time they are called, have an undesirable impact on measurement. The measurement overhead for such routines is large in comparison to the execution time of the uninstrumented routine, resulting in measurement dilation. Recording these events requires significant space and analysis takes longer with relatively little improvement in quality. Filtering can be employed during measurement (described in Section ‘Filtering’) to ignore events from compiler-instrumented routines or user-instrumented routines.

Another possibility is not to record the whole application run. In many cases, only parts of the application are of interest for analysis (e.g., a frequently performed calculation) while other parts are of less interest (e.g., initialization and finalization) for performance analysis. Or the calculation itself shows iterative behavior, where recording of one iteration would be sufficient for analysis. Restricting recording to one or multiple time intervals during measurement would reduce the required space and overhead. This approach is called selective recording.

Score-P provides two possibilities for selective recording.
• A configuration file can specify recorded regions. The entry and exit of those regions define an interval during which events are recorded.

• With user instrumentation, the recording can be manually switched on/off. (See Section ‘Manual Region Instrumentation’).

Switching recording on or off, can result in inconsistent traces or profiles, if not applied with care. Especially, switching recording on/off manually via `SCOREP_RECORDING_ON` and `SCOREP_RECORDING_OFF` from the Score-P user instrumentation macros is not recommended. Inconsistent traces may result in errors or deadlocks during analysis, or show unusable data. The consistency is endangered if:

• OpenMP events are missing in one thread while other threads have them. Furthermore, the OpenMP parallel region events are required if any event inside a parallel region is recorded. To prevent inconsistencies from incomplete recording of OpenMP events, it is not possible to switch recording on/off from inside a parallel region.

• MPI a communication is only recorded partially, e.g., if a send is missing, but the corresponding receive on another process is recorded. To ensure recording of complete communication is the responsibility of the user.

• enter/exit events are not correctly nested.

How recording can be controlled through Score-P macros which are inserted in the application's source code, is explained in Section ‘Manual Region Instrumentation’. Thus, this section focuses on first possibility, where the user specify recorded regions via a configuration file. Selective recording affects tracing and profiling.

For selective recording, you can specify one or multiple traced regions. The recording is enabled when a recorded region is entered. If the region is exited, recording of events is switched off again. If a recorded region is called inside another recorded region, thus, the recording is already enabled, it will not disable recording of it exits, but recording will be switched off, if all recorded regions are exited.

For recorded regions only regions from Score-P user instrumentation can be selected. If regions from other instrumentation methods are specified in the configuration file for selective recording, they are ignored.

For a recorded region, the recording can be restricted to certain executions of that region. Therefor, the enters for a recorded region are counted, and a particular execution can be specified by the number of its enter. If a recorded region is called recursively, the recording is only switched off, if the exit is reached, that corresponds to the enter that enabled recording.

The configuration file is a simple text file, where every line contains the name of exactly one region. Optionally, a comma-separated list of execution numbers or intervals of execution numbers can be specified. A configuration file could look like follows:

```
foo
bar 23:25, 50, 60:62
baz 1
```

This configuration file would record all executions of foo, the executions 23, 24, 25, 50, 60, 61, and 62 of bar, and the second (numbering starts with 0) execution of baz.

To apply the selective recording configuration file to a measurement run of your application, set the environment variable `SCOREP_SELECTIVE_CONFIG_FILE` to the configuration file and run your instrumented application. If `SCOREP_SELECTIVE_CONFIG_FILE` is empty, or the given file cannot be opened, the whole application run will be recorded (no selective recording will apply).
5.5 Trace Buffer Rewind

Introducing a long-term event-trace recording mode, the trace buffer rewind feature allows to discard the preceding section of the event trace at certain control points or phase markers. The live decision whether to keep or discard a section can depend on the presence or absence of certain behaviour patterns as well as on similarity or difference with other sections.

Based on user regions (see ‘Manual Region Instrumentation’), three macros are given which control the rewind. These are:

```c
// to define a local region handle based on the function
// SCOREP_USER_REGION_DEFINE( ... )
SCOREP_USER_REWIND_DEFINE( regionHandle )
// similar to SCOREP_USER_REGION_BEGIN( ... )
SCOREP_USER_REWIND_POINT( regionHandle, "name" )
// similar to SCOREP_USER_REGION_END( ... )
// w/ additional parameter to control the rewind (yes or no)
SCOREP_USER_REWIND_CHECK( regionHandle, boolean )
```

The user has to specify whether or not a rewind is requested with a boolean variable in the SCOREP_USER_REWIND_CHECK function. There are two different approaches what to do with the rewind region in the trace based on the boolean variable. If the boolean variable is true, the trace buffer will be reset to an old snapshot and after that rewind region enter and leave events will be written into the trace buffer to mark the presence of the trace buffer rewind. This rewind region then looks like a normal user-defined region in the trace. If the variable is false, than no events of the rewind region are written into the trace, so that the trace buffer looks like the user never instrumented the code w/ rewind regions. Trace buffer flushes have an impact on the rewind regions, i.e. if a flush occurs all previous stored rewind points (which are not "checked", i.e. the flush is in between the region) will be deleted and the SCOREP_USER_REWIND_CHECK function won’t write the enter/leave events into the trace independently from the boolean variable. Wrong nested rewind regions are handled as follows:

```c
SCOREP_USER_REWIND_POINT( point 1, ...);
... do stuff ...
SCOREP_USER_REWIND_POINT( point 2, ...);
... do stuff ...
SCOREP_USER_REWIND_CHECK( point 1, true );
... do stuff ...
SCOREP_USER_REWIND_CHECK( point 2, true );
```

The check for point 2 would corrupt the trace buffer, so point 2 would be deleted and ignored in the second check.

5.6 Recording Performance Metrics

If Score-P has been built with performance metric support it is capable of recording performance counter information. To request the measurement of certain counters, the user is required to set individual environment variables. The user can leave these environment variables unset to indicate that no counters are requested. Requested counters will be recorded with every enter/exit event.

5.6.1 PAPI Hardware Performance Counters

Score-P provides the possibility to query hardware performance counters and include these metrics into the trace and/or profile. Score-P uses the Performance Application Programming Interface (PAPI) to access hardware performance counters. Recording of PAPI performance counters is enabled by setting the environment variable SCOREP_METRIC_PAPI to a comma-separated list of counter names. Counter names can be any PAPI preset names or PAPI native counter names.

Example:
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SCOREP_METRIC_PAPI=PAPI_FP_OPS,PAPI_L2_TCM

This will record the number of floating point instructions and level 2 cache misses. If any of the requested counters is not recognized, program execution will be aborted with an error message. The PAPI utility programs papi_avail and papi_native_avail report information about the counters available on the current platform.

If you want to change the separator used in the list of PAPI counter names, set the environment variable SCOREP_METRIC_PAPI_SEP to the desired character.

Note

In addition it is possible to specify metrics that will be recorded only by the initial thread of a process. Please use SCOREP_METRIC_PAPI_PER_PROCESS for that reason.

5.6.2 Resource Usage Counters

Besides PAPI, Resource Usage Counters can be recorded. These metrics use the Unix system call `getrusage` to provide information about consumed resources and operating system events such as user/system time, received signals, and number of page faults. The manual page of `getrusage` provides a list of resource usage counters. Please note that the availability of specific counters depends on the operating system.

You can enable recording of resource usage counters by setting the SCOREP_METRIC_RUSAGE environment variable. The variable should contain a comma-separated list of counter names.

Example:

SCOREP_METRIC_RUSAGE=ru_utime,ru_stime

This will record the consumed user time and system time. If any of the requested counters is not recognized, program execution will be aborted with an error message.

Note

Please be aware of the scope of displayed resource usage statistics. Score-P records resource usage statistics for each individual thread, if the output while configuring your Score-P installation contains something like

RUSAGE_THREAD support: yes

Otherwise, the information displayed is valid for the whole process. That means, for multi-threaded programs the information is the sum of resources used by all threads in the process.

A shorthand to record all resource usage counters is

SCOREP_METRIC_RUSAGE=all

However, this is not recommended as most operating systems does not support all metrics.

If you want to change the separator used in the list of resource usage metrics, set the environment variable SCOREP_METRIC_RUSAGE_SEP to the desired character.

Example:

SCOREP_METRIC_RUSAGE_SEP=:

This indicates that counter names in the list are separated by colons.

Note

In addition it is possible to specify metrics that will be recorded only by the initial thread of a process. Please use SCOREP_METRIC_RUSAGE_PER_PROCESS for that reason.
5.6 Recording Performance Metrics

5.6.3 Recording Linux Perf Metrics

This metric source uses the Linux Perf Interface to access hardware performance counters. First it is explained how to specify PERF metrics that will be recorded by every location.

You can enable the recording of PERF performance metrics by setting the environment variable `SCOREP_METRIC_PERF` to a comma-separated list of metric names. Metric names can be any PERF preset names or PAPI native counter names.

Example:

```
SCOREP_METRIC_PERF=cycles,page-faults,LLC-load-misses
```

In this example the number of CPU cycles, the number of page faults, and Last Level Cache Load Misses will be recorded. If any of the requested metrics is not recognized program execution will be aborted with an error message. The user can leave the environment variable unset to indicate that no metrics are requested. Use the tool `perf list` to get a list of available PERF events.

If you want to change the separator used in the list of PERF metrics, set the environment variable `SCOREP_METRIC_PERF_SEP` to the desired character.

Example:

```
SCOREP_METRIC_PERF_SEP=:
```

This indicates that counter names in the list are separated by colons.

Note

In addition it is possible to specify metrics that will be recorded per-process. Please use `SCOREP_METRIC_PERF_PER_PROCESS` for that reason.

5.6.4 Metric Plugins

Metric plugins extend the functionality of Score-P by providing additional counters as external libraries. The libraries are loaded when tracing or profiling your application. So there is no need to recompile your application or instrument it manually.

A simple example of a synchronous metric plugin can be found in Appendix 'Score-P Metric Plugin Example'. Every plugin needs to include `SCOREP_MetricPlugins.h`. The commands to build the corresponding library of this plugin might look like:

```
gcc -c -fPIC hello_world.c
   -o libHelloWorld_plugin.so.o `scorep-config --cppflags`
gcc -shared -Wl,-soname,libHelloWorld_plugin.so
   -o libHelloWorld.so libHelloWorld_plugin.so.o
```

To enable a metric plugin, add the plugin `<PLUGINNAME>` to the environment variable `SCOREP_METRIC_PLUGINS` and configure the used metrics through the environment variable `SCOREP_METRIC_PLUGINNAME`. In the following example we want to use the above HelloWorld plugin. We select two counters `metric1` and `metric2` from the plugin. Make sure that the metric plugin library is placed in a directory which is part of `LD_LIBRARY_PATH`.

```
SCOREP_METRIC_PLUGINS=HelloWorld_plugin
SCOREP_METRIC_HELLOWORLD_PLUGIN=metric1,metric2
```

Note

Plugins are not supposed to trigger events (e.g., via MPI, OpenMP, Pthreads or user instrumentation) during initialization and finalization of the plugin. A set of open source metric plugins is available at GitHub.
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<tr>
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5.7 MPI Performance Measurement

The Message Passing Interface (MPI) adapter of Score-P supports the tracing of most of MPI's 300+ function calls. MPI defines a so-called 'profiling interface' that supports the provision of wrapper libraries that can easily interposed between the user application and the MPI library calls.

5.7.1 Selection of MPI Groups

The general Score-P filtering mechanism is not applied to MPI functions. Instead, the user can decide whether event generation is turned on or off for a group of MPI functions, at start time of the application. These groups are the listed sub-modules of this adapter. Each module has a short string token that identifies this group. To activate event generation for a specific group, the user can specify a comma-separated list of tokens in the configuration variable SCOREP_MPI_ENABLE_GROUPS. Additionally, special tokens exist to ease the handling by the user. A complete list of available tokens that can be specified in the runtime configuration is listed below.

Note

Event generation in this context only relates to flow and transfer events. Tracking of communicators, groups, and other internal data is unaffected and always turned on.

Example:

SCOREP_MPI_ENABLE_GROUPS=ENV,P2P

This will enable event generation for environmental management, including MPI_Init and MPI_Finalize, as well as point-to-point communication, but will disable it for all other functions groups.

A shorthand to get event generation for all supported function calls is

SCOREP_MPI_ENABLE_GROUPS=ALL

A shorthand to add a single group, e.g., TYPE, to the configured default is
5.8 CUDA Performance Measurement

SCOREP_MPI_ENABLE_GROUPS=DEFAULT,TYPE

A detailed overview of the MPI functions associated with each group can be found in Appendix 'MPI wrapper affiliation'.

A somehow special role plays the X NONBLOCK flag. This flag determines what kind of events are generated by non-blocking peer-to-peer MPI function calls. If XNONBLOCK is not set, an OTF2_MPI_Send event is created at the non-blocking send call and an OTF2_MPI_Recv event is recorded when a non-blocking receive request has completed. If XNONBLOCK is set, an OTF2_Isend event is recorded at the non-blocking send and an OTF2←_IsendComplete event when the event was completed. Furthermore, on a non-blocking receive, it records an OTF2_IRecvRequest event. On request completion an OTF2_IRecv event is recorded. In both cases the group P2P must be enabled. Otherwise Score-P records no events for peer-to-peer communication functions.

5.7.2 Recording MPI Communicator Names

The measurement system tracks also the names of MPI communicators to easily identify them later in the analysis. This is done via the MPI_Comm_set_name call. But there are some restrictions. First, the name of a communicator is only recorded at the first call to MPI_Comm_set_name for this communicator. Later calls are ignored. Also this call is only honored when the call was made from the rank which is rank 0 in this communicator. Other calls from other ranks are ignored. And lastly the name will also be not recorded if the communicator has only one member.

5.8 CUDA Performance Measurement

If Score-P has been built with CUDA support it is capable of recording CUDA API function calls and GPU activities. The measurement is based on NVIDIA’s CUDA Profiling and Tool Interface (CUPTI), which is an integral part of the CUDA Toolkit since version 4.1.

Score-P can wrap the NVIDIA compiler (scorep nvcc) to instrument .cu files. If Score-P has been built with the Intel compiler an additional flag has to be added for instrumentation:

--compiler-bindir=<path-to-intel-compiler-command>

Otherwise the program will not be instrumented, as nvcc uses the GNU compiler by default.

Setting the environment variable SCOREP_CUDA_ENABLE to yes enables CUDA measurement. Please refer to the description of this variable to enable a particular combination of CUDA measurement features.

CUPTI uses an extra buffer to store its activity records. If the size of this buffer is too small, Score-P will print a warning about the current buffer size and the number of dropped records. To avoid dropping of records increase the buffer size via the environment variable SCOREP_CUDA_BUFFER (default: 1M).

Since CUDA toolkit version 5.5 the chunk size for the CUPTI activity buffer can be specified via the environment variable SCOREP_CUDA_BUFFER_CHUNK (default: 8k). Buffer chunks are allocated whenever CUPTI requests a buffer (e.g., to record activities on a CUDA stream). SCOREP_CUDA_BUFFER specifies the upper bound of memory to be allocated for CUPTI activities. Therefore it should be a multiple of SCOREP_CUDA_BUFFER_CHUNK.
Note

Make sure to call `cudaDeviceReset()` or `cudaDeviceSynchronize()` before the exit of the program. Otherwise GPU activities might be missing in the trace. Previous versions of Score-P allowed users to optionally mitigate this through the `flushatexit` value in `SCOREP_CUDA_ENABLE`. This has been inverted; now users who perform this synchronization and would like to see if performance improves by removing a redundant synchronize in Score-P may set `dontflushatexit` in `SCOREP_CUDA_ENABLE` instead. `flushatexit` is deprecated and will be removed in a future version of Score-P.

For CUDA 5.5 there is an error in CUPTI buffer handling. The last activity in a CUPTI activity buffer (`SCOREP_CUDA_BUFFER_CHUNK`) gets lost, when the buffer is full. To avoid this issue specify `SCOREP_CUDA_BUFFER_CHUNK` as large as necessary to store all CUDA device activities until the CUDA device is synchronized with the host. In CUDA 6.0 this issue is fixed and CUPTI does not request buffers for individual streams any more.

Score-P supports CUDA monitoring since CUDA toolkit version 4.1. Make sure that the Score-P installation has configured CUDA support. The configure summary should contain the line:

```
CUDA support: yes
```

If not, for most systems it is sufficient to specify the CUDA toolkit directory at Score-P configuration time:

```
--with-libcudart=<path-to-cuda-toolkit-directory>
```

Otherwise check the configure help output to specify the location of the CUDA toolkit and CUPTI libraries and include files:

```
./configure --help=recursive | grep -E "(cuda|cupti)"
```

CUDA device and host activities can be filtered by name at runtime using the Score-P filter file (see Section 'Filtering'). Filtering does not remove CUDA activities inserted by Score-P or CUDA data transfers inserted as RDMA events. If a kernel is filtered, no kernel launch properties activated in `SCOREP_CUDA_ENABLE` using `kernel_counter` are inserted for this kernel. GPU idle time is not affected by kernel filtering.

5.9 OpenCL Performance Measurement

If Score-P has been built with OpenCL support it is capable of recording OpenCL API function calls.

Setting the environment variable `SCOREP_OPENCL_ENABLE` to `yes` enables OpenCL measurement. Please refer to the description of this variable to enable a particular combination of OpenCL measurement features.

OpenCL measurement uses an extra buffer to store its activity records. If the size of this buffer is too small, Score-P will print a warning about the current buffer size and the number of dropped records. To avoid dropping of records increase the buffer size via the environment variable `SCOREP_OPENCL_BUFFER` (default: 1M). Memory in bytes for the OpenCL command queue buffer can be adjusted by setting the environment variable `SCOREP_OPENCL_BUFFER_QUEUE` (default: 8k).

5.10 OpenACC Performance Measurement

If Score-P has been built with OpenACC support it is capable of recording OpenACC regions as well as activities such as enqueuing kernels, data uploads, and data downloads. OpenACC activities that are implicitly generated by the compiler are attributed with `acc_implicit`.

To enable OpenACC measurement in Score-P the user has to:

- Build and install shared libraries of Score-P (use `--enable-shared` option when configuring Score-P).
- Set the environment variable `ACC_PROFLIB` to specify the OpenACC profiling library.
  Example:
  ```
  export ACC_PROFLIB=<path_to_scorep_installation>/lib/libscorep_adapter_openacc_event.so
  ```
- Set the environment variable `SCOREP_OPENACC_ENABLE` to `yes`. Please refer to the description of this variable to enable a particular combination of OpenACC measurement features.
5.11 Kokkos Performance Measurement

Note

Score-P supports OpenACC monitoring, if the respective OpenACC compiler implements the OpenACC profiling interface that is part of the OpenACC standard since version 2.5. Make sure that the Score-P installation has configured OpenACC support. The configure summary should contain the line:

OpenACC support: yes

5.11 Kokkos Performance Measurement

Score-P is capable of recording information from the Kokkos performance portability framework's tools interface, including parallel regions, user regions, memory allocation, and memory copies. As with OpenACC, the user must perform the following steps:

- Build and install shared libraries of Score-P (use --enable-shared option when configuring Score-P).
- Set the environment variable KOKKOS_PROFILE_LIBRARY to specify the Kokkos profiling library. Example:

  ```
  export KOKKOS_PROFILE_LIBRARY=<path_to_scorep_installation>/lib/libscorep_adapter_kokkos_event.so
  ```
- Set the environment variable SCOREP_KOKKOS_ENABLE to yes. Please refer to the description of this variable to enable a particular combination of Kokkos measurement features.

Kokkos events can be filtered by name at runtime using the Score-P filter file (see Section 'Filtering'). This applies to all types of Kokkos events. Users should note that the Kokkos tools interface allows explicit naming of parallel regions, and those names, if provided, will be the names used for filtering.

5.12 Online Access Interface

Online Access (OA) is an interface to the measurement system of Score-P allowing online analysis capable tools to configure and retrieve profile measurements remotely over sockets.

The Online Access interface implements a client-server paradigm, where Score-P acts as a server accepting connections from the remote tool. During the initialization, the OA module of the Score-P creates one socket for each application process. The network addresses and the ports of these sockets are published at the registry service and could be later queried by the remote tool. The hostname and the port of the registry service should be specified via the SCOREP_ONLINEACCESS_REG_HOST and SCOREP_ONLINEACCESS_REG_PORT environment variables, respectively. After publishing the socket addresses and ports, the OA module will accept connections. Once the connection is established the OA module will suspend the application execution and wait for requests. The format of the requests is plain text following the syntax below:

```
<request> = <metric_configuration> | <execution> | <retrieval>
<metric_configuration> = BEGINREQUESTS GLOBAL <request_type>
ENDREQUESTS
<request_type> = MPI | EXECUTION_TIME | METRIC <metric_specification>
<metric_specification> = PERISCOPE <periscope_metric_code> | PAPI "<papi_counter_name>" | RUSAGE "<rusage_metric_name>" | PLUGIN "<metric_plugin_name>" "<plugin_metric_name>" | OTHER "metric_name"
<execution> = TERMINATE | RUNTOSTART | RUNTOEND
<retrieval> = GETSUMMARYDATA
```

where
CHAPTER 5. APPLICATION MEASUREMENT

- **BEGINREQUESTS** indicates the beginning of the request list,
- **ENDREQUESTS** indicates the end of the request list,
- **GLOBAL** indicates that the following measurement request is applied to all locations,
- **MPI** requests mpi wait states analysis,
- **EXECUTION_TIME** requests execution time,
- **METRIC** indicates the begin of the metric request,
- **PERISCOPE** \(<\text{periscope\_metric\_code}>\) requests a metric by the Periscope internal code,
- **PAPI** \(<\text{papi\_counter\_name}>\) requests a PAPI hardware counter metric by the counter name,
- **PERF** \(<\text{perf\_counter\_name}>\) requests a PERF hardware counter metric by the counter name,
- **RUSAGE** \(<\text{rusage\_counter\_name}>\) requests a Resource Usage Counter metric by the counter name,
- **PLUGIN** \("<\text{metric\_plugin\_name}>"\) \("<\text{plugin\_metric\_name}>"\) requests a metric supported by the specified metric plugin,
- **OTHER** \(<\text{metric\_name}>\) requests a metric, to be defined in Score-P definition system, specified by the name,
- **TERMINATE** requests termination of the application,
- **RUNTOSTART** requests Score-P to run the beginning of the OA phase,
- **RUNTOEND** requests Score-P to run the end of the OA phase,
- **GETSUMMARYDATA** requests retrieval of the profile data.

When the **GETSUMMARY** request is received, the OA module will transform the call-path profile into a flat profile and send the data back to the remote tool. The flat profile is sent in two parts, where the first part carries the region definition data and the second part carries profile measurements. Each part starts with the key word **MERGED_RREGION_DEFINITIONS** or **FLAT_PROFILE** and followed by the number of the entries and the buffer containing the data.

### 5.13 Substrate Plugins

Substrate plugins extend the functionality of Score-P by providing additional backends. The libraries are loaded when your application is started and Score-P is initialized. So there is no need to recompile your application or instrument it manually.

A simple example of a backend can be found in Appendix ‘Score-P Substrate Plugin Example’. Every plugin needs to include **SCOREP_SubstratePlugins.h** and define its name via **SCOREP_SUBSTRATE_PLUGIN_ENSTRY(<name>).** The same name must be used with the prefix **scorep_substrate** as library name. The commands to build the corresponding library of this plugin might look like:

```bash
gcc -c -fPIC print_regions.c  
-o libscorep_substrate_PrintRegions.so.o 'scorep-config --cppflags'  
gcc -shared -Wl,-soname,libscorep_substrate_PrintRegions.so  
-o libscorep_substrate_PrintRegions.so libscorep_substrate_PrintRegions.so.o
```

To enable a substrate plugin, add the plugin \(<\text{PLUGINNAME}>\) to the environment variable **SCOREP_SUBSTRATE_PLUGINS**. In the following example we want to use the above **PrintRegions** plugin. Make sure that the substrate plugin library is placed in a directory which is part of **LD_LIBRARY_PATH**.

**SCOREP_SUBSTRATE_PLUGINS**=**PrintRegions**
Note

Multiple substrate plugins can be loaded by listing them `SCOREP_SUBSTRATE_PLUGINS=foo, bar`, the default separator `','` can be changed by setting the environment variable `SCOREP_SUBSTRATE_PLUGIN←S_SEP`.

Developers of plugins are highly encouraged to use environment variables in their plugins with the naming scheme `SCOREP_SUBSTRATE←<substrate name>←<variable>`, e.g., `SCOREP_SUBSTRATE←E_PRINTREGIONS_VERBOSE`
scorep-score is a tool that allows to estimate the size of an OTF2 trace from a CUBE4 profile. Furthermore, the effects of filters are estimated. The main goal is to define appropriate filters for a tracing run from a profile.

The general work-flow for performance analysis with Score-P is:

1. Instrument an application (see Section 'Application Instrumentation').
2. Perform a measurement run and record a profile (see Section 'Application Measurement'). The profile already gives an overview what may happen inside the application.
3. Use scorep-score to define an appropriate filter for an application. Otherwise the trace file may become too large. This step is explained in this Chapter.
4. Perform a measurement run with tracing enabled and the filter applied (see Section 'Tracing' and Section 'Filtering').
5. Perform in-depth analysis on the trace data.

6.1 Basic usage

To invoke scorep-score you must provide the filename of a CUBE4 profile as argument. Thus, the basic command looks like this:

```
scorep-score profile.cubex
```

The output of the command may look like this (taking an MPI/OpenMP hybrid application as an example):

```
Estimated aggregate size of event trace: 20MB
Estimated requirements for largest trace buffer (max_buf): 20MB
Estimated memory requirements (SCOREP_TOTAL_MEMORY): 24MB
(hint: When tracing set SCOREP_TOTAL_MEMORY=24MB to avoid intermediate flushes or reduce requirements using USR regions filters.)

flt type max_buf[B] visits time[s] time[%] time/visit[us] region
ALL 19,377,048 786,577 27.48 100.0 34.93 ALL
USR 16,039,680 668,320 0.36 1.3 0.53 USR
OMP 3,328,344 117,881 26.92 98.0 228.37 OMP
COM 9,024 376 0.20 0.7 532.17 COM
SCOREP 41 1 0.00 0.0 13.82 SCOREP
```
The first line of the output gives an estimation of the total size of the trace, aggregated over all processes. This information is useful for estimating the space required on disk. In the given example, the estimated total size of the event trace is 20MB.

The second line prints an estimation of the memory space required by a single process for the trace. The memory space that Score-P reserves on each process at application start must be large enough to hold the process’ trace in memory in order to avoid flushes during runtime, because flushes heavily disturb measurements. In addition to the trace, Score-P requires some additional memory to maintain internal data structures. Thus, it provides also an estimation for the total amount of required memory on each process. The memory size per process that Score-P reserves is set via the environment variable `SCOREP_TOTAL_MEMORY`. In the given example the per process memory should be larger than 24MB.

Beginning with the 6th line, `scorep-score` prints a table that show how the trace memory requirements and the runtime is distributed among certain function groups. The column `max_tbc` shows how much trace buffer is needed on a single process. The column `time(s)` shows how much execution time was spend in regions of that group in seconds, the column `%` shows the fraction of the overall runtime that was used by this group, and the column `time/visit(us)` shows the average time per visit in microseconds.

The following groups exist:

- **ALL**: Includes all functions of the application
- **OMP**: This group contains all regions that represent an OpenMP construct
- **MPI**: This group contains all MPI functions
- **SHMEM**: This group contains all SHMEM functions
- **PTHREAD**: This group contains all Pthread functions
- **CUDA**: This group contains all CUDA API functions and kernels
- **OPENCL**: This group contains all OpenCL API functions and kernels
- **OPENACC**: This group contains all OpenACC API functions and kernels
- **MEMORY**: This group contains all libc and C++ memory (de)allocation functions
- **COM**: This group contains all functions, implemented by the user that appear on a call-path to any functions from the above groups, except ALL
- **USR**: This group contains all user functions except those in the **COM** group
- **LIB**: This group contains all user wrapped library functions (See ‘Score-P User Library Wrapping’)
- **IO**: This group contains all I/O functions
- **SCOREP**: This group aggregates activities within the measurement system

### 6.2 Additional per-region information

For a more detailed output, which shows the data for every region, you can use the `-r` option. The command could look like this.

```
scorep-score profile.cubex -r
```

This command adds information about the used buffer sizes and execution time of every region to the table. The additional lines of the output may look like this:
6.3 Defining and testing a filter

<table>
<thead>
<tr>
<th>fit type</th>
<th>max_buf[B]</th>
<th>visits</th>
<th>time[s]</th>
<th>time[%]</th>
<th>time/visit[us]</th>
<th>region</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM</td>
<td>24</td>
<td>4</td>
<td>0.00</td>
<td>0.0</td>
<td>67.78</td>
<td>Init</td>
</tr>
<tr>
<td>COM</td>
<td>24</td>
<td>4</td>
<td>0.00</td>
<td>0.0</td>
<td>81.20</td>
<td>main</td>
</tr>
<tr>
<td>USR</td>
<td>24</td>
<td>4</td>
<td>0.12</td>
<td>2.0</td>
<td>30931.14</td>
<td>InitializeMatrix</td>
</tr>
<tr>
<td>COM</td>
<td>24</td>
<td>4</td>
<td>0.05</td>
<td>0.8</td>
<td>12604.78</td>
<td>CheckError</td>
</tr>
<tr>
<td>USR</td>
<td>24</td>
<td>4</td>
<td>0.00</td>
<td>0.0</td>
<td>23.76</td>
<td>PrintResults</td>
</tr>
<tr>
<td>COM</td>
<td>24</td>
<td>4</td>
<td>0.01</td>
<td>0.2</td>
<td>3441.83</td>
<td>Finish</td>
</tr>
<tr>
<td>COM</td>
<td>24</td>
<td>4</td>
<td>0.48</td>
<td>7.7</td>
<td>120338.17</td>
<td>Jacobi</td>
</tr>
</tbody>
</table>

The region name is displayed in the column named `region`. The column `type` shows to which group this region belongs. In the example above, the function `main` belongs to group `COM` required 24 bytes per process and used 0 s execution time. By default, the regions are sorted by their buffer requirements. With the option `-s <choice>` a different sorting mode can be chosen. Available options are `totaltime`, `timepervisit`, `maxbuffer`, `visits` and `name`.

By default `scorep-score` uses demangled function names. However, if you want to map data to tools which use mangled names you might want to display mangled names. Furthermore, if you have trouble with function signatures that contain characters that also have a wildcard meaning, defining filters on mangled names might be easier. To display mangled names instead of demangled names, you can use the `-m` flag, e.g.,

```
scorep-score profile.cubex -r -m
```

**Note**

The `-m` flag takes only effect if you display region names. In particular it means that the `-m` flag is only effective if also the `-r` is specified.

In some cases, the same name is shown for the mangled and the demangled name. Some instrumentation methods, e.g., user instrumentation, provide only a demangled name. For C-compilers mangled and demangled names are usually identical. Or the demangling might have failed and only a mangled name is available. In these cases we show always the one name that is available.

6.3 Defining and testing a filter

For defining a filter, it is recommended to exclude short frequently called functions from measurement, because they require a lot of buffer space (represented by a high value under `max_tbc`) but incur a high measurement overhead. Furthermore, for communication analysis, functions that appear on a call-path to MPI functions and OpenMP constructs (regions of type `COM`) are usually of more interest than user functions of type `USR` which do not appear on call-path to communications. MPI functions and OpenMP constructs cannot be filtered. Thus, it is usually a good approach to exclude regions of type `USR` starting at the top of the list until you reduced the trace to your needs. Section 'Filtering' describes the format of a filter specification file.

If you have a filter file, you can test the effect of your filter on the trace file. Therefor, you need to pass a `-f` followed by the file name of your filter. E.g., if your filter file name is `myfilter`, the command looks like this:

```
scorep-score profile.cubex -f myfilter
```

An example output is:
CHAPTER 6. SCORING A PROFILE MEASUREMENT

Estimated aggregate size of event trace: 7kB
Estimated requirements for largest trace buffer (max_buf): 1806 bytes
Estimated memory requirements (SCOREP_TOTAL_MEMORY): 5MB
(hint: When tracing set SCOREP_TOTAL_MEMORY=5MB to avoid intermediate flushes or reduce requirements using USR regions filters.)

<table>
<thead>
<tr>
<th>flt type</th>
<th>max_buf[B]</th>
<th>visits</th>
<th>time[s]</th>
<th>time[%]</th>
<th>time/visit[us]</th>
<th>region</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL</td>
<td>2,093</td>
<td>172</td>
<td>5.17</td>
<td>100.0</td>
<td>30066.64</td>
<td>ALL</td>
</tr>
<tr>
<td>MPI</td>
<td>1,805</td>
<td>124</td>
<td>4.20</td>
<td>81.3</td>
<td>33910.31</td>
<td>MPI</td>
</tr>
<tr>
<td>COM</td>
<td>240</td>
<td>40</td>
<td>0.84</td>
<td>16.3</td>
<td>21092.44</td>
<td>COM</td>
</tr>
<tr>
<td>USR</td>
<td>48</td>
<td>8</td>
<td>0.12</td>
<td>2.4</td>
<td>15360.71</td>
<td>USR</td>
</tr>
<tr>
<td>SCOREP</td>
<td>41</td>
<td>4</td>
<td>0.00</td>
<td>0.0</td>
<td>13.82</td>
<td>SCOREP</td>
</tr>
<tr>
<td>ALL-FLT</td>
<td>1,805</td>
<td>124</td>
<td>4.20</td>
<td>81.3</td>
<td>33910.31</td>
<td>ALL-FLT</td>
</tr>
<tr>
<td>MPI-FLT</td>
<td>1,805</td>
<td>124</td>
<td>4.20</td>
<td>81.3</td>
<td>33910.31</td>
<td>MPI-FLT</td>
</tr>
<tr>
<td>SCOREP-FLT</td>
<td>41</td>
<td>4</td>
<td>0.00</td>
<td>0.0</td>
<td>13.82</td>
<td>SCOREP-FLT</td>
</tr>
<tr>
<td>FLT</td>
<td>288</td>
<td>48</td>
<td>0.97</td>
<td>18.7</td>
<td>20137.15</td>
<td>FLT</td>
</tr>
</tbody>
</table>

Now, the output estimates the total trace size and the required memory per process, if you would apply the provided filter for the measurement run which records the trace. A new group FLT appears, which contains all regions that are filtered. Under max_tbc the group FLT displays how the memory requirements per process are reduced. Furthermore, the groups that end on -FLT, like ALL-FLT contain only the unfiltered regions of the original group. E.g., USR-FLT contains all regions of group USR that are not filtered.

Furthermore, the column flt is no longer empty but contain a symbol that indicates how this group is affected by the filter. A '-' means 'not filtered', a '+' means 'filtered' and a '*' appears in front of groups that potentially can be affected by the filter.

You may combine the -f option with a -r option. In this case, for each function a '+' or '-' indicates whether the function is filtered.

6.4 Calculating the effects of recording hardware counters

Recording additional metrics, e.g., hardware counters may significantly increase the trace size, because for many events additional metric values are stored. In order to estimate the effects of these metrics, you may add a -c followed by the number of metrics you want to record, e.g.,

```
scorep-score profile.cubex -c 3
```

would mean that scorep-score estimates the disk and memory requirements for the case that you record 3 additional metrics.

6.5 Generating initial filter files

With the -g option scorep-score can generate an initial filter file in Score-P filter file format. It provides a starting point for the user to adapt and change the filter file to his requirements.

The user can provide an optional list of parameters to control the inclusion heuristic of the filter file generation. A valid parameter list has the form KEY=VALUE[,KEY=VALUE] *. By default, the following control parameters are used:

```
bufferpercent=1,timepervisit=1
```

A region is included in the filter file (i.e., excluded from measurement) if it matches all of the given conditions, with the following keys:
6.5 Generating initial filter files

1. **bufferpercent**: The estimated memory requirements exceed the given threshold in percent of the total estimated trace buffer requirements. This limits the inclusion to relevant regions based on total memory impact.

2. **bufferabsolute**: The estimated memory requirements exceed the given absolute threshold in MB.

3. **visits**: The number of visits exceeds the given threshold.

4. **timepervisit**: The time per visit value is below the given threshold in microseconds. This limits the inclusion to relevant regions based on per visit time overhead.

5. **type**: The region type matches the given value. Allowed values are 'usr', 'com', and 'both'.

**Note**

If the file name already exists, the previous file will be renamed instead overwritten to safeguard against unintentional deletion and to allow being used in an iterative use of the filter file generation. To that end, filtered regions from a file specified via `-f` will be included at the end of the newly generated file. Those regions are marked and added 'as is' without being checked against the inclusion heuristics.
Chapter 7

Performance Analysis Workflow Using Score-P

This chapter demonstrates a typical performance analysis workflow using Score-P. It consist of the following steps:

1. Program instrumentation (Section ‘Program Instrumentation’)
2. Summary measurement collection (Section ‘Summary Measurement Collection’)
3. Summary report examination (Section ‘Summary report examination’)
4. Summary experiment scoring (Section ‘Summary experiment scoring’)
5. Advanced summary measurement collection (Section ‘Advanced summary measurement collection’)
6. Advanced summary report examination (Section ‘Advanced summary report examination’)
7. Event trace collection and examination (Section ‘Event trace collection and examination’)

The workflow is demonstrated using NPB BT-MZ benchmark as an example. BT-MZ solves a discretized version of unsteady, compressible Navier-Stokes equations in three spatial dimensions. It performs 200 time-steps on a regular 3-dimensional grid using ADI and verifies solution error within acceptable limit. It uses intra-zone computation with OpenMP and inter-zone communication with MPI. The benchmark can be build with a predefined data class (S,W,A,B,C,D,E,F) and any number of MPI processes and OpenMP threads.

NPB BT-MZ distribution already prepared for this example could be obtained from here.

7.1 Program Instrumentation

In order to collect performance measurements, BT-MZ has to be instrumented. There are various types of instrumentation supported by Score-P which cover a broad spectrum of performance analysis use cases (see Chapter ‘Application Instrumentation’ for more details).

In this example we start with automatic compiler instrumentation by prepending compiler/linker specification variable MPIF77 found in config/make.def with scorep:
# 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 = mpif77
# Alternative variants to perform instrumentation
#MPIF77 = scorep mpif77
# This links MPI Fortran programs; usually the same as ${MPIF77}
FLINK = $(MPIF77)

... 

After the makefile is modified and saved, it is recommended to return to the root folder of the application and clean-up previously build files:

% make clean

Now the application is ready to be instrumented by simply issuing the standard build command:

% make bt-mz CLASS=W NPROCS=4

After the command is issued, the make command should produce the output similar to the one below:

cd BT-MZ; make CLASS=W NPROCS=4 VERSION=
makes: Entering directory 'BT-MZ'
cd ..;/sys; cc -o setparams setparams.c -lm
..;/sys/setparams bt-mz 4 W
scorep mpif77 -O3 -fopenmp bt.f
 [...]
cd ..;/common; scorep --user mpif77 -O3 -fopenmp timers.f
scorep mpif77 -O3 -fopenmp -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'

When make finishes, the built and instrumented application could be found under bin.scorep/bt-mz_W.4.

7.2 Summary Measurement Collection

Now instrumented BT-MZ is ready to be executed and to be profiled by Score-P at the same time. However before doing so, one has an opportunity to configure Score-P measurement by setting Score-P environment variables. For the complete list of variables please refer to Appendix 'Score-P Measurement Configuration'.

The typical Score-P performance analysis workflow implies collecting summary performance information first and then in detail performance exploration using execution traces. Therefore Score-P has to be configured to perform profiling and tracing has to be disabled. This is done by setting corresponding environment variables:

% export SCOREP_ENABLE_PROFILING=1
% export SCOREP_ENABLE_TRACING=0

Performance data collected by Score-P will be stored in an experiment directory. In order to efficiently manage multiple experiments, one can specify a meaningful name for the experiment directory by setting
7.3 Summary report examination

% export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_W_4x4_sum

After Score-P is prepared for summary collection, the instrumented application can be started as usual:

% cd bin.scorep
% export OM_NUM_THREADS=4
% mpiexec -np 4 ./bt-mz_W.4

The BT-MZ output should look similar to the listing below:

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
Use the default load factors with threads
Total number of threads: 16 (4.0 threads/process)

Calculated speedup = 15.78

Time step 1
[... More application output ...]

After application execution is finished, the summary performance data collected by Score-P is stored in the experiment directory bin.scorep/scorep_bt-mz_W_4x4_sum. The directory contains the following files:

- scorep.cfg - a record of the measurement configuration used in the run
- profile.cubex - the analysis report that was collated after measurement

7.3 Summary report examination

After BT-MZ finishes execution, the summary performance data measured by Score-P can be investigated with CUBE or ParaProf interactive report exploration tools.

CUBE:

% cube scorep_bt-mz_W_4x4_sum/profile.cubex

ParaProf:

% paraprof scorep_bt-mz_W_4x4_sum/profile.cubex

Both tools will reveal the call-path profile of BT-MZ annotated with metrics: Time, Visits count, MPI message statistics (bytes sent/received). For more information on using the tool please refer to the corresponding documentation (CUBE, ParaProf).
CHAPTER 7. PERFORMANCE ANALYSIS WORKFLOW USING SCORE-P

7.4 Summary experiment scoring

Though we were able to collect the profile data, one can mention that the execution took longer in comparison to un-instrumented run, even when the time spent for measurement start-up/finalization is disregarded. Longer execution times of the instrumented application is a sign of high instrumentation/measurement overhead. Furthermore, this overhead might result in large trace files and buffer flushes in the later tracing experiment if Score-P is not properly configured.

In order to investigate sources of the overhead and to tune measurement configuration for consequent trace collection with Score-P, scorep-score tool (see Section 'Scoring a Profile Measurement' for more details about scorep-score) can be used:

```bash
% scorep-score scorep_bt-mz_W_4x4_sum/profile.cubex
```

Estimated aggregate size of event trace (total_tbc):

990247448 bytes

Estimated requirements for largest trace buffer (max_tbc):

256229936 bytes

The textual output of the tool generates an estimation of the size of an OTF2 trace produced, should Score-P be run using the current configuration. Here the trace size estimation could be also seen as a measure of overhead, since both are proportional to the number of recorded events. Additionally, the tool shows the distribution of the required trace size over call-path classes. From the report above one can see that the estimated trace size needed is equal to 1 GB in total or 256 MB per MPI rank, which is significant. From the breakdown per call-path class one can see that most of the overhead is due to user-level computations. In order to further localize the source of the overhead, scorep-score can print the breakdown of the buffer size on per-region basis:

```bash
% scorep-score -r scorep_bt-mz_W_4x4_sum/profile.cubex
```

The regions marked as USR type contribute to around 32% of the total time, however, much of that is very likely to be measurement overhead due to frequently-executed small routines. Therefore, it is highly recommended to remove these routines from measurements. This can be achieved by placing them into a filter file (please refer to Section 'Defining and testing a filter' for more details about filter file specification) as regions to be excluded from measurements. There is already a filter file prepared for BT-MZ which can be used:

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

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One can use `scorep-score` once again to verify the effect of the filter file:

```
% scorep-score -f ../config/scorep.filt scorep_bt-mz_W_4x4_sum
```

Estimated aggregate size of event trace (total_tbc):
20210360 bytes

Estimated requirements for largest trace buffer (max_tbc):
6290888 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.)

Now one can see that the trace size is reduced to just 20MB in total or 6MB per MPI rank. The regions filtered out will be marked with "+" in the left-most column of the per-region report.

### 7.5 Advanced summary measurement collection

After the filtering file is prepared to exclude the sources of the overhead, it is recommended to repeat summary collection, in order to obtain more precise measurements.

In order to specify the filter file to be used during measurements, the corresponding environment variable has to be set:

```
% export SCOREP_FILTERING_FILE=../config/scorep.filt
```

It is also recommended to adjust the experiment directory name for the new run:

```
% export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_W_4x4_sum_with_filter
```

Score-P also has a possibility to record hardware counters (see Section 'PAPI Hardware Performance Counters') and operating system resource usage (see Section 'Resource Usage Counters') in addition to default time and number of visits metrics. Hardware counters could be configured by setting Score-P environment variable `SCOREP_METRIC_PAPI_PAPI_TOT_INS,PAPI_FP_INS`:

```
% export SCOREP_METRIC_PAPI=PAPI_TOT_INS,PAPI_FP_INS
```

Note

The specified combination of the hardware events has to be valid, otherwise Score-P will abort execution. Please run `papi_avail` and `papi_native_avail` in order to get the list of the available PAPI generic and native events.

Operating system resource usage metrics are configured by setting the following variable:

```
% export SCOREP_METRIC_RUSAGE=ru_maxrss,ru_stime
```

Additionally Score-P can be configured to record only a subset of the mpi functions. This is achieved by setting `SCOREP_MPI_ENABLE_GROUPS` variable with a comma-separated list of sub-groups of MPI functions to be recorded (see Appendix 'MPI wrapper affiliation'):

```
% export SCOREP_MPI_ENABLE_GROUPS
```

---

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In case performance of the CUDA code is of interest, Score-P can be configured to measure CUPTI metrics as follows (see Section ‘CUDA Performance Measurement’):

% export SCOREP_CUDA_ENABLE=gpu,kernel,idle

In case performance of the OpenCL code is of interest, Score-P can be configured to measure OpenCL events as follows (see Section ‘OpenCL Performance Measurement’):

% export SCOREP_OPENCL_ENABLE=api,kernel,memcpy

When the granularity offered by the automatic compiler instrumentation is not sufficient, one can use Score-P manual user instrumentation API (see Section ‘Manual Region Instrumentation’) for more fine-grained annotation of particular code segments. For example initialization code, solver or any other code segment of interest can be annotated.

In order to enable user instrumentation, an --user argument has to be passed to Score-P command prepending compiler and linker specification:

% MPIF77 = scorep --user mpif77

Below, the loop found on line ... in file ... is annotated as a user region:

#include "scorep/SCOREP_User.inc"

subroutine foo(...)
    ! Declarations
SCOREP_USER_REGION_DEFINE( solve )
    ! Some code...
SCOREP_USER_REGION_BEGIN( solve, "<solver>", 
SCOREP_USER_REGION_TYPE_LOOP )
do i=1,100
    [...] 
end do
SCOREP_USER_REGION_END( solve )
    ! Some more code...
end subroutine

This will appear as an additional region in the report.

BT-MZ has to be recompiled and relinked in order to complete instrumentation.

% make clean
% make bt-mz CLASS=W NPROCS=4

After applying advanced configurations described above, summary collection with Score-P can be started as usual:

% mpiexec -np 4 ./bt-mz_W.4
### 7.6 Advanced summary report examination

After execution is finished, one can use `scorep-score` tool to verify the effect of filtering:

```bash
% scorep-score scorep_bt-mz_W_4x4_sum_with_filter/profile.cubex
```

Estimated aggregate size of event trace (total_tbc):

```
20210360 bytes
```

Estimated requirements for largest trace buffer (max_tbc):

```
6290888 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.)

<table>
<thead>
<tr>
<th>flt type</th>
<th>max_tbc</th>
<th>time</th>
<th>% region</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL</td>
<td>6290888</td>
<td>241.77</td>
<td>100.0 ALL</td>
</tr>
<tr>
<td>OMP</td>
<td>5853120</td>
<td>168.94</td>
<td>69.9 OMP</td>
</tr>
<tr>
<td>COM</td>
<td>343344</td>
<td>35.57</td>
<td>14.7 COM</td>
</tr>
<tr>
<td>MPI</td>
<td>93776</td>
<td>37.25</td>
<td>15.4 MPI</td>
</tr>
<tr>
<td>USR</td>
<td>672</td>
<td>0.01</td>
<td>0.0 USR</td>
</tr>
</tbody>
</table>

The report above shows significant reduction in runtime (due to elimination of the overhead) not only in USR regions but also in MPI/OMP regions as well.

Now, the extended summary report can be interactively explored using CUBE:

```bash
% cube scorep_bt-mz_W_4x4_sum_with_filter/profile.cubex
```

or ParaProf:

```bash
% paraprof scorep_bt-mz_W_4x4_sum_with_filter/profile.cubex
```

### 7.7 Event trace collection and examination

After exploring extended summary report, additional insight into performance of BT-MZ can be gained by performing trace collection. In order to do so, Score-P has to be configured to perform tracing by setting corresponding variable to `true` and disabling profile generation:

```bash
% export SCOREP_ENABLE_TRACING=true
% export SCOREP_ENABLE_PROFILING=false
```

Additionally it is recommended to set a meaningful experiment directory name:

```bash
% export SCOREP_EXPERIMENT_DIRECTORY=scorep_bt-mz_W_4x4_trace
```

After BT-MZ execution is finished, a separate trace file per thread is written into the new experiment directory. In order to explore it, Vampir tool can be used:

```bash
% vampir scorep_bt-mz_W_4x4_trace/traces.otf2
```

Please consider that traces can become extremely large and unwieldy, because the size of the trace is proportional to number of processes/threads (width), duration (length) and detail (depth) of measurement. When the trace is too large to hold in the memory allocated by Score-P, flushes can happen. Unfortunately the resulting traces are of little value, since uncoordinated flushes result in cascades of distortion.

Traces should be written to a parallel file system, e.g., to `/work` or `/scratch` which are typically provided for this purpose.
Appendices
Appendix A

Score-P INSTALL

Score-P INSTALL GUIDE

This file describes how to configure, compile, and install the Score-P measurement infrastructure. If you are not familiar with using the configure scripts generated by GNU autoconf, read the "Generic Installation Instructions" section below, then return here. Also, make sure to carefully read and follow the platform-specific installation notes (especially when building for the Intel Xeon Phi platform).

Quick start
============

In a nutshell, configuring, building, and installing Score-P can be as simple as executing the shell commands

```shell
mkdir _build
cd _build
./configure --prefix=<installdir>
make
make install
```

If you don’t specify --prefix, /opt/scorep will be used.

Depending on your system configuration and specific needs, the build process can be customized as described below.

Configuration
==============

The configure script in this package tries to automatically determine the platform for which Score-P will be compiled in order to provide reasonable defaults for backend (i.e., compute node) compilers, MPI compilers, and, in case of cross-compiling environments, frontend (i.e., login node) compilers.

Depending on the environment it is possible to override the platform defaults by using the following configure options:

```shell
--with-machine-name=<default machine name>
```

The default machine name used in profile and trace output. We suggest using a unique name, e.g., the fully qualified domain name. If not set, a name based on the detected platform is used. Can be overridden at measurement time by setting the environment variable SCOREP_MACHINE_NAME.

Score-P requires a full compiler suite with language support for C99, C++98 and optionally Fortran 77 and Fortran 90. The following section
describes how to select supported compiler suits.

In non-cross-compiling environments, the compiler suite used to build the backend parts can be specified explicitly if desired. On Linux clusters it is currently recommended to use this option to select a compiler suite other than GCC.

```
--with-nocross-compiler-suite=(gcc|ibm|intel|pgi|studio|clang)
```

The compiler suite used to build this package in non-cross-compiling environments. Needs to be in $PATH.

[Default: gcc]

Note: if you select ‘pgi’, CXX will be set to ‘pgc++’, which is PGI’s default C++ compiler. If you have a PGI compiler installation prior to 16.1, you might want to use ‘pgCC’ instead if your MPI and SHMEM compiler wrappers use this one. To select pgCC, please add ‘CXX=pgCC’ to your configure line.

Note: for the NVIDIA HPC SDK, select ‘pgi’.

In cross-compiling environments, the compiler suite used to build the frontend parts can be specified explicitly if desired.

```
--with-frontend-compiler-suite=(gcc|ibm|intel|pgi|studio|clang)
```

The compiler suite used to build the frontend parts of this package in cross-compiling environments. Needs to be in $PATH.

[Default: gcc]

The MPI compiler, if in $PATH, is usually autodetected. Users should normally not need to specify which compiler will be invoked by the MPI compiler wrapper; Score-P handles this automatically using the appropriate command line arguments for the correct version of MPI. While many MPI distributions also allow selecting the compiler that the wrapper will invoke via environment variables, this mechanism should not be used with Score-P.

Note that this also applies to instrumentation time. Here, users should use the command line arguments along with the Score-P wrappers for the MPI compiler wrappers: scorep-mpicc -cc=/path/to/specific/compiler ...

If there are several MPI compilers in $PATH the user should select one using the configure option:

```
--with-mpi=(bullxmpi|hp|ibmpoe|intel|intel2|intelpoe|lam| mpiibull2|mpich|mpich2|mpich3|openmpi|openmpi3|platform| scal|sgimpt|sgimptwrapper|spectrum|sun)
```

The MPI compiler suite to build this package in non cross-compiling mode. Usually autodetected. Needs to be in $PATH.

Note that there is currently no consistency check if backend and MPI compiler are from the same vendor. If they are not, linking problems (undefined references) might occur.

The SHMEM compiler, if in $PATH, is usually autodetected. If there are several SHMEM compilers in $PATH the user is requested to select one using the configure option:

```
--with-shmem=(openshmem|openmpi|openmpi3|sgimpt|sgimptwrapper|spectrum)
```

The SHMEM compiler suite to build this package in non cross-compiling mode. Usually autodetected. Needs to be in $PATH.

If a particular system requires to use compilers different to those Score-P currently supports, please edit the three files build-config/common/platforms/platform--user-provided to your needs and use the following configure option:

```
--with-custom-compilers
```

Customize compiler settings by 1. copying the three files <srcdir>/build-config/common/platforms/platform--user-provided to the directory where you run configure <builddir>,

APPENDIX A. SCORE-P INSTALL
2. editing those files to your needs, and 3. running configure. Alternatively, edit the files under <srdir> directly. Files in <builddir> take precedence. You are entering unsupported terrain. Namaste, and good luck!

On cross-compile systems the default frontend compiler is IBM XL for the Blue Gene series and GCC on all other platforms. The backend compilers will either be automatically selected by the platform detection (IBM Blue Gene series) or by the currently loaded environment modules (Cray X series). If you want to customize these settings please use the configure option ‘--with-custom-compilers’ as described above.

Although this package comes with recent versions of the OTF2 and Cube libraries as well as the OPARI2 instrumenter included, it is possible to use existing installations instead. Here, the --without option means 'without external installation', i.e., the component provided with the tarball will be used:

--with-otf2[=<otf2-bindir>]
Use an already installed and compatible OTF2 library (v2.0 or newer). Provide path to otf2-config. Auto-detected if already in $PATH.

--with-cubew[=<cubew-bindir>]
Use an already installed and compatible cubew library. Provide path to cubew-config. Auto-detected if already in $PATH.

--with-cubelib[=<cubelib-bindir>]
Use an already installed and compatible cubelib library. Provide path to cubelib-config. Auto-detected if already in $PATH.

--with-opari2[=<opari2-bindir>]
Use an already installed and compatible OPARI2 (v2.0 or newer). Provide path to opari2-config. Auto-detected if already in $PATH.

For the components otf2, cubew, cubelib, and opari2, the corresponding --without-<component> or --with-<component>=no options will ignore the <component>-config in $PATH but use the Score-P internal components.

To enable support for CUDA measurement via the CUPTI interface we provide three configure options: the path to the CUDA runtime, the path to the CUPTI library, and the path to the CUDA library. Usually you just need to provide the path to the runtime via --with-libcudart; CUPTI will be detected automatically in the extras/CUPTI subdirectory and the system libcuda will be used. This usually works for GNU and Intel compilers:

--with-libcudart=<Path to libcudart installation>
If you want to build scorep with libcudart but do not have a libcudart in a standard location then you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes], on cross-compile systems however, you have to specify a path [no]. --with-libcudart is a shorthand for --with-libcudart-include=<Path/include> and --with-libcudart-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.

--with-libcudart-include=<Path to libcudart headers>
--with-libcudart-lib=<Path to libcudart libraries>

For PGI compilers since version 16.10 you need at least two options, --with-libcudart pointing to the <PGI CUDA runtime> and --with-libcupti pointing to <NVIDIA CUDA runtime>/extras/CUPTI. Note that CUDA/CUPTI support in Score-P with PGI compilers prior to 16.10 does not work (unless you modify the NVIDIA CUDA runtime headers).

--with-libcupti={yes|no|<Path to libcupti installation>}
If you want to build with libcupti support but do not have a libcupti in a standard location, you need to explicitly specify the directory where it is
installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-libcupti is a shorthand for --with-libcupti-include=<Path/include> and --with-libcupti-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.
--with-libcupti-include=<Path to libcupti headers>
--with-libcupti-lib=<Path to libcupti libraries>

If you want to use a CUDA library different from the system one you need to specify its location via:

--with-libcuda=<Path to libcuda installation>
Usually not needed, specifying --with-libcuda should be fine!
If you want to build scorep with libcuda but do not have a libcuda in a standard location then you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes], on cross-compile systems however, you have to specify a path [no]. --with-libcuda is a shorthand for --with-libcuda-include=<Path/include> and --with-libcuda-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.
--with-libcuda-include=<Path to libcuda headers>
--with-libcuda-lib=<Path to libcuda libraries>

If libnvidia-ml, which is used to determine correct device-IDs in a multi-GPU/multi-process environment, isn’t detected automatically, you can specify its location via:

--with-libnvidia-ml=(yes|no)<Path to libnvidia-ml installation>)
If you want to build with libnvidia-ml support but do not have a libnvidia-ml in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-libnvidia-ml is a shorthand for --with-libnvidia-ml-include=<Path/include> and --with-libnvidia-ml-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.
--with-libnvidia-ml-include=<Path to libnvidia-ml headers>
--with-libnvidia-ml-lib=<Path to libnvidia-ml libraries>

Options to further specify which features and external packages should be used to build Score-P are as follows:

--enable-platform-mic Force build for Intel Xeon Phi co-processors [no]. This option is only needed for Xeon Phi co-processors, like the Knights Corner (KNC). It is not needed for self-hosted Xeon Phis, like the Knights Landing (KNL); for these chips no special treatment is required.
--enable-experimental-platform Enables builds on platforms that are not officially supported (currently macOS and MinGW).
--enable-debug activate internal debug output [no]
--enable-shared[=PKGS] build shared libraries [default=no]
--enable-static[=PKGS] build static libraries [default=yes]
--enable-backend-test-runs Enable execution of tests during `make check` [no] (does not affect building of tests, though). If disabled, the files `check-file-<file>` and/or `skipped_tests` listing the tests are generated in the corresponding build directory.
--enable-cuda
Enable or disable support for CUDA. Fails if support cannot be satisfied but was requested.

--enable-openacc
Enable or disable support for OpenACC. (defaults to yes)

--disable-gcc-plugin
Disable support for the GCC plug-in instrumentation. Default is to determine support automatically. This disables it by request and fails if support cannot be satisfied but was requested.

--disable-online-access
Enable or disable Online Access. Fails if support cannot be satisfied but was requested.

--with-pdt=<path-to-binaries>
Specifies the path to the program database toolkit (PDT) binaries, e.g., cparsen.

--with-sionlib[=<sionlib-bindir>]
Use an already installed sionlib. Provide path to sionconfig. Auto-detected if already in $PATH. This option is not used by Score-P itself but passed to an internal OTP2.

--with-papi-header=<path-to-papi.h>
If papi.h is not installed in the default location, specify the dirname where it can be found.

--with-papi-lib=<path-to-libpapi.*>
If libpapi.* is not installed in the default location, specify the dirname where it can be found.

--with-libunwind=(yes|no|<Path to libunwind installation>)
If you want to build with libunwind support but do not have a libunwind in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-libunwind is a shorthand for --with-libunwind-includ=<Path/include> and --with-libunwind-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.

--with-libunwind-includ=<Path to libunwind headers>
--with-libunwind-lib=<Path to libunwind libraries>

--with-openacc-include=<path-to-openacc.h>
If openacc.h is not installed in the default location, specify the directory where it can be found.

--with-openacc-prof-includ=<path-to-acc_prof.h>
If acc_prof.h is not installed in the default location, specify the directory where it can be found.

--with-libOpenCL=(yes|no|<Path to libOpenCL installation>)
If you want to build with libOpenCL support but do not have a libOpenCL in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-libOpenCL is a shorthand for --with-libOpenCL-includ=<Path/include> and --with-libOpenCL-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.

--with-libOpenCL-includ=<Path to libOpenCL headers>
--with-libOpenCL-lib=<Path to libOpenCL libraries>

--with-libpmi=(yes|no|<Path to libpmi installation>)
If you want to build with libpmi support but do not have a libpmi in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-libpmi is a shorthand for --with-libpmi-includ=<Path/include> and --with-libpmi-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the
explicit include and lib options directly.
--with-libpmi-include=<Path to libpmi headers>
--with-libpmi-lib=<Path to libpmi libraries>
--with-librca=(yes|no|<Path to librca installation>)

If you want to build with librca support but do not have a librca in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-librca is a shorthand for --with-librca-include=<Path/include> and --with-librca-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.
--with-librca-include=<Path to librca headers>
--with-librca-lib=<Path to librca libraries>

--with-liblustreapi=(yes|no|<Path to liblustreapi installation>)

If you want to build with liblustreapi support but do not have a liblustreapi in a standard location, you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes]; on cross-compile systems, however, you have to specify a path [no]. --with-liblustreapi is a shorthand for --with-liblustreapi-include=<Path/include> and --with-liblustreapi-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.
--with-liblustreapi-include=<Path to liblustreapi headers>
--with-liblustreapi-lib=<Path to liblustreapi libraries>

--with-libbfd=<Path to libbfd installation>

If you want to build scorep with libbfd but do not have a libbfd in a standard location then you need to explicitly specify the directory where it is installed. On non-cross-compile systems we search the system include and lib paths per default [yes], on cross-compile systems however, you have to specify a path [no]. --with-libbfd is a shorthand for --with-libbfd-include=<Path/include> and --with-libbfd-lib=<Path/lib>. If these shorthand assumptions are not correct, you can use the explicit include and lib options directly.
--with-libbfd-include=<Path to libbfd headers>
--with-libbfd-lib=<Path to libbfd libraries>

Please note that if a Score-P installation uses libbfd, the Score-P instrumented binaries may only be distributed under GPLv3 licensing. 
--with-llvm[=<llvm-bindir>]
Use an already installed LLVM, including libclang as we need libclang for library-wrapping. Provide path to llvms-config. Auto-detected if already in $PATH.

Instead of passing command-line options to the 'configure' script, the package configuration can also be influenced by setting the following environment variables:

CC C compiler command
CFLAGS C compiler flags
LDFLAGS linker flags, e.g. -L<lib dir> if you have libraries in a nonstandard directory <lib dir>
LIBS libraries to pass to the linker, e.g. -l<library>
CPPFLAGS (Objective) C/C++ preprocessor flags, e.g. -I<include dir> if you have headers in a nonstandard directory <include dir>
LT_SYS_LIBRARY_PATH User-defined run-time library search path.
CPP C preprocessor
CXX C++ compiler command
CXXFLAGS C++ compiler flags
CXXCPP C++ preprocessor
CCAS assembler compiler command (defaults to CC)
CCASFLAGS assembler compiler flags (defaults to CFLAGS)
CXXCPP C++ preprocessor
F77
Fortran 77 compiler command
FFLAGS
Fortran 77 compiler flags
FC
Fortran compiler command
FCFLAGS
Fortran compiler flags
CC_FOR_BUILD
C compiler command for the frontend build
CXX_FOR_BUILD
C++ compiler command for the frontend build
F77_FOR_BUILD
Fortran 77 compiler command for the frontend build
FC_FOR_BUILD
Fortran compiler command for the frontend build
CPPFLAGS_FOR_BUILD
(Objective) C/C++ preprocessor flags for the frontend build, e.g. -I<include dir> if you have headers in a nonstandard directory <include dir>
CFLAGS_FOR_BUILD
C compiler flags for the frontend build
CXXFLAGS_FOR_BUILD
C++ compiler flags for the frontend build
FFLAGS_FOR_BUILD
Fortran 77 compiler flags for the frontend build
FCFLAGS_FOR_BUILD
Fortran compiler flags for the frontend build
LDFLAGS_FOR_BUILD
linker flags for the frontend build, e.g. -L<lib dir> if you have libraries in a nonstandard directory <lib dir>
LIBS_FOR_BUILD
libraries to pass to the linker for the frontend build, e.g. -l<library>
LIBCLANG_CPPFLAGS
Additional C preprocessor flags when compiling against libclang
LIBCLANG_CXXFLAGS
Additional C++ compile flags when compiling against libclang
LIBCLANG_LDFLAGS
Additional linker flags when linking against libclang
LIBCLANG_LIBS
Additional libs when linking against libclang
MPICC
MPI C compiler command
MPICXX
MPI C++ compiler command
MPIF77
MPI Fortran 77 compiler command
MPIFC
MPI Fortran compiler command
MPI_CFLAGS
MPI (Objective) C/C++ preprocessor flags, e.g. -I<include dir> if you have headers in a nonstandard directory <include dir>
MPI_CFLAGS
MPI C compiler flags
MPI_CXXFLAGS
MPI C++ compiler flags
MPI_FFLAGS
MPI Fortran 77 compiler flags
MPI_FCFLAGS
MPI Fortran compiler flags
MPI_LDFLAGS
MPI linker flags, e.g. -L<lib dir> if you have libraries in a nonstandard directory <lib dir>
MPI_LIBS
MPI libraries to pass to the linker, e.g. -l<library>
SHMEMCC
SHMEM C compiler command
SHMEMCXX
SHMEM C++ compiler command
SHMEFM77
SHMEM Fortran 77 compiler command
SHMPCMFC
SHMEM Fortran compiler command
SHMEMCPPFLAGS
SHMEM (Objective) C/C++ preprocessor flags, e.g. -I<include dir> if you have headers in a nonstandard directory <include dir>
SHMEM_CFLAGS
SHMEM C compiler flags
SHMEM_CXXFLAGS
SHMEM C++ compiler flags
SHMEM_FFLAGS
SHMEM Fortran 77 compiler flags
SHMEM_FCFLAGS
SHMEM Fortran compiler flags
SHMEM_LDFLAGS
SHMEM linker flags, e.g. -L<lib dir> if you have libraries in a nonstandard directory <lib dir>
SHMEM_LIBS
SHMEM libraries to pass to the linker, e.g. -l<library>
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SHMEM_LIB_NAME
text of the SHMEM library

SHMEM_NAME
text of the implemented SHMEM specification

CXXFLAGS_FOR_BUILD_SCORE
C++ compiler flags for building scorep-score

YACC
The ‘Yet Another Compiler Compiler’ implementation to use.
Defaults to the first program found out of: ‘bison -y’, ‘byacc’, ‘yacc’.

YFLAGS
The list of arguments that will be passed by default to $YACC.
This script will default YFLAGS to the empty string to avoid a default value of ‘-d’ given by some make applications.

PTHREAD_CFLAGS
CFLAGS used to compile Pthread programs

PTHREAD_LIBS
LIBS used to link Pthread programs

RUNTIME_MANAGEMENT_TIMINGS
Whether to activate time measurements for Score-P’s
SCOREP_InitMeasurement() and scorep_finalize() functions.
Activation values are ‘1’, ‘yes’, and ‘true’. For developer use.

PAPI_INC
Include path to the papi.h header.

PAPI_LIB
Library path to the papi library.

LIBUNWIND_INCLUDE
Path to libunwind headers.

LIBUNWIND_LIB
Path to libunwind libraries.

LIBCUDART_INCLUDE
Path to libcudart headers.

LIBCUDART_LIB
Path to libcudart libraries.

LIBCUDA_INCLUDE
Path to libcuda headers.

LIBCUDA_LIB
Path to libcuda libraries.

LIBCUPTI_INCLUDE
Path to libcupti headers.

LIBCUPTI_LIB
Path to libcupti libraries.

LIBNVIDIA_ML_INCLUDE
Path to libnvidia-ml headers.

LIBNVIDIA_ML_LIB
Path to libnvidia-ml libraries.

LIBOPENCL_INCLUDE
Path to libOpenCL headers.

LIBLUSTREAPI_INCLUDE
Path to liblustreapi headers.

LIBLUSTREAPI_LIB
Path to liblustreapi libraries.

LIBOPENCL_LIB
Path to libOpenCL libraries.

LIBBFD_INCLUDE
Path to libbfd headers.

LIBBFD_LIB
Path to libbfd libraries.

OPENACC_INCLUDE
Path to openacc.h header.

OPENACC_PROFILING_INCLUDE
Path to acc_prof.h header.

LIBPMI_INCLUDE
Path to libpmi headers.

LIBPMI_LIB
Path to libpmi libraries.

LIBRCA_INCLUDE
Path to librca headers.

LIBRCA_LIB
Path to librca libraries.

BACKEND_TEST_RUNS_NON_RECURSIVE
Whether to prevent passing --enable-backend-test-runs to
sub-packages. Activation values are ‘1’, ‘yes’, and ‘true’.

Building & Installing
======================

Before building Score-P, carefully check whether the configuration summary
printed by the configure script matches your expectations (i.e., whether MPI
and/or OpenMP support is correctly enabled/disabled, external libraries are
used, etc). If everything is OK, Score-P can be built and installed using
make
make install

Note that parallel builds (i.e., using ‘make -j <n>’) are fully supported.

Platform-specific Instructions
=====================================

GNU Compiler Plug-In
=====================================

On some systems the necessary header files, for compiling with support for the GNU Compiler plug-in instrumentation, are not installed by default. Therefore an extra package needs to be installed.

On Debian and its derivatives the package is called:

gcc-<version>-plugin-dev

On Fedora and its derivatives the package is called:

gcc-plugin-devel

Intel Xeon Phi (aka. MIC) co-processors
========================================

[Note: The following instructions only apply to Intel Xeon Phi co-processors, like the Knights Corner (KNC). They do not apply to self-hosted Xeon Phis, like the Knights Landing (KNL); for these chips no special treatment is required.]

Building Score-P for Intel Xeon Phi co-processors requires some extra care, and in some cases two installations into the same location. Therefore, we strongly recommend to strictly follow the procedure as described below.

1. Ensure that Intel compilers and Intel MPI (if desired) are installed and available in $PATH, and that the Intel Manycore Platform Software Stack (MPSS) is installed.

2. Configure Score-P to use the MIC platform:

```
mkdir _build-mic
cd _build-mic
../configure --enable-platform-mic [other options, e.g., '--prefix']
```

3. Build and install:

```
make; make install
```

In case a native MIC-only installation serves your needs, that’s it. However, if the installation should also support instrumentation and measurement of host code, a second installation *on top* of the just installed one is required:

4. Create a new build directory for the host build:

```
cd..
mkdir _build-host
cd _build-host
```

5. Reconfigure for the host using *identical directory options* (e.g., '--prefix' or '--bindir') as in step 2:

```
../configure [other options as used in step 2]
```

This will automatically detect the already existing native MIC build and enable the required support in the host tools. On non-cross-compile systems (e.g., typical Linux clusters), make sure to explicitly select Intel compiler support by passing ‘--with-nocross-compiler-suite=intel’ to the configure script.
6. Build and install:

   make; make install

   Note that this approach also works with VPATH builds (even with two
   separate build directories) as long as the same options defining directory
   locations are passed in steps 2 and 5.

User Library Wrapping
=====================

To enable the user library wrapping feature, Score-P needs the LLVM compiler
infrastructure. For one the 'llvm-config' program is needed, and also 'libclang'
and it's developer packages. The clang/clang++ compilers are not strictly
needed, but will be used when available.

On Debian and it's derivatives the packages are called:

   llvm-dev
   libclang-dev

On Fedora and it's derivatives the packages are called:

   llvm-devel
   clang-devel

Or the pre-built packages at:

   http://llvm.org/releases/download.html

Generic Installation Instructions
================================


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Basic Installation
==================

Briefly, the shell commands './configure; make; make install' should
configure, build, and install this package. The following more-detailed
instructions are generic; see the section above for instructions
specific to this package. Some packages provide this 'INSTALL' file but
do not implement all of the features documented below. The lack of an
optional feature in a given package is not necessarily a bug.

The 'configure' shell script attempts to guess correct values for
various system-dependent variables used during compilation. It uses
those values to create a 'Makefile' in each directory of the package.
It may also create one or more '.h' files containing system-dependent
definitions. Finally, it creates a shell script 'config.status' that
you can run in the future to recreate the current configuration, and a
file 'config.log' containing compiler output (useful mainly for
debugging 'configure').

It can also use an optional file (typically called 'config.cache'
and enabled with '--cache-file=config.cache' or simply '-C') that saves
the results of its tests to speed up reconfiguring. Caching is
disabled by default to prevent problems with accidental use of stale
file caches.

If you need to do unusual things to compile the package, please try
to figure out how 'configure' could check whether to do them, and mail
diffs or instructions to support@score-p.org so they can be considered
for the next release. If you are using the cache, and at some point
'config.cache' contains results you don’t want to keep, you may remove
or edit it.
The file 'configure.ac' (or 'configure.in') is used to create 'configure' by a program called 'autoconf'. You need 'configure.ac' if you want to change it or regenerate 'configure' using a newer version of 'autoconf'.

The simplest way to compile this package is:

1. 'cd' to the directory containing the package's source code and type './configure' to configure the package for your system.

   Running 'configure' might take a while. While running, it prints some messages telling which features it is checking for.

2. Type 'make' to compile the package.

3. Optionally, type 'make check' to run any self-tests that come with the package, generally using the just-built uninstalled binaries.

4. Type 'make install' to install the programs and any data files and documentation. When installing into a prefix owned by root, it is recommended that the package be configured and built as a regular user, and only the 'make install' phase executed with root privileges.

5. Optionally, type 'make installcheck' to repeat any self-tests, but this time using the binaries in their final installed location. This target does not install anything. Running this target as a regular user, particularly if the prior 'make install' required root privileges, verifies that the installation completed correctly.

6. You can remove the program binaries and object files from the source code directory by typing 'make clean'. To also remove the files that 'configure' created (so you can compile the package for a different kind of computer), type 'make distclean'. There is also a 'make maintainer-clean' target, but that is intended mainly for the package's developers. If you use it, you may have to get all sorts of other programs in order to regenerate files that came with the distribution.

7. Often, you can also type 'make uninstall' to remove the installed files again. In practice, not all packages have tested that uninstallation works correctly, even though it is required by the GNU Coding Standards.

8. Some packages, particularly those that use Automake, provide 'make distcheck', which can by used by developers to test that all other targets like 'make install' and 'make uninstall' work correctly. This target is generally not run by end users.

Compilers and Options
====================

Some systems require unusual options for compilation or linking that the 'configure' script does not know about. Run './configure --help' for details on some of the pertinent environment variables.

You can give 'configure' initial values for configuration parameters by setting variables in the command line or in the environment. Here is an example:

```
./configure CC=c99 CFLAGS=-g LIBS=-lposix
```

*Note Defining Variables*, for more details.

Compiling For Multiple Architectures
====================================

You can compile the package for more than one kind of computer at the same time, by placing the object files for each architecture in their own directory. To do this, you can use GNU 'make'. 'cd' to the directory where you want the object files and executables to go and run...
the 'configure' script. 'configure' automatically checks for the source code in the directory that 'configure' is in and in '..'. This is known as a "VPATH" build.

With a non-GNU 'make', it is safer to compile the package for one architecture at a time in the source code directory. After you have installed the package for one architecture, use 'make distclean' before reconfiguring for another architecture.

On MacOS X 10.5 and later systems, you can create libraries and executables that work on multiple system types—known as "fat" or "universal" binaries—by specifying multiple '-arch' options to the compiler but only a single '-arch' option to the preprocessor. Like this:

```
./configure CC="gcc -arch i386 -arch x86_64 -arch ppc -arch ppc64" \
   CXX="g++ -arch i386 -arch x86_64 -arch ppc -arch ppc64" \
   CPP="gcc -E" CXXCPP="g++ -E"
```

This is not guaranteed to produce working output in all cases; you may have to build one architecture at a time and combine the results using the 'lipo' tool if you have problems.

Installation Names
==================

By default, 'make install' installs the package's commands under '/usr/local/bin', include files under '/usr/local/include', etc. You can specify an installation prefix other than '/usr/local' by giving 'configure' the option '--prefix=PREFIX', where PREFIX must be an absolute file name.

You can specify separate installation prefixes for architecture-specific files and architecture-independent files. If you pass the option '--exec-prefix=PREFIX' to 'configure', the package uses PREFIX as the prefix for installing programs and libraries. Documentation and other data files still use the regular prefix.

In addition, if you use an unusual directory layout you can give options like '--bindir=DIR' to specify different values for particular kinds of files. Run 'configure --help' for a list of the directories you can set and what kinds of files go in them. In general, the default for these options is expressed in terms of '${prefix}', so that specifying just '--prefix' will affect all of the other directory specifications that were not explicitly provided.

The most portable way to affect installation locations is to pass the correct locations to 'configure'; however, many packages provide one or both of the following shortcuts of passing variable assignments to the 'make install' command line to change installation locations without having to reconfigure or recompile.

The first method involves providing an override variable for each affected directory. For example, 'make install prefix=alternate/directory' will choose an alternate location for all directory configuration variables that were expressed in terms of '${prefix}'. Any directories that were specified during 'configure', but not in terms of '${prefix}', must each be overridden at install time for the entire installation to be relocated. The approach of makefile variable overrides for each directory variable is required by the GNU Coding Standards, and ideally causes no recompilation. However, some platforms have known limitations with the semantics of shared libraries that end up requiring recompilation when using this method, particularly noticeable in packages that use GNU Libtool.

The second method involves providing the 'DESTDIR' variable. For example, 'make install DESTDIR=alternate/directory' will prepend 'alternate/directory' before all installation names. The approach of 'DESTDIR' overrides is not required by the GNU Coding Standards, and does not work on platforms that have drive letters. On the other hand, it does better at avoiding recompilation issues, and works well even when some directory options were not specified in terms of '${prefix}' at 'configure' time.
Optional Features
==================

If the package supports it, you can cause programs to be installed with an extra prefix or suffix on their names by giving 'configure' the option `--program-prefix=PREFIX' or `--program-suffix=SUFFIX'.

Some packages pay attention to `--enable-FEATURE' options to 'configure', where FEATURE indicates an optional part of the package. They may also pay attention to `--with-PACKAGE' options, where PACKAGE is something like 'gnu-as' or 'x' (for the X Window System).

For packages that use the X Window System, 'configure' can usually find the X include and library files automatically, but if it doesn’t, you can use the 'configure' options `--x-includes=DIR' and `--x-libraries=DIR' to specify their locations.

Some packages offer the ability to configure how verbose the execution of 'make' will be. For these packages, running './configure --enable-silent-rules' sets the default to minimal output, which can be overridden with 'make V=1'; while running './configure --disable-silent-rules' sets the default to verbose, which can be overridden with 'make V=0'.

Particular systems
==================

On HP-UX, the default C compiler is not ANSI C compatible. If GNU CC is not installed, it is recommended to use the following options in order to use an ANSI C compiler:

```
./configure CC="cc -Ae -D_XOPEN_SOURCE=500"
```

and if that doesn’t work, install pre-built binaries of GCC for HP-UX.

On OSF/1 a.k.a. Tru64, some versions of the default C compiler cannot parse its `<wchar.h>' header file. The option `-nodtk' can be used as a workaround. If GNU CC is not installed, it is therefore recommended to try

```
./configure CC="cc"
```

and if that doesn’t work, try

```
./configure CC="cc -nodtk"
```

On Solaris, don’t put `/usr/ucb' early in your 'PATH'. This directory contains several dysfunctional programs; working variants of these programs are available in `/usr/bin'. So, if you need `/usr/ucb' in your 'PATH', put it _after_ `/usr/bin'.

On Haiku, software installed for all users goes in `/boot/common', not `/usr/local'. It is recommended to use the following options:

```
./configure --prefix=/boot/common
```

Specifying the System Type
===========================

There may be some features 'configure' cannot figure out automatically, but needs to determine by the type of machine the package will run on. Usually, assuming the package is built to be run on the _same_ architectures, 'configure' can figure that out, but if it prints a message saying it cannot guess the machine type, give it the `--build=TYPE' option. TYPE can either be a short name for the system type, such as 'sun4', or a canonical name which has the form:

```
CPU-COMPANY-SYSTEM
```

where SYSTEM can have one of these forms:

OS
Appendix A. Score-P Install

Kernel OS

See the file `config.sub` for the possible values of each field. If `config.sub` isn't included in this package, then this package doesn't need to know the machine type.

If you are _building_ compiler tools for cross-compiling, you should use the option `--target=TYPE` to select the type of system they will produce code for.

If you want to _use_ a cross compiler, that generates code for a platform different from the build platform, you should specify the "host" platform (i.e., that on which the generated programs will eventually be run) with `--host=TYPE`.

Sharing Defaults
===============

If you want to set default values for `configure` scripts to share, you can create a site shell script called `config.site` that gives default values for variables like `CC`, `cache_file`, and `prefix`. `configure` looks for `PREFIX/share/config.site` if it exists, then `PREFIX/etc/config.site` if it exists. Or, you can set the `CONFIG_SITE` environment variable to the location of the site script. A warning: not all `configure` scripts look for a site script.

Defining Variables
==================

Variables not defined in a site shell script can be set in the environment passed to `configure`. However, some packages may run configure again during the build, and the customized values of these variables may be lost. In order to avoid this problem, you should set them in the `configure` command line, using `VAR=value`. For example:

```
./configure CC=/usr/local2/bin/gcc
```

causes the specified `gcc` to be used as the C compiler (unless it is overridden in the site shell script).

Unfortunately, this technique does not work for `CONFIG_SHELL` due to an Autoconf bug. Until the bug is fixed you can use this workaround:

```
CONFIG_SHELL=/bin/bash /bin/bash ./configure CONFIG_SHELL=/bin/bash
```

`configure` Invocation
======================

`configure` recognizes the following options to control how it operates.

`--help`

`-h`

Print a summary of all of the options to `configure`, and exit.

`--help=short`

`--help=recursive`

Print a summary of the options unique to this package’s `configure`, and exit. The `short` variant lists options used only in the top level, while the `recursive` variant lists options also present in any nested packages.

`--version`

`-v`

Print the version of Autoconf used to generate the `configure` script, and exit.

`--cache-file=FILE`

Enable the cache: use and save the results of the tests in FILE, traditionally `config.cache`. FILE defaults to `/dev/null` to disable caching.

`--config-cache`
'-C'
  Alias for ‘--cache-file=config.cache’.

'--quiet'
'--silent'
'-q'
  Do not print messages saying which checks are being made. To suppress all normal output, redirect it to ‘/dev/null’ (any error messages will still be shown).

'--srcdir=DIR'
  Look for the package’s source code in directory DIR. Usually ‘configure’ can determine that directory automatically.

'--prefix=DIR'
  Use DIR as the installation prefix. Note Installation Names:: for more details, including other options available for fine-tuning the installation locations.

'--no-create'
'-n'
  Run the configure checks, but stop before creating any output files.

‘configure’ also accepts some other, not widely useful, options. Run ‘configure --help’ for more details.
Appendix B

MPI wrapper affiliation

Some wrapper functions are affiliated with a function group that has not been described for direct user access in section ‘Selection of MPI Groups’. These groups are subgroups that contain function calls that are only enabled when both main groups are enabled. The reason for this is to control the amount of events generated during measurement, a user might want to turn off the measurement of non-critical function calls before the measurement of the complete main group is turned off. Subgroups can either be related to MISC (miscellaneous functions, e.g., handle conversion), EXT (external interfaces, e.g., handle attributes), or ERR (error handlers).

For example, the functions in group CG_MISC will only generate events if both groups CG and MISC are enabled at runtime.

Furthermore, the group REQUEST cannot be enabled directly by the user. The group is automatically enabled if any of the groups CG, COLL, EXT, IO, P2P, or RMA is enabled. It is disabled only if all of these groups are disabled as well.

B.1 Function to group

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### B.2 Communicators and Groups

- **CG** - Communicators and Groups
  - MPI_Comm_compare, MPI_Comm_create, MPI_Comm_create_group, MPI_Comm_dup,
  - MPI_Comm_dup_with_info, MPI_Comm_free, MPI_Comm_group, MPI_Comm_idup, MPI_Comm_rank,
  - MPI_Comm_remote_group, MPI_Comm_remote_size, MPI_Comm_size, MPI_Comm_split,
  - MPI_Comm_split_type, MPI_Comm_test_inter, MPI_Group_compare, MPI_Group_difference,
  - MPI_Group_excl, MPI_Group_free, MPI_Group_incl, MPI_Group_intersection, MPI_Group_range_excl,
  - MPI_Group_range_incl, MPI_Group_rank, MPI_Group_size, MPI_Group_translate_ranks, MPI_Group_union,
  - MPI_Intercomm_create, MPI_Intercomm_merge,

### B.2 Error handlers for Communicators and Groups

- **CG_ERR** - Error handlers for Communicators and Groups
  - MPI_Comm_call_errhandler, MPI_Comm_create_errhandler, MPI_Comm_get_errhandler,
  - MPI_Comm_set_errhandler,
**APPENDIX B. MPI WRAPPER AFFILIATION**

### CG_EXT - External interfaces for Communicators and Groups
- MPI_Attr_delete, MPI_Attr_get, MPI_Attr_put, MPI_Comm_create_keyval, MPI_Comm_delete_attr,
- MPI_Comm_free_keyval, MPI_Comm_get_attr, MPI_Comm_get_info, MPI_Comm_get_name,
- MPI_Comm_set_attr, MPI_Comm_set_info, MPI_Comm_set_name, MPI_Keyval_create, MPI_Keyval_free,

### CG_MISC - Miscellaneous functions for Communicators and Groups
- MPI_Comm_c2f, MPI_Comm_f2c, MPI_Group_c2f, MPI_Group_f2c,

### COLL - Collective communication
- MPI_Allgather, MPI_Allgatherv, MPI_Allreduce, MPI_Alltoall, MPI_Alltoallv, MPI_Alltoallw, MPI_BARRIER,
- MPI_Bcast, MPI_Exscan, MPI_Gather, MPI_Gatherv, MPI_Iallgather, MPI_Iallgatherv, MPI_Iallreduce,
- MPI_Ialltoall, MPI_Ialltoallv, MPI_Ialltoallw, MPI_Ibarrier, MPI_Ibcast, MPI_Iexscan, MPI_Igather, MPI_Igatherv,
- MPI_Ireduce, MPI_Ireduce_scatter, MPI_Ireduce_scatter_block, MPI_Iiscan, MPI_Iiscatter, MPI_Iiscatterv,
- MPI_Reduce, MPI_Reduce_local, MPI_Reduce_scatter, MPI_Reduce_scatter_block, MPI_Scan, MPI_Scatter,
- MPI_Scatterv,

### ENV - Environmental management
- MPI_Finalize, MPI_Finalized, MPI_Get_library_version, MPI_Init, MPI_Init_thread, MPI_Initialized,
- MPI_Is_thread_main, MPI_Query_thread,

### ERR - Common error handlers
- MPI_Add_error_class, MPI_Add_error_code, MPI_Add_error_string, MPI_Errhandler_create,
- MPI_Errhandler_free, MPI_Errhandler_get, MPI_Errhandler_set, MPI_Error_class, MPI_Error_string,

### IO - Parallel I/O
- MPI_File_close, MPI_File_delete, MPI_File_get_amode, MPI_File_get_atomicity, MPI_File_get_byte_offset,
- MPI_File_get_group, MPI_File_get_info, MPI_File_get_position, MPI_File_get_position_shared,
- MPI_File_get_size, MPI_File_get_type_extent, MPI_File_get_view, MPI_File_iread, MPI_File_iread_all,
- MPI_File_iread_at, MPI_File_iread_at_all, MPI_File_iread_shared, MPI_File_iwrite, MPI_File_iwrite_all,
- MPI_File_iwrite_at, MPI_File_iwrite_at_all, MPI_File_iwrite_shared, MPI_File_open, MPI_File_preallocate,
- MPI_File_read, MPI_File_read_all, MPI_File_read_all_begin, MPI_File_read_all_end, MPI_File_read_at,
- MPI_File_read_at_all, MPI_File_read_at_all_begin, MPI_File_read_at_all_end, MPI_File_read_ordered,
- MPI_File_read_ordered_begin, MPI_File_read_ordered_end, MPI_File_read_shared, MPI_File_seek,
- MPI_File_write, MPI_File_write_all, MPI_File_write_all_begin, MPI_File_write_all_end, MPI_File_write_at,
- MPI_File_write_at_all, MPI_File_write_at_all_begin, MPI_File_write_at_all_end, MPI_File_write_ordered,
- MPI_File_write_ordered_begin, MPI_File_write_ordered_end, MPI_File_write_shared, MPI_Register_datarep,

### IO_ERR - Error handlers for Parallel I/O
- MPI_File_call_errhandler, MPI_File_create_errhandler, MPI_File_get_errhandler, MPI_Errhandler_set,

### IO_MISC - Miscellaneous functions for Parallel I/O
- MPI_File_c2f, MPI_File_f2c,

### EXT - Common external interfaces
- MPI_Get_count, MPI_Get_elements, MPI_Get_elements_x, MPI_Get_processor_name,
- MPI_Grequest_complete, MPI_Grequest_start, MPI_Status_set_cancelled, MPI_Status_set_elements,
- MPI_Status_set_elements_x, MPI_Wtick, MPI_Wtime,

### MISC - Miscellaneous functions
- MPI_Address, MPI_Alloc_mem, MPI_Free_mem, MPI_Get_address, MPI_Get_version, MPI_Info_c2f,
- MPI_Info_create, MPI_Info_delete, MPI_Info_dup, MPI_Info_f2c, MPI_Info_free, MPI_Info_get,
- MPI_Info_get_nkeys, MPI_Info_get_nthkey, MPI_Info_get_values, MPI_Info_set, MPI_Op_c2f,
- MPI_Op_commutative, MPI_Op_create, MPI_Op_f2c, MPI_Op_free, MPI_Request_c2f, MPI_Request_f2c,
- MPI_Request_get_status, MPI_Status_c2f, MPI_Status_f2c,
### B.2 Group to function

#### P2P - Point-to-point communication
- `MPI_Bsend`, `MPI_Bsend_init`, `MPI_Buffer_attach`, `MPI_Buffer_detach`, `MPI_IBsend`, `MPI_Improbe`, `MPI_Irecv`, `MPI_Isend`, `MPI_Isend_init`, `MPI_Irecv`, `MPI_Irecv_init`, `MPI_Isend`, `MPI_Send`, `MPI_Send_init`, `MPI_Sendrecv`, `MPI_Sendrecv_replace`, `MPI_Ssend`, `MPI_Ssend_init`,

#### PERF - Profiling Interface
- `MPI_Pcontrol`,

#### REQUEST - Completion of request-based operations
- `MPI_Cancel`, `MPI_Request_free`, `MPI_Start`, `MPI_Startall`, `MPI_Test`, `MPI_Test_cancelled`, `MPI_Testall`,
- `MPI_Testany`, `MPI_Testsome`, `MPI_Wait`, `MPI_Waitall`, `MPI_Waitsome`,

#### RMA - One-sided communication (Remote Memory Access)
- `MPI_Accumulate`, `MPI_Compare_and_swap`, `MPI_Fetch_and_op`, `MPI_Get`, `MPI_Get_accumulate`, `MPI_Put`,
- `MPI_Raccumulate`, `MPI_Rget`, `MPI_Rget_accumulate`, `MPI_Rput`, `MPI_Win_allocate`,
- `MPI_Win_allocate_shared`, `MPI_Win_attach`, `MPI_Win_complete`, `MPI_Win_create`, `MPI_Win_create_dynamic`,
- `MPI_Win_detach`, `MPI_Win_fence`, `MPI_Win_flush`, `MPI_Win_flush_all`, `MPI_Win_flush_local`,
- `MPI_Win_flush_local_all`, `MPI_Win_free`, `MPI_Win_get_group`, `MPI_Win_lock`, `MPI_Win_lock_all`,
- `MPI_Win_post`, `MPI_Win_shared_query`, `MPI_Win_start`, `MPI_Win_sync`, `MPI_Win_test`, `MPI_Win_unlock`,
- `MPI_Win_unlock_all`, `MPI_Win_wait`,

#### RMA_ERR - Error handlers for One-sided communication (Remote Memory Access)
- `MPI_Win_call_errhandler`, `MPI_Win_create_errhandler`, `MPI_Win_get_errhandler`, `MPI_Win_set_errhandler`,

#### RMA_EXT - External interfaces for One-sided communication (Remote Memory Access)
- `MPI_Win_create_keyval`, `MPI_Win_delete_attr`, `MPI_Win_free_keyval`, `MPI_Win_get_attr`, `MPI_Win_get_info`,
- `MPI_Win_get_name`, `MPI_Win_set_attr`, `MPI_Win_set_info`, `MPI_Win_set_name`,

#### RMA_MISC - Miscellaneous functions for One-sided communication (Remote Memory Access)
- `MPI_Win_c2f`, `MPI_Win_f2c`,

#### SPAWN - Process spawning
- `MPI_Close_port`, `MPI_Comm_accept`, `MPI_Comm_connect`, `MPI_Comm_disconnect`, `MPI_Comm_get_parent`,
- `MPI_Comm_join`, `MPI_Comm_spawn`, `MPI_Comm_spawn_multiple`, `MPI.Lookup_name`, `MPI_Open_port`,
- `MPI_Publish_name`, `MPI_Unpublish_name`,

#### TOPO - Topology (cartesian and graph) communicators
- `MPI_Cart_coords`, `MPI_Cart_create`, `MPI_Cart_get`, `MPI_Cart_map`, `MPI_Cart_rank`, `MPI_Cart_shift`,
- `MPI_Cart_sub`, `MPI_Cartdim_get`, `MPI_Dims_create`, `MPI_Dist_graph_create`,
- `MPI_Distgraph_create_adjacent`, `MPI_Dist_graph_neighbors`, `MPI_Dist_graph_neighbors_count`,
- `MPI_Graph_create`, `MPI_Graph_get`, `MPI_Graph_map`, `MPI_Graph_neighbors`, `MPI_Graph_neighbors_count`,
- `MPI_graphdims_get`, `MPI_Inneighbor_allgather`, `MPI_Inneighbor_allgatherv`, `MPI_Inneighbor_allgatherv`,
- `MPI_Inneighbor_alltoall`, `MPI_Inneighbor_alltoallv`, `MPI_Inneighbor_alltoallw`, `MPI_Inneighbor_alltoallw`,
- `MPI_Inneighbor_alltoallw`, `MPI_Inneighbor_alltoallw`,

#### TYPE - Datatypes
- `MPI_Type_contiguous`, `MPI_Type_create_darray`, `MPI_Type_create_f90_complex`,
- `MPI_Type_create_f90_integer`, `MPI_Type_create_f90_real`, `MPI_Type_create_hindexed`,
- `MPI_Type_create_hindexed_block`, `MPI_Type_create_hvector`, `MPI_Type_create_indexed_block`,
- `MPI_Type_create_resized`, `MPI_Type_create_struct`, `MPI_Type_create_subarray`, `MPI_Type_dup`,
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- `MPI_Type_get_extent`, `MPI_Type_get_true_extent`, `MPI_Type_get_true_extent_x`, `MPI_Type_hindexed`,
- `MPI_Type_hvector`, `MPI_Type_indexed`, `MPI_Type_lb`, `MPI_Type_match_size`, `MPI_Type_size`,
- `MPI_Type_size_x`, `MPI_Type_struct`, `MPI_Type_ub`, `MPI_Type_vector`, `MPI_Unpack`, `MPI_Unpack_external`,

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### APPENDIX B. MPI WRAPPER AFFILIATION

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Appendix C

Score-P Metric Plugin Example

Simple example of a Score-P metric plugin

```c
#include <scorep/SCOREP_MetricPlugins.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

/* Maximum number of metrics */
#define NUMBER_METRICS 5
/* Maximum string length */
#define MAX_BUFFER_LENGTH 255
/* Number of individual metrics */
static int32_t num_metrics = 0;

int32_t init()
{
    return 0;
}

int32_t add_counter( char* eventName )
{
    int id = num_metrics;
    num_metrics++;
    return id;
}

SCOREP_Metric_Plugin_MetricProperties*
get_event_info( char* eventName )
{
    SCOREP_Metric_Plugin_MetricProperties* return_values;
    char name_buffer[ MAX_BUFFER_LENGTH ];
    int i;

    /* If wildcard is specified, add some default counters */
    if ( strcmp( eventName, "*" ) == 0 )
    {
        return_values = malloc( ( NUMBER_METRICS + 1 ) * sizeof( SCOREP_Metric_Plugin_MetricProperties ) );
        for ( i = 0; i < NUMBER_METRICS; i++ )
        {
            snprintf( name_buffer, MAX_BUFFER_LENGTH, "sync counter #i", i );
            return_values[ i ].name = strdup( name_buffer );
            return_values[ i ].description = NULL;
            return_values[ i ].unit = NULL;
            return_values[ i ].mode = SCOREP_METRIC_MODE_ABSOLUTE_LAST;
            return_values[ i ].value_type = SCOREP_METRIC_VALUE_UINT64;
            return_values[ i ].base = SCOREP_METRIC_BASE_DECIMAL;
            return_values[ i ].exponent = 0;
        }
        return_values[ NUMBER_METRICS ].name = NULL;
    }
    return return_values;
}
```
else
{
    /* If no wildcard is given create one counter with the passed name */
    return_values = malloc( 2 * sizeof(SCOREP_Metric_Plugin_MetricProperties ) );
    snprintf( name_buffer, MAX_BUFFER_LENGTH, "sync counter #%s", eventName );
    return_values[ 0 ].name = strdup( name_buffer );
    return_values[ 0 ].description = NULL;
    return_values[ 0 ].unit = NULL;
    return_values[ 0 ].mode = SCOREP_METRIC_MODE_ABSOLUTE_LAST;
    return_values[ 0 ].value_type = SCOREP_METRIC_VALUE_UINT64;
    return_values[ 0 ].base = SCOREP_METRIC_BASE_DECIMAL;
    return_values[ 0 ].exponent = 0;
    return_values[ 1 ].name = NULL;
    return return_values;
}
}

bool
get_value( int32_t counterIndex,
        uint64_t* value )
{
    *value = counterIndex;
    return true;
}

void
fini()
{
    return;
}

SCOREP_METRIC_PLUGIN_ENTRY( HelloWorld )
{
    /* Initialize info data (with zero) */
    SCOREP_Metric_Plugin_Info info;
    memset( &info, 0, sizeof( SCOREP_Metric_Plugin_Info ) );
    /* Set up */
    info.plugin_version = SCOREP_METRIC_PLUGIN_VERSION;
    info.run_per = SCOREP_METRIC_PER_PROCESS;
    info.sync = SCOREP_METRIC_SYNC;
    info.initialize = init;
    info.finalize = fini;
    info.get_event_info = get_event_info;
    info.add_counter = add_counter;
    info.get_optional_value = get_value;
    return info;
}

See also
SCOREP_MetricPlugins.h
Appendix D

Experiment Directory Contents

The contents of the experiment directory might vary depending on the settings for the measurement run. The following table shows the possible files and the environment variables they are depending on.

Files that should be present from the start, e.g., in an aborted measurement:

**README**  Information about this measurement, e.g., list of expected files

**scorep.cfg**  Listing of used environment variables

**scorep.filter**  Copy of the used filter file
SCOREP_FILTERING_FILE

**scorep.selective**  Copy of the used config file for selective recording
SCOREP_SELECTIVE_CONFIG_FILE

Files that will be created at the end of the measurement:

**profile.cubex**  Cube4 result file of the summary measurement or an extended set of statistics
SCOREP_ENABLE_PROFILING, SCOREP_PROFILING_BASE_NAME, SCOREP_PROFILING_FORMAT

**tau/snapshot.[rank].0.0**  TAU snapshot files
SCOREP_ENABLE_PROFILING, SCOREP_PROFILING_BASE_NAME, SCOREP_PROFILING_FORMAT

**traces/**  Sub-directory with per location trace data
SCOREP_ENABLE_TRACING

**traces.def**  OTF2 global definitions file
SCOREP_ENABLE_TRACING
traces.otf2  OTF2 anchor file
SCOREP_ENABLE_TRACING

Additional debug information, the files and their contents may vary depending on the measurement progress:

profile.[rank].[thread].core  Profiling core file in case of error
SCOREP_PROFILING_ENABLE_CORE_FILES, SCOREP_PROFILING_BASE_NAME
Appendix E

Score-P Substrate Plugin Example

Simple example of a Score-P substrate plugin

```c
#include <assert.h>
#include <inttypes.h>
#include <stdio.h>
#include <string.h>
#include <scorep/SCOREP_SubstratePlugins.h>

static const SCOREP_SubstratePluginCallbacks* callbacks;
static size_t plugin_id;

static void
print( const char* event, struct SCOREP_Location* location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t stackdepth )
{
  uint64_t i;
  const char* slocation = callbacks->SCOREP_Location_GetName( location );
  const char* sregion = callbacks->SCOREP_RegionHandle_GetName( regionHandle );
  printf( "%" PRIu64 " : %s >%" PRIu64 " %s %s
", timestamp, slocation, stackdepth, event, sregion );
}

/* An enter event has been received from Score-P */
static void
enter_region( struct SCOREP_Location* location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t* metricValues )
{
  uint64_t* stackdepth = callbacks->SCOREP_Location_GetData( location, plugin_id );
  print( "Enter", location, timestamp, regionHandle, *stackdepth );
  (*stackdepth)++;
}

/* An exit event has been received from Score-P */
static void
exit_region( struct SCOREP_Location* location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t* metricValues )
{
  uint64_t* stackdepth = callbacks->SCOREP_Location_GetData( location, plugin_id );
  print( "Exit", location, timestamp, regionHandle, *stackdepth );
  (*stackdepth)--;
}

/* is only called when process is currently not parallel */
static void
disable(
```
struct SCOREP_Location* location,
uint64_t timestamp,
SCOREP_RegionHandle regionHandle,
uint64_t* metricValues
{
    const char* slocation = callbacks->SCOREP_Location_GetName(location);
    const char* sregion = callbacks->SCOREP_RegionHandle_GetName(regionHandle);
    printf("--------Disabled recording (%s - %s)----------\n", slocation, sregion);
}

/* is only called when process is currently not parallel */
static void enable(
    struct SCOREP_Location* location,
    uint64_t timestamp,
    SCOREP_RegionHandle regionHandle,
    uint64_t* metricValues
{
    const char* slocation = callbacks->SCOREP_Location_GetName(location);
    const char* sregion = callbacks->SCOREP_RegionHandle_GetName(regionHandle);
    printf("--------Enabled recording (%s - %s)----------\n", slocation, sregion);
}

/* Register event functions */
static uint32_t get_event_functions(
    SCOREP_Substrates_Mode mode,
    SCOREP_Substrates_Callback** returned
{
    SCOREP_Substrates_Callback* functions = calloc(SCOREP_SUBSTRATES_NUM_EVENTS, sizeof(SCOREP_Substrates_Callback));
    /* Only print region events when recording is enabled */
    if (mode == SCOREP_SUBSTRATES_RECORDING_ENABLED)
    {
        functions[SCOREP_EVENT_ENTER_REGION] = (SCOREP_Substrates_Callback)enter_region;
        functions[SCOREP_EVENT_EXIT_REGION] = (SCOREP_Substrates_Callback)exit_region;
    /* function prototypes for other events can be found in scorep/SCOREP_SubstrateEvents.h */
    /* enable and disable are guaranteed to be called for SCOREP_SUBSTRATES_RECORDING_ENABLED */
    functions[SCOREP_EVENT_ENABLE_RECORDING] = (SCOREP_Substrates_Callback)enable;
    functions[SCOREP_EVENT_DISABLE_RECORDING] = (SCOREP_Substrates_Callback)disable;
    }
    *returned = functions;
    return SCOREP_SUBSTRATES_NUM_EVENTS;
}

/* Receive callbacks from Score-P */
static void set_callbacks(
    const SCOREP_SubstratePluginCallbacks* incoming_callbacks,
    size_t size)
{
    assert(sizeof(SCOREP_SubstratePluginCallbacks) <= size);
    callbacks = incoming_callbacks;
}

/* assign id */
static void assign_id(
    size_t id)
{
    plugin_id = id;
}

static void create_location(
    const struct SCOREP_Location* location,
    const struct SCOREP_Location* parentLocation)
{
    /* we store the stackdepth per location and initialize it with 0 */
    uint64_t* stackdepth = calloc(sizeof(uint64_t), 1);
    callbacks->SCOREP_Location_SetData(location, plugin_id, (void*)stackdepth);
}

/* Define plugins and some plugin functions */
SCOREP_SUBSTRATE_PLUGIN_ENTRY( PrintRegions )
{
SCOREP_SubstratePluginInfo info;
memset( &info, 0, sizeof( SCOREP_SubstratePluginInfo ) );
info.plugin_version = SCOREP_SUBSTRATE_PLUGIN_VERSION;
info.set_callbacks = set_callbacks;
info.create_location = create_location;
info.assign_id = assign_id;
info.get_event_functions = get_event_functions;
return info;
}

See also
SCOREP_SubstratePlugins.h
Appendix F

Score-P Tools

F.1 scorep

A call to scorep has the following syntax:

This is the Score-P instrumentation tool. The usage is:

scorep <options> <original command>

Common options are:

--help, -h  Show help output. Does not execute any other command.
-v, --verbose[=<value>]  Specifies the verbosity level. The following levels are available:
  0 = No output
  1 = Executed commands are displayed (default if no value is specified)
  2 = Detailed information is displayed
--dry-run  Only displays the executed commands. It does not execute any command.
--keep-files  Do not delete temporarily created files after successful instrumentation. By default, temporary files are deleted if no error occurs during instrumentation.
--instrument-filter=<file>  Specifies the filter file for filtering functions during compile-time. Not supported by all instrumentation methods. It applies the same syntax, as the one used by Score-P during run-time.
--version  Prints the Score-P version and exits.
--disable-preprocessing  Tells scorep to skip all preprocessing related steps, the input files are already preprocessed.
--static  Enforce static linking of the Score-P libraries.
--dynamic  Enforce dynamic linking of the Score-P libraries.
--no-as-needed  Adds a GNU ld linker flag to fix undefined references when using shared Score-P libraries. This happens on systems using --as-needed as linker default. It will be handled transparently in future releases of Score-P.
--thread=<paradigm>  Possible paradigms and variants are:
  none  No thread support.
  omp  OpenMP support using thread tracking via ancestry functions in OpenMP 3.0 and later or via an OPARI2-instrumented threadprivate variable.
  It requires and, thus, automatically enables OPARI2 instrumentation.
  pthread  Pthread support using thread tracking via library wrapping
  It conflicts and, thus, automatically disables OPARI2
APPENDIX F. SCORE-P TOOLS

--mpp=<paradigm>[[:<variant>]]
   Possible paradigms and variants are:
   none
   No multi-process support.
   mpi
   MPI support using library wrapping
   shmem
   SHMEM support using library wrapping
--io=[<wrap-mode>[:]<paradigm>[[:<variant>]]](,[<wrap-mode>[:]<paradigm>[[:<variant>]])*
   <wrap-mode> may be 'linktime' or 'runtime'.
   The default is the first supported mode in the above order.
   Possible paradigms and variants are:
   none
   No I/O wrapping support.
   posix
   POSIX I/O support using library wrapping. This includes the
   file descriptor based POSIX API (i.e., 'open'/'close'). The
   POSIX asynchronous I/O API (i.e., 'aio_read'/'aio_write'), if
   available. And the ISO C 'FILE' handle based API (i.e.,
   'fopen'/'fclose').
--compiler Enables compiler instrumentation.
   By default, it disables pdt instrumentation.
--nocompiler Disables compiler instrumentation.
--cuda Enables CUDA instrumentation. Enabled by default, if the
   nvcc compiler is in use. In this case it also conflicts and
   thus automatically disables preprocessing.
--nocuda Disables CUDA instrumentation.
--online-access Enables online-access support. It is disabled by default.
--ononline-access
   Disables online-access support.
--pomp Enables pomp user instrumentation. By default, it also
   enables preprocessing.
--nopomp Disables pomp user instrumentation. (Default)
--openmp Enables instrumentation of OpenMP directives. By default,
   it also enables preprocessing. (Default for compile units
   with enabled OpenMP support during the compilation)
--noopenmp Disables instrumentation of OpenMP directives.
   Note: To ensure thread-safe execution of the measurement,
   parallel regions still need to be tracked and will appear
   in the results. (Default for compile units without OpenMP
   enabled compilation)
--opari=<parameter-list>
   Pass options to the source-to-source instrumenter OPARI2
   to have finer control over the instrumentation process.
   Please refer to the OPARI2 user documentation for more
   details.
--pdt[=<parameter-list>]
   Enables pdt instrumentation.
   You may add additional parameters that are passed to pdt.
   It requires and, thus, automatically enables user
   instrumentation.
   It conflicts and, thus, automatically disables preprocess
   instrumentation.
   By default, it disables compiler instrumentation.
--nopdt Disables pdt instrumentation.
--preprocess Enables preprocess instrumentation.
   It cannot be enabled, if not at least one of the following is
   enabled: OPARI2 instrumentation.
   It conflicts and, thus, automatically disables pdt
   instrumentation.
--nopreprocess Disables preprocess instrumentation.
--user Enables user instrumentation.
--nouser Disables user instrumentation.
--opencl[=<wrap-mode>]
   Enables OpenCL instrumentation.
--noopencl Disables OpenCL instrumentation.
--openacc Enables OpenACC instrumentation.
--noopenacc Disables OpenACC instrumentation.
--memory Enables memory usage instrumentation. It is enabled by default.
--nomemory Disables memory usage instrumentation.
--libwrap=[<wrap-mode>][(<wrapper-name>...)<path-to-wrapper>]
   Enables user library wrapping for specified libraries.
F.2 scorep-config

<wrap-mode> may be ’linktime’ or ’runtime’. The default is the first supported mode in the above order. <wrapper-name>... is a comma-separated list of library wrappers which will be looked up in the paths of the colon-separated ’SCOREP_LIBWRAP_PATH’ environment variable and in the installation directory of Score-P. <path-to-wrapper> is a full path to the .libwrap anchor file. Use ’scorep-info libwrap-summary’ for a more detailed listing of available library wrappers.

--kokkos Enables Kokkos instrumentation.
--nokokkos Disables Kokkos instrumentation.

Report bugs to <support@score-p.org>

F.2 scorep-config

A call to scorep-config has the following syntax:

Usage:
scorep-config <command> [options]

Commands:
--prefix Prints the canonical installation prefix of this Score-P installation.
--cflags Prints additional compiler flags for a C compiler. They already contain the include flags.
--cxxflags Prints additional compiler flags for a C++ compiler. They already contain the include flags.
--fflags Prints additional compiler flags for a Fortran compiler. They already contain the include flags.
--cppflags[-language] Prints the include flags. They are already contained in the output of the --cflags, --cxxflags, and --fflags commands. language may be one of c (default), c++, or fortran.
--ldflags Prints the library path flags for the linker.
--libs Prints the required libraries to link against (combines --event-libs and --mgmt-libs).
--event-libs Prints only the required libraries to link against which includes event entry points into the measurement.
--mgmt-libs Prints only the required libraries to link against which includes management code from the Score-P measurement and their dependencies.
--preload-libs Prints only the required libraries which should be listed in LD_PRELOAD.
--cc Prints the C compiler name.
--cxx Prints the C++ compiler name.
--fc Prints the Fortran compiler name.
--mpicc Prints the MPI C compiler name.
--mpicxx Prints the MPI C++ compiler name.
--mpifc Prints the MPI Fortran compiler name.
--shmcc Prints the SHMEM C compiler name.
--shmemcxx Prints the SHMEM C++ compiler name.
--shmemfc Prints the SHMEM Fortran compiler name.
--libtool Prints the path to the libtool script used to build Score-P libraries.
--mpilibtool Prints the path to the libtool script used to build Score-P MPI libraries.
--shmemlibtool Prints the path to the libtool script used to build Score-P SHMEM libraries.
--help Prints this usage information.
--version Prints the version number of the Score-P package.
--scorep-revision Prints the revision number of the Score-P package.
--common-revision
APPENDIX F. SCORE-P TOOLS

Prints the revision number of the common package.
--remap-specfile
   Prints the path to the remapper specification file.
--adapter-init
   Prints the code for adapter initialization.
--libwrap-support=linktame
   Prints true if link-time library wrapping is supported.
--libwrap-support=runtime
   Prints true if run-time library wrapping is supported.

Options:
--target
   Get flags for specified target, e.g., mic.
--nvcc
   Convert flags to be suitable for the nvcc compiler.
--static
   Use only static Score-P libraries if possible.
--dynamic
   Use only dynamic Score-P libraries if possible.
--online-access|--noonline-access
   Specifies whether online access (needed by Periscope) is enabled. On default it is enabled.
--compiler|--nocompiler
   Specifies whether compiler instrumentation is used. On default compiler instrumentation is enabled.
--user|--nouser
   Specifies whether user instrumentation is used. On default user instrumentation is disabled.
--pomp|--nopomp
   Specifies whether pomp instrumentation is used. On default pomp instrumentation is disabled.
--cuda|--nocuda
   Specifies whether cuda instrumentation is used. On default cuda instrumentation is enabled.
--openacc|--noopenacc
   Specifies whether openacc instrumentation is used. On default openacc instrumentation is enabled.
--opencl[:<wrapping mode>]|--noopencl
   Specifies whether opencl instrumentation is used. On default opencl instrumentation is enabled. Available wrapping modes are:
   linktame (default)
   runtime
--kokkos|--nokokkos
   Specifies whether kokkos instrumentation is used. On default kokkos instrumentation is enabled.
--preprocess|--nopreprocess
   Specifies whether preprocess instrumentation is used. On default preprocess instrumentation is disabled.
--memory=<api list>|--nomemory
   Specifies whether memory usage recording is used. On default memory usage recording is disabled.
   The following memory interfaces may be recorded:
   libc:
   malloc, realloc, calloc, free, memalign, posix_memalign, valloc
   libc11:
   aligned_alloc
   c++L32|c++L64:
   new,new[], delete, delete[] (IA-64 C++ ABI)
   pgCCL32|pgCCL64:
   new,new[], delete, delete[] (old PGI/EDG C++ ABI)
--io=[<wrap-mode>:]<paradigm,...>|--noio
   Specifies whether I/O recording is used. On default I/O recording is disabled.
   The following I/O paradigms may be recorded:
   none
   posix
--libwrap=<wrap-mode>:<libwrap-anchor-file>
   Uses the specified library wrapper.
--thread=<threading system>
   Available threading systems are:
   none (default)
   omp
   pthread
--mpp=<multi-process paradigm>
   Available multi-process paradigms are:
   none (default)
   mpi
F.3 scorep-info

A call to scorep-info has the following syntax:

Usage: scorep-info <info command> <command options>
        scorep-info --help [<info command>]

This is the Score-P info tool.

Available info commands:

config-summary:
    Shows the configure summary of the Score-P package.

config-vars:
    Shows the list of all measurement config variables with a short description.

Info command options:
    --help    Displays a description of the Score-P measurement configuration system.
    --full    Displays a detailed description for each config variable.
    --values  Displays the current values for each config variable.
             Warning: These values may be wrong, please consult the
             manual of the batch system how to pass the values
             to the measurement job.

libwrap-summary:
    Shows known library wrappers available to this Score-P installation.

Info command options:
    --build    Shows detailed information about how the library wrapper
               was built.

open-issues:
    Shows open and known issues of the Score-P package.

Report bugs to <support@score-p.org>

F.4 scorep-score

A call to scorep-score has the following syntax:

Usage: scorep-score [options] <profile>

Options:
    -r         Show all regions.
    -h, --help Show this help and exit.
    -f <filter> Shows the result with the filter applied.
    -c <num>   Specifies the number of hardware counters that shall be measured.
               By default, this value is 0, which means that only a timestamp
               is measured on each event. If you plan to record hardware counters
               specify the number of hardware counters. Otherwise, scorep-score
               may underestimate the required space.
    -m         Prints mangled region names instead of demangled names.
    -s <choice> Sorting of entries. Possible choices are totaltime, timepervisit,
                 maxbuffer, visits and name (default=maxbuffer).
    -g [<list>] Generation of an initial filter file with the name
                 'initial_scorep.filter'. A valid parameter list has the form
                 KEY=VALUE[,KEY=VALUE]*. By default, uses the following control
                 parameters:
                 'bufferpercent=1,timepervisit=1'
A region is included in the filter file (i.e., excluded from measurement) if it matches all of the given conditions, with the following keys:

- **'bufferpercent'**: estimated memory requirements exceed the given threshold in percent of the total estimated trace buffer requirements
- **'bufferabsolute'**: estimated memory requirements exceed the given absolute threshold in MB
- **'visits'**: number of visits exceeds the given threshold
- **'timepervisit'**: time per visit value is below the given threshold in microseconds
- **'type'**: region type matches the given value (allowed: ‘usr’, ‘com’, ‘both’)

### F.5 scorep-backend-info

**Note**

This tool is intended to run as a batch job. Please consult the manual of the batch system how to submit jobs.

A call to **scorep-backend-info** has the following syntax:

Usage: scorep-backend-info <info command> <command options>

scorep-backend-info --help

This is the Score-P backend info tool.

Available info commands:

- **system-tree**:
  Shows the available system tree levels, starting with the root.

- **config-vars**:
  Shows the current values of all measurement config variables.
Appendix G

Score-P Measurement Configuration

Introduction

Score-P allows to configure several measurement parameters via environment variables. After the measurement run you can find a 'scorep.cfg' file in your experiment directory which contains the configuration of the measurement run. If you did not set any configuration values explicitly, this file will contain the default values. This file is safe to be used as input for a POSIX shell. For example, if you want to reuse the same configuration from a previous measurement run, do something like this:

```
$ set -a
$ . scorep.cfg
$ set +a
```

Measurement configuration variables have a specific type which accepts certain values.

Supported Types

String

An arbitrary character sequence, no white space trimming is done.

Path

Like String but a path is expected. Though no validation is performed.

Boolean

A Boolean value, no white space trimming is done. Accepted Boolean values for true are case insensitive and the following:

- 'true'
- 'yes'
- 'on'
- any positive decimal number

Everything else is interpreted as the Boolean value false.
APPENDIX G. SCORE-P MEASUREMENT CONFIGURATION

Number

A decimal number, white space trimming is done.

Number with size suffixes

Like Number, but also accepts unit case insensitive suffixes after optional white space:

- 'B', 'Kb', 'Mb', 'Gb', 'Tb', 'Pb', 'Eb'

The 'b' suffix can be omitted.

Set

A symbolic set. Accepted members are listed in the documentation of the variable. Multiple values are allowed, are case insensitive, and are subject to white space trimming. They can be separated with one of the following characters:

- ' ' - space
- ',' - comma
- ':' - colon
- ';' - semicolon

Acceptable values can also have aliases, which are listed in the documentation and separated by '/'. Values can be negated by preceding it with '~'. Order of evaluation is from left to right.

Option

Like Set, but only one value allowed to be selected.

List of Configuration Variables

This is the list of all known configure variables to control a Score-P measurement.
Note

Not all variables are supported by one Score-P installation. Use the `scorep-info config-vars` command to list only those supported by the used installation.

**SCOREP_ENABLE_PROFILING**  Enable profiling

- **Type:** Boolean
- **Default:** true

**SCOREP_ENABLE_TRACING**  Enable tracing

- **Type:** Boolean
- **Default:** false

**SCOREP_ENABLE_UNWINDING**  Enables recording calling context information for every event

- **Type:** Boolean
- **Default:** false

The calling context is the call chain of functions to the current position in the running program. This call chain will also be annotated with source code information if possible.

This is a prerequisite for sampling but also works with instrumented applications.

Note that when tracing is also enabled, Score-P does not write the usual Enter/Leave records into the OTF2 trace, but new records.

See also `SCOREP_TRACING_CONVERT_CALLING_CONTEXT_EVENTS`.

Note also that this supresses events from the compiler instrumentation.

**SCOREP_VERBOSE**  Be verbose

- **Type:** Boolean
- **Default:** false

**SCOREP_TOTAL_MEMORY**  Total memory in bytes per process to be consumed by the measurement system

- **Type:** Number with size suffixes
- **Default:** 16000k

Score-P uses total memory to allocate measurement pages. The pages are of size `SCOREP_PAGE_SIZE` bytes. The size is allowed to be reduced to a multiple of `SCOREP_PAGE_SIZE`. Maximum size is 4 GB minus one `SCOREP_PAGE_SIZE`.

**SCOREP_PAGE_SIZE**  Memory page size in bytes
**APPENDIX G. SCORE-P MEASUREMENT CONFIGURATION**

**Type:** Number with size suffixes

**Default:** 8k

If not a power of two, SCOREP_PAGE_SIZE will be increased to the next larger power of two. SCOREP_PAGE_SIZE will be split up into pages of (the adjusted) SCOREP_PAGE_SIZE. Minimum size is 512 bytes.

**SCOREP_EXPERIMENT_DIRECTORY** Name of the experiment directory as child of the current working directory

**Type:** Path

**Default:** ""

The experiment directory is created directly under the current working directory. No parent directories will be created. The experiment directory is only created if it is requested by at least one substrate. When no experiment name is given (the default) Score-P names the experiment directory 'scorep-measurement-temp' and renames this after a successful measurement to a generated name based on the current time.

**SCOREP_OVERWRITE_EXPERIMENT_DIRECTORY** Overwrite an existing experiment directory

**Type:** Boolean

**Default:** true

If you specified a specific experiment directory name, but this name is already given, you can force overwriting it with this flag. The previous experiment directory will be renamed.

**SCOREP_MACHINE_NAME** The machine name used in profile and trace output

**Type:** String

**Default:** "Linux"

We suggest using a unique name, e.g., the fully qualified domain name. The default machine name was set at configure time (see the INSTALL file for customization options).

**SCOREP_EXECUTABLE** Executable of the application

**Type:** Path

**Default:** ""

File name, preferably with full path, of the application's executable. This is a fallback if Score-P cannot determine the executable's name automatically. The name is required by some compiler adapters. They will complain if this environment variable is needed.

**SCOREP_ENABLE_SYSTEM_TREE_SEQUENCE_DEFINITIONS** Use system tree sequence definitions

**Type:** Boolean
Enables an internal system tree representation that specifies a sequence of system tree nodes with one record instead of creating one record per system tree node, location group or location. It is more scalable and has less memory requirements than single-node records. However, it costs individual names of nodes, but simply enumerates them based on types. Currently, system tree sequence definitions support only MPI (and trivially single-process) applications.

**SCOREP_FORCE_CFG_FILES**  Force the creation of experiment directory and configuration files

- **Type:** Boolean
- **Default:** true

If this is set to 'true' (which is the default), the experiment directory will be created along with some configuration files, even if no substrate writes data (i.e., profiling and tracing are disabled and no substrate plugin registered for writing).

If this is set to 'false', the directory will only be created if any substrate actually writes data.

**SCOREP_TIMER**  Timer used during measurement

- **Type:** Option
- **Default:** tsc

The following timers are available for this installation:

- **tsc**  Low overhead time stamp counter (X86_64) timer.
- **gettimeofday**  gettimeofday timer.
- **clock_gettime**  clock_gettime timer with CLOCK_MONOTONIC_RAW as clock.

**SCOREP_NM_SYMBOLS**  Application’s symbol table obtained via ‘nm -f’ for compiler instrumentation

- **Type:** Path
- **Default:** ""

File name, preferably with full path, of `<file>` that contains the `<application>’s symbol table that was obtained by the command:

```
$ nm -f `<application> 2> /dev/null > `<file`
```

Only needed if generating the file at measurement initialization time fails, e.g., if using the 'system()' command from the compute nodes isn't possible.

**SCOREP_DEBUG_UNIFY**  Writes the pre-unified definitions also in the local definition trace files

- **Type:** Boolean
- **Default:** true
APPENDIX G. SCORE-P MEASUREMENT CONFIGURATION

**SCOREP_PROFILING_TASK_EXCHANGE_NUM**  Number of foreign task objects that are collected before they are put into the common task object exchange buffer

*Type:* Number with size suffixes  
*Default:* 1K

The profiling creates a record for every task instance that is running. To avoid locking, the required memory is taken from a preallocated memory block. Each thread has its own memory block. On task completion, the created object can be reused by other tasks. However, if tasks migrate, the data structure migrates with them. Thus, if there is an imbalance in the migration from a source thread that starts the execution of tasks towards a sink thread that completes the tasks, the source thread may continually creating new task objects while in the sink, released task objects are collected. Thus, if the sink collected a certain number of tasks it should trigger a backflow of its collected task objects. However, this requires locking which should be avoided as much as possible. Thus, we do not want the locking to happen on every migrated task, but only if a certain imbalance occurs. This environment variable determines the number of migrated task instances that must be collected before the backflow is triggered.

**SCOREP_PROFILING_MAX_CALLPATH_DEPTH**  Maximum depth of the calltree

*Type:* Number  
*Default:* 30

**SCOREP_PROFILING_BASE_NAME**  Base for construction of the profile filename

*Type:* String  
*Default:* “profile”

String which is used as based to create the filenames for the profile files.

**SCOREP_PROFILING_FORMAT**  Profile output format

*Type:* Option  
*Default:* default

Sets the output format for the profile.

The following formats are supported:

- **none**  No profile output. This does not disable profile recording.
- **tau_snapshot**  Tau snapshot format.
- **cube4**  Stores the sum for every metric per callpath per location in Cube4 format.
- **cube_tuple**  Stores an extended set of statistics in Cube4 format.
- **thread_sum**  Sums all locations within a location group and stores the data in Cube4 format.
- **thread_tuple**  Sums all locations within a location group and store in addition some statistical data about the distribution among the location of a location group.
- **key_threads**  Stores the initial location, the slowest location and the fastest location per process. Sums all other locations within a location group. The result is stored in Cube4 format.
- **cluster_threads**  Clusters locations within a location group if they have the same calltree structure. Sums locations within a cluster. Stores the result in Cube4 format.
**default** Default format. If Cube4 is supported, Cube4 is the default else the Tau snapshot format is default.

**SCOREP_PROFILING_ENABLE_CLUSTERING** Enable clustering

*Type:* Boolean  
*Default:* true

**SCOREP_PROFILING_CLUSTER_COUNT** Maximum cluster count for iteration clustering

*Type:* Number with size suffixes  
*Default:* 64

**SCOREP_PROFILING_CLUSTERING_MODE** Specifies the level of strictness when comparing call trees for equivalence

*Type:* Option  
*Default:* subtree  
Possible levels:
- **none/0** No structural similarity required.
- **subtree/1** The sub-trees structure must match.
- **subtree_visits/2** The sub-trees structure and the number of visits must match.
- **mpi/3** The structure of the call-path to MPI calls must match. Nodes that are not on an MPI call-path may differ.
- **mpi_visits/4** Like above, but the number of visits of the MPI calls must match, too.
- **mpi_visits_all/5** Like above, but the number of visits must match also match on all nodes on the call-path to an MPI function.

**SCOREP_PROFILING_CLUSTERED_REGION** Name of the clustered region

*Type:* String  
*Default:* “”

The clustering can only cluster one dynamic region. If more than one dynamic region are defined by the user, the region is clustered which is exited first. If another region should be clustered instead you can specify the region name in this variable. If the variable is unset or empty, the first exited dynamic region is clustered.

**SCOREP_PROFILING_ENABLE_CORE_FILES** Write .core files if an error occurred

*Type:* Boolean
APPENDIX G. SCORE-P MEASUREMENT CONFIGURATION

Default: false
If an error occurs inside the profiling system, the profiling is disabled. For debugging reasons, it might be feasible to get the state of the local stack at these points. It is not recommended to enable this feature for large scale measurements.

SCOREP_TRACING_USE_SION Whether or not to use libson as OTF2 substrate

Type: Boolean
Default: false

SCOREP_TRACING_MAX_PROCS_PER_SION_FILE Maximum number of processes that share one sion file (must be > 0)

Type: Number with size suffixes
Default: 1K
All processes are than evenly distributed over the number of needed files to fulfill this constraint. E.g., having 4 processes and setting the maximum to 3 would result in 2 files each holding 2 processes.

SCOREP_TRACING_CONVERT_CALLING_CONTEXT_EVENTS Write calling context information as a sequence of Enter/Leave events to trace

Type: Boolean
Default: false
When recording the calling context of events (instrumented or sampled) than these could be stored in the trace either as the new CallingContext records from OTF2 or they could be converted to the legacy Enter/Leave records. This can be controlled with this variable, where the former is the false value. This is only in effect if SCOREP_ENABLING_UNWINDING is on.
Note that enabling this will result in an increase of records per event and also of the loss of the source code locations.
This option exists only for backwards compatibility for tools, which cannot handle the new OTF2 records. This option my thus be removed in future releases.

SCOREP_ONLINEACCESS_ENABLE Enable online access interface

Type: Boolean
Default: false

SCOREP_ONLINEACCESS_REG_PORT Online access registry service port

Type: Number
Default: 50100
SCOREP_ONLINEACCESS_REG_HOST  Online access registry service hostname

  Type: String
  Default: "localhost"

SCOREP_ONLINEACCESS_BASE_PORT  Base port for online access server

  Type: Number
  Default: 50010

SCOREP_ONLINEACCESS_APPL_NAME  Application name to be registered

  Type: String
  Default: "appl"

SCOREP_FILTERING_FILE  A file name which contain the filter rules

  Type: Path
  Default: ""

SCOREP_SUBSTRATE_PLUGINS  Specify list of used plugins

  Type: String
  Default: ""
  List of requested substrate plugin names that will be used during program run.

SCOREP_SUBSTRATE_PLUGINS_SEP  Separator of substrate plugin names

  Type: String
  Default: ","
  Character that separates plugin names in SCOREP_SUBSTRATE_PLUGINS.

SCOREP_METRIC_PAPI  PAPI metric names to measure
APPENDIX G. SCORE-P MEASUREMENT CONFIGURATION

Type: String
Default: ""

List of requested PAPI metric names that will be collected during program run.

SCOREP_METRIC_PAPI_PER_PROCESS  PAPI metric names to measure per-process

Type: String
Default: ""

List of requested PAPI metric names that will be recorded only by first thread of a process.

SCOREP_METRIC_PAPI_SEP  Separator of PAPI metric names

Type: String
Default: ","

Character that separates metric names in SCOREP_METRIC_PAPI and SCOREP_METRIC_PAPI_PER_PROCESS.

SCOREP_METRIC_RUSAGE  Resource usage metric names to measure

Type: String
Default: ""

List of requested resource usage metric names that will be collected during program run.

SCOREP_METRIC_RUSAGE_PER_PROCESS  Resource usage metric names to measure per-process

Type: String
Default: ""

List of requested resource usage metric names that will be recorded only by first thread of a process.

SCOREP_METRIC_RUSAGE_SEP  Separator of resource usage metric names

Type: String
Default: ","

Character that separates metric names in SCOREP_METRIC_RUSAGE and SCOREP_METRIC_RUSAGE_PER_PROCESS.

SCOREP_METRIC_PLUGINS  Specify list of used plugins
Type: String
Default: ""
List of requested metric plugin names that will be used during program run.

SCOREP_METRIC_PLUGINS_SEP  Separator of plugin names

Type: String
Default: ","
Character that separates plugin names in SCOREP_METRIC_PLUGINS.

SCOREP_METRIC_PERF  PERF metric names to measure

Type: String
Default: ""
List of requested PERF metric names that will be collected during program run.

SCOREP_METRIC_PERF_PER_PROCESS  PERF metric names to measure per-process

Type: String
Default: ""
List of requested PERF metric names that will be recorded only by first thread of a process.

SCOREP_METRIC_PERF_SEP  Separator of PERF metric names

Type: String
Default: ","
Character that separates metric names in SCOREP_METRIC_PERF and SCOREP_METRIC_PERF_PER_PROCESS.

SCOREP_SAMPLING_EVENTS  Set the sampling event and period: <event>[:<period>]

Type: String
Default: "perf_cycles@10000000"
This selects the interrupt source for sampling.
This is only in effect if SCOREP_ENABLE_UNWINDING is on.

Possible values:
- perf event (perf_{<event>}, see "perf list")
- period in number of events, default: 10000000
  e.g., perf_cycles@2000000
APPENDIX G. SCORE-P MEASUREMENT CONFIGURATION

- PAPI event (PAPI_<event>, see "papi_avail")
  period in number of events, default: 10000000
  e.g., PAPI_TOT_CYC@2000000
- timer (POSIX timer, invalid for multi-threaded)
  period in us, default: 10000
  e.g., timer@2000

**SCOREP_SAMPLING_SEP** Separator of sampling event names

  **Type:** String
  **Default:** ","
  Character that separates sampling event names in SCOREP_SAMPLING_EVENTS

**SCOREP_TOPOLOGY_PLATFORM** Record hardware topology information for this platform, if available.

  **Type:** Boolean
  **Default:** true

**SCOREP_TOPOLOGY_PROCESS** Record the Process x Thread topology.

  **Type:** Boolean
  **Default:** true

**SCOREP_TOPOLOGY_USER** Record topologies provided by user instrumentation

  **Type:** Boolean
  **Default:** true

**SCOREP_TOPOLOGY_MPI** Record MPI cartesian topologies.

  **Type:** Boolean
  **Default:** true

**SCOREP_SELECTIVE_CONFIG_FILE** A file name which configures selective recording

  **Type:** Path
  **Default:** ""
**SCOREP_MPI_MAX_COMMUNICATORS**  Determines the number of concurrently used communicators per process

*Type:* Number  
*Default:* 50

**SCOREP_MPI_MAX_WINDOWS**  Determines the number of concurrently used windows for MPI one-sided communication per process

*Type:* Number  
*Default:* 50

**SCOREP_MPI_MAX_EPOCHS**  Maximum amount of concurrently active access or exposure epochs per process

*Type:* Number  
*Default:* 50

**SCOREP_MPI_MAX_GROUPS**  Maximum number of concurrently used MPI groups per process

*Type:* Number  
*Default:* 50

**SCOREP_MPI_ENABLE_GROUPS**  The names of the function groups which are measured

*Type:* Set  
*Default:* default  
Other functions are not measured.

Possible groups are:

- **all**  All MPI functions  
- **cg**  Communicator and group management  
- **coll**  Collective functions  
- **default**  Default configuration.  Includes:
  - **cg**  
  - **coll**  
  - **env**  
  - **io**
- p2p
- rma
- topo
- xnonblock

env  Environmental management
err  MPI Error handling
ext  External interface functions
io   MPI file I/O
p2p  Peer-to-peer communication
misc Miscellaneous
perf PControl
rma  One sided communication
spawn Process management
topo Topology
type MPI datatype functions
xnonblock  Extended non-blocking events
xreqtest  Test events for uncompleted requests
none/no Disable feature

SCOREP_MPI_MEMORY_RECORDING  Enable tracking of memory allocations done by calls to MPI_ALLOC_LOC_MEM and MPI_FREE_MEM

Type: Boolean
Default: false
Requires that the MISC group is also recorded.

SCOREP_MPI_ONLINE_ANALYSIS  Enable online mpi wait states analysis

Type: Boolean
Default: false

SCOREP_SHMEM_MEMORY_RECORDING  Enable tracking of memory allocations done by calls to the SHMEM_HMEM allocation API

Type: Boolean
Default: false

SCOREP_CUDA_ENABLE  CUDA measurement features

Type: Set
Default: no
Sets the CUDA measurement mode to capture:
runtime  CUDA runtime API
driver   CUDA driver API
kernel   CUDA kernels
kernel_serial  Serialized kernel recording
kernel_counter Fixed CUDA kernel metrics
memcpy   CUDA memory copies
sync     Record implicit and explicit CUDA synchronization
idle     GPU compute idle time
pure_idle GPU idle time (memory copies are not idle)
gpumemusage Record CUDA memory (de)allocations as a counter
references Record references between CUDA activities
dontflushatexit Disable flushing CUDA activity buffer at program exit
flushatexit [DEPRECATED] Flush CUDA activity buffer at program exit (see 'dontflushatexit')
default/yes/1 CUDA runtime API and GPU activities.
   Includes:
   - runtime
   - kernel
   - memcpy
none/no   Disable feature

SCOREP_CUDA_BUFFER  Total memory in bytes for the CUDA record buffer

Type: Number with size suffixes
Default: 1M

SCOREP_CUDA_BUFFER_CHUNK  Chunk size in bytes for the CUDA record buffer (ignored for CUDA 5.5 and earlier)

Type: Number with size suffixes
Default: 8k

SCOREP_OPENCL_ENABLE  OpenCL measurement features

Type: Set
Default: no
Sets the OpenCL measurement mode to capture:
api  OpenCL runtime API
kernel  OpenCL kernels
memcpy  OpenCL buffer reads/writes
default/yes/true/1 OpenCL API and GPU activities.
   Includes:
   - api
   - kernel
   - memcpy
none/no   Disable feature
SCOREP_OPENCL_BUFFER_QUEUE Memory in bytes for the OpenCL command queue buffer

Type: Number with size suffixes
Default: 8k

SCOREP_OPENACC_ENABLE OpenACC measurement features

Type: Set
Default: no
Sets the OpenACC measurement mode to capture:
- regions OpenACC regions
- wait OpenACC wait operations
- enqueue OpenACC enqueue operations (kernel, upload, download)
- device_alloc OpenACC device memory allocations
- kernel_properties Record kernel properties such as the kernel name as well as the gang, worker and vector size for kernel launch operations
- variable_names Record variable names for OpenACC data allocation and enqueue upload/download
default/yes/1 OpenACC regions, enqueue and wait operations.
  Includes:
  - regions
  - wait
  - enqueue
none/no Disable feature

SCOREP_MEMORY_RECORDING Memory recording

Type: Boolean
Default: false
Memory (de)allocations are recorded via the libc/C++ API.

SCOREP_KOKKOS_ENABLE Kokkos measurement features

Type: Set
Default: no
Sets the Kokkos measurement mode to capture:
- regions Kokkos parallel regions
- user Kokkos user regions
- malloc Kokkos memory allocation
- memcpy Kokkos deep copy
default/yes/1 Kokkos parallel regions, user regions, and allocations
none/no Disable feature
Appendix H

Score-P Compiler Wrapper Usage

Usage

scorep-wrapper --create COMPILER [BINDIR]
scorep-<compiler> [COMPILER_FLAGS...]

Description

The scorep-wrapper script instances (like scorep-gcc, see below for a list of provided instances) are intended to simplify configuration and instrumentation of applications where the usual means of instrumentation, i.e., prefixing the compilation command with scorep, does not work out of the box. This applies, e.g., to applications that use autotools or CMake.

The intended usage of the wrapper instances is to replace the application’s compiler and linker with the corresponding wrapper at configuration time so that they will be used at build time. As compiler and linker commands are usually assigned to build variables like CC, CXX, or F77 (e.g., CC=gcc), using the corresponding wrapper is as simple as prefixing the value with scorep- (e.g., CC=scorep-gcc).

E.g., say the original compile command is

$ gcc COMPILER_FLAGS...

Using the wrapper instead

$ scorep-gcc COMPILER_FLAGS...

will expand to the following call:

$ scorep $SCOREP_WRAPPER_INSTRUMENTER_FLAGS \  gcc $SCOREP_WRAPPER_COMPILER_FLAGS \  COMPILER_FLAGS...
APPENDIX H. SCORE-P COMPILER WRAPPER USAGE

Used at build time, this expansion performs the desired Score-P instrumentation.

The variables SCOREP_WRAPPER_INSTRUMENTER_FLAGS and SCOREP_WRAPPER_COMPILER_FLAG can be used to pass extra arguments to scorep and to the compiler, respectively. Please see the Examples section below for details.

If the application's build system includes a configuration step (like it is the case for autotools and CMake based projects) the expansion needs to be prevented at this stage (the configuration step compiles and runs lots of small test programs; instrumenting these would in almost all cases result in failure of the configuration). To do so, one needs to set the variable SCOREP_WRAPPER to off when invoking the configuration command. The wrapper command from above will then expand to the original compile command:

$ gcc COMPILER_FLAGS...

See also the EXAMPLES section below.

Note on MPI: while many MPI distributions also allow selecting the compiler that the wrapper will invoke via environment variables, this mechanism should not be used with Score-P. Instead, users should use the command line arguments along with the Score-P wrappers for the MPI compiler wrappers:

$ scorep-mpicc -cc=/path/to/specific/compiler ...

Wrapper Instances

The installation provides wrapper instances based on the compilers used to build Score-P. Run scorep-wraper --help to see a listing of all default instances of the used Score-P installation.

Additional wrapper instances can be created with scorep-wraper --create.

Examples

• The most prominent use case is the CMake build system. As CMake prohibits to change the compiler after the CMake step and it also prohibits that the compiler variable value includes any flags (which renders the usual prefixing scorep gcc to a non-functional value). One needs to use a wrapper script which introduces the Score-P instrumenter as a compiler replacement to CMake as early as possible so that they are hard-coded into the generated build files. Apart from that one needs to make sure that the wrappers don't perform their usual instrumentation at this early stage or else the configuration step is likely to fail. However, at make time we want the wrappers to do the actual instrumentation. These goals can be achieved by invoking cmake like follows:

$ SCOREP_WRAPPER=off cmake .. \  -DCMAKE_C_COMPILER=scorep-gcc \  -DCMAKE_CXX_COMPILER=scorep-g++

The SCOREP_WRAPPER=off disables the instrumentation only in the environment of the cmake command. Subsequent calls to make are not affected and will instrument the application as expected.

Please note, that CMake 3.18.0 and 3.18.1 broke this workflow. But it was reinstated with 3.18.2.

• For autotools based build systems it is recommended to configure in the following way:

$ SCOREP_WRAPPER=off ../configure \  CC=scorep-gcc \  CXX=scorep-g++ \  --disable-dependency-tracking

• Both autoconf and CMake based build systems, may automatically re-configure the build tree when calling make, because some build related files have changed (i.e., Makefile.am or CMakelists.txt files). This usage is not supported by the Score-P wrapper. Please re-start the configuration from an empty build directory again as described above.
To pass options to the `scorep` command in order to diverge from the default instrumentation or to activate verbose output, use the variable `SCOREP_WRAPPER_INSTRUMENTER_FLAGS` at make time:

```
$ make SCOREP_WRAPPER_INSTRUMENTER_FLAGS=--verbose
```

This will result in the execution of:

```
$ scorep --verbose gcc ...
```

The wrapper also allows to pass flags to the wrapped compiler call by using the variable `SCOREP.WRAPPER_PER_COMPILER_FLAGS`:

```
$ make SCOREP.WRAPPER_COMPILER_FLAGS="-D_GNU_SOURCE"
```

Will result in the execution of:

```
$ scorep gcc -D_GNU_SOURCE ...
```

If there is a need to create additional wrapper instances, e.g., if your build system already uses compiler wrappers, you can do so by calling the `scorep-wrapper` script with the `--create` option:

```
$ scorep-wrapper --create cc
```

This will create a new wrapper instance for the `cc` compiler named `scorep-cc` in the same directory where `scorep-wrapper` resides.
Appendix I

Score-P User Library Wrapping

Usage

scorep-libwrap-init --name <wrappername> -x <language> [options] \n [workspacedir]

Initializes the working directory for creating a user library wrapper, named wrappername, into workspacedir. The final wrapper will be installed into directory. language has to be either c or c++ plus optionally a standard, e.g., c++11. The default workspace is the current directory.

Options

• --prefix <directory> Directory where to install the wrapper into. Defaults to Score-P’s installation directory.

• --display-name A more descriptive name for this wrapper. Can contain spaces and special characters. Defaults to --name.

• --backend <which> Backend compiler to be used for building the wrapper. Has to be either vanilla, mpi or shmem.

• --cppflags "\<flags\>" Compiler flags for the to-be-wrapped library

• --ldflags "\<flags\>" Linker flags for the to-be-wrapped library

• --libs "\<libraries\>" To-be-wrapped libraries and their dependencies, e.g., "-lm -lgmp".

• --static-only-target-library Add this flag if the to-be-wrapped library does not provide a shared library. This implies switching off runtime wrapping as well as not having a shared wrapper library for linktime wrapping.

• --update Do not exit if the working directory is already initialized. Overwrites Makefile and creates any file that is not already present.

• -h, --help Display this help message
Overview

User library wrapping enables users to install library wrappers for any C or C++ library they want.

In contrast to wrappers integrated into Score-P, e.g., PThreads, MPI, and OpenCL, user library wrappers do not extract semantic information from the library. It only intercepts function calls and provides their timing information.

Without this mechanism, in order to intercept calls to a library, users need to either build this library with Score-P or add manual instrumentation to the application using the library. Another advantage of user library wrapping is you don't need access to the source code of the to-be-wrapped library. Headers and library files suffice.

Requirements:

To enable this feature, Score-P needs to be built with libclang from the LLVM compiler infrastructure. More details can be found in Score-P's INSTALL file under "User Library Wrapping".

You can find out whether user library wrapping is enabled in the configure summary or via scorep-info config-summary in Section "Score-P (libwrap)".

Linktime vs. runtime wrapping:

There exist two ways to wrap calls to the to-be-wrapped (or target-) library. The main difference lies in when the actual wrapping takes place - at linktime or runtime. While they are in essence the same, they differ in which function calls can be intercepted. Specifically:

- linktime: Wraps calls originating from object files that are part of the linker command line. In addition, calls originating from static libraries are wrapped as well. The actual technique used is the -wrap linker flag.

- runtime: Wraps all calls that linktime wrapping would, plus those which originate from already linked shared objects. The actual technique used is replacing the original function of the target library and using dlopen and dlsym in the wrapper to open the target library plus finding and calling the original function.

You can choose linktime or runtime wrapping manually via the --libwrap flag by prefixing the wrapper name with either linktime: or runtime:.

When creating a wrapper, the build infrastructure automatically builds all wrapper libraries supported by your Score-P installation. If the target library only provides a static library, the runtime wrapper and the shared wrapper library of the linktime wrapper will not work. In this case you should reinitialize the workspace by appending --update --static-only-target-library to your scorep-libwrap-init command line.
Workflow for wrapping a library

Step 1: Initialize the working directory

To initialize the working directory for a new library wrapper use the `scorep-libwrap-init` command. `scorep-libwrap-init` has a number of obligatory and optional arguments. You need to supply:

- A name for the wrapper library via `--name`, and
- The used programming language (either c or c++) via `--x`. Optionally you can add a specific standard, e.g., `c++11`.

Optional arguments:

- The last argument for `scorep-libwrap-init` specifies the working directory. It defaults to the current directory.
- `--prefix` contains the installation prefix. It defaults to Score-P’s installation directory.
- `--display-name` contains a more descriptive name for the wrapper.
- `--backend` lets you choose the backend compiler between vanilla/none, mpi and shmem. If applications using the library use a special compiler like `mpicc` or `oshcc`, you have to change that value to the corresponding backend.
- `--cppflags` contains the preprocessing/compiler flags required to compile an application using the target library.
- `--ldflags` contains the linker flags required to link an application using the target library.
- `--libs` contains the target library and libraries it depends on as a space-separated list of `-l`-flags.
- `--static-only-target-library` specifies whether or not the target library is only installed as a static library.
- `--update` overwrites Makefile in order to update the current wrapper, instead of exiting due to the working directory already being initialized.

Example:

```
$ scorep-libwrap-init --name=mylib --display-name="My Lib" -x c \
   --cppflags="-DSOME_DEFINE -I/opt/mylib/include -I/opt/somelib/include" \
   --ldflags="-L/opt/mylib/lib -L/opt/somelib/lib" \
   --libs="-lmylib -lsomelib -lz -lm" \
   $(pwd)/mylibwrapper
```

This step tries to find shared library files matching the supplied `--libs`-flags. During application runtime, these will be used for calling `dlopen` and opening the target library and depending libraries. If `scorep-libwrap-init` cannot find them, it will provide a warning. You can add these shared libraries manually to Makefile via the `LW_LIBLIST` variable. If you do not intend to use runtime wrapping, and only use linktime wrapping, you can ignore this warning. It is only needed for runtime wrapping via `dlopen`.

On completion, `scorep-libwrap-init` prints a short-form of how to build and use the wrapper library to the terminal.

`scorep-libwrap-init` creates a number of files in the working directory:
• *libwrap.c* just includes *libwrap.h* and should not be changed.

• *libwrap.h* needs to be edited to contain the headers typically included when using the target library.

• *main.c* will be used to compile and link test programs to make sure the target library and wrapper work correctly.

• *Makefile* can be modified and will be guide you through user library wrapper creation workflow.

• *.*.filter* is a Score-P filter file used for excluding/including certain files and functions from wrapping. By default it excludes every file except the ones in the directories specified via -I arguments in the ccppflags. This means, hopefully, only the target library will be wrapped, and sub-headers from, e.g., /usr/include will not be wrapped.

• *README.md* is the file containing this text

---

**Step 2: Add library headers**

The next step is to add *#include* statements to *libwrap.h*. The included files should be headers that applications using the target library usually include.

**Step 3: Create a simple example application**

After this, add some basic calls to the target library to *main.c*. This file will later be compiled, linked and executed to test whether the target library and wrapper work correctly.

**Step 4: Further configure the build parameters**

There are a number of variables at the top of *Makefile* that can be adjusted:

• LW_NAME is the name of the wrapper library (same as the *--name*-argument)

• LW_DISPLAY_NAME is the display name of the wrapper library (same as the *--display-name*-argument)

• LW_PREFIX is the installation directory (same as the *--prefix*-argument)

• LW_BACKEND contains the compiler backend (same as the *--backend*-argument)

• CPPFLAGS contains the preprocessing flags (same as the *--cppflags*-argument)

• LDFLAGS contains the linker flags (same as the *--ldflags*-argument)

• LIBS contains the target library and libraries on which the target library depends (same as the *--libs*-argument)

• LW_LIBLIST shared libraries found according to the LIBS variable. This is internally used for runtime wrapping. This list of files will be used to call *dlopen* at runtime in order to open the target library and corresponding dependencies. File names can have paths.

There are more variables that hopefully need no manual adjustment.
Step 5: Build the wrapper

Run

$ make

Possible errors:

- Cannot find any function to wrap: Reasons for this can be that there are no include statements in libwrap.h or that the filter removes all functions. *filter contains some examples on how to use it. Make sure that the header files of the target library are included/whitelisted. File names in the filter are matched against the file names and paths of headers that the preprocessing step of the compiler provides.

- There is mismatch between functions found in the header files and the symbols present in the target library: This means the header file analysis found functions that are not present in the library files. Follow the steps in the next section and find out whether these symbols ought to be wrapped or can be ignored.

- Incorrect or unexpected wrapper: Enable verbose and make anew via make V=1. If the LLVM/Clang prints out parsing errors, this likely means the preprocessing step executed by your compiler, by default, generates code which is of a newer language standard than what Clang's default is. You can solve this by explicitly specifying the appropriate standard via -x or the Makefile variable LW_LANGUAGE, e.g., c++11.

Possible warnings:

- Ignoring variadic function: variadic functions can not be wrapped, because forwarding ellipsis parameters is not possible in C. The warning describes how to adjust Makefile in case a va_list-version of this function (like what vprintf is to printf) exists. Add ellipsis_function:va_list_function to LI ← BWRAP_ELLIPSIS_MAPPING_SYMBOLS.

- Ignoring function with unknown argument: C functions having an empty parameter list are assumed to have an unknown number of parameters. In case this function has zero parameters, you can add it to LIBWRAP← P_VARIADIC_IS_VOID_SYMBOLS in Makefile.

This step creates a number of files:

- main is main.c linked to the target library. Execute it to make sure the executable works.
- libscorep_libwrap_∗ are the wrapper libraries. Up to four versions exist, depending on your Score-P configuration.
- libwrap.i is the preprocessed version of libwrap.h/c used for analyzing and creating the wrapper code.
- ∗.wrap contains linker flags used for linktime wrapping. It lists every function to be wrapped.
- scorep_libwrap_∗.c is the source of the wrapper library.

If you change libwrap.h, main.c, Makefile or ∗.filter repeat this step. i.e., execute make again. Usually the wrapper creation workflow requires to run make, make check and after adjusting the wrapper settings to account for errors and warnings you again run make and make check. It can also take more iterations.
Step 6: Verify the wrapper

Run

$ make check

For each function found in the header files this step first checks whether there is a corresponding symbol in the library files. Second, it checks whether this symbol is also present when linking without the target library, i.e., is present in the executable or system libraries itself.

A list of functions that have no corresponding symbol in the target library is provided in the filter file missing.filter. If there are symbols in it you want to wrap, reconsider your wrapper settings, if not add these symbols to the filter file for this wrapper.

If there are symbols that are also present when linking without the target library, the file uncertain.filter, containing these symbols, is created. Calls to these functions might not be intercepted. It is up to you to decide whether this behavior is OK or not. You can, but don’t have add some or all of these symbols to the filter file for this wrapper.

As mentioned in the last paragraph of the previous section, repeat make and make check if you adjust your wrapper.

Step 7: Install the wrapper

Once the wrapper builds without errors, you are ready to install it. Run

$ make install

This step installs the wrapper into the Score-P installation or the directory specified via --prefix, and prints a short description of how to use the wrapper.

Step 8: Verify the installed wrapper

Run

$ make installcheck

Links main.c in up to four different ways using Score-P and the --libwrap flag. There are now a number of files beginning with main_. Execute them to make sure they are working. Executing these applications will create Score-P experiment directories with measurements of main.c and the wrapped target library. Inspect the experiments to make sure the wrapper works as expected.
Step 9: Use the wrapper

If you installed the wrapper to somewhere other than the Score-P installation via the --prefix-flag, add the appropriate prefix to SCOREP_LIBWRAP_PATH.

$ export SCOREP_LIBWRAP_PATH=$SCOREP_LIBWRAP_PATH:<prefix>

You can then use Score-P to link your application in the usual way and additionally provide --libwrap=<wrappername> to enable library wrapping for the target library. Note, library wrapping happens at link time. Thus, you can apply the --libwrap flag only to the link command of the application. No need to re-compile the whole application, if this was necessary in the first place.

Example with only relinking the application:

$ scorep --libwrap=mylib,myotherlib gcc -o main main.o \
   -L/opt/mylib/lib -L/opt/myotherlib/lib -L/opt/somelib/lib \
   -lmylib -lmyotherlib -lsomelib -lz -lm

Example with both recompiling and linking the application:

$ scorep --libwrap=mylib,myotherlib --nocompiler gcc -o main \
   -DSOME_DEFINE -I/opt/mylib/include -I/opt/myotherlib/include \
   -I/opt/somelib/include main.c \
   -L/opt/mylib/lib -L/opt/myotherlib/lib -L/opt/somelib/lib \
   -lmylib -lmyotherlib -lsomelib -lz -lm

You can manually choose between linktime and runtime wrapping by prepending linktime: or runtime: to the wrapper name provided to --libwrap.

In order to use multiple wrappers for one application you can use --libwrap=<wrap-mode>←lib1,lib2,... In order to mix linktime and runtime wrapping, you add two --libwrap-arguments, one with each mode.

To find out which user library wrappers are installed call

$ scorep-info libwrap-summary

It lists all found wrappers, either installed into Score-P's installation directory or found via the SCOREP_LIBWRAP_PATH environment variable. Optionally you can run

$ scorep-info libwrap-summary <wrappername>

to show the configuration of a specific wrapper.

Workflow in short

$ scorep-libwrap-init --name=<name> -x c --cppflags="<>" --ldflags="<>" \
   --libs="<>" <workingdir>
$ cd <workingdir>
# Add headers to libwrap.h
# Add example to main.c
$ make
$ make check
# Remove errors by adjusting the wrapper settings and adding symbols to
# filter
# Repeat make && make check until all errors are solved
$ make install
$ make installcheck
$ scorep --libwrap=<name> gcc -o myprogram ...
$ ./myprogram
# Inspect the experiment directory scorep-*
Implementation details

Score-P user library wrapping enables users to intercept and analyse any C or C++ library. For this we rely on libclang to produce a list of functions from the header files of the target library. The wrapper itself relies on symbol-based wrapping supplied by the linker and dynamic linker.

Many C++-libraries rely heavily on inlining and templates. Wrapping libraries based on symbols being present in the target library means that this technique is unable to intercept any inlined function calls.

Libclang's ability to detect to-be-inlined functions in header files improved with LLVM 3.9. For LLVM versions <= 3.8 the library wrapper generator will likely generate function wrappers for functions that are inlined and cannot be wrapped. The workflow will provide you with a warning and what to do in this case.

Miscellaneous

$ make show-summary

This command displays how the wrapper is currently configured. Use this information to, e.g., redo the wrapper, or update the wrapper files via --update if, e.g., there is new Score-P version.

FAQ

- Open issues can be found in Score-P's OPEN_ISSUES file under "User library wrapping"
Appendix J

Module Documentation

J.1 Score-P User Adapter

Files

- file SCOREP_User.h
  
  *This file contains the interface for the manual user instrumentation.*

- file SCOREP_User_Types.h

  *This file contains type definitions for manual user instrumentation.*

Macros for region instrumentation

- \#define SCOREP_USER_OA_PHASE_BEGIN(handle, name, type)
- \#define SCOREP_USER_OA_PHASE_END(handle) SCOREP_User_OaPhaseEnd( handle );
- \#define SCOREP_USER_REGION_BEGIN(handle, name, type)
- \#define SCOREP_USER_REGION_INIT(handle, name, type)
- \#define SCOREP_USER_REGION_END(handle) SCOREP_User_RegionEnd( handle );
- \#define SCOREP_USER_REGION_ENTER(handle) SCOREP_User_RegionEnter( handle );
- \#define SCOREP_USER_REGION_DEFINE(handle) static SCOREP_User_RegionHandle handle = SCOREP_USER_INVALID_REGION;
- \#define SCOREP_USER_FUNC_DEFINE()
- \#define SCOREP_USER_FUNC_BEGIN()
- \#define SCOREP_USER_FUNC_END() SCOREP_User_RegionEnd( scorep_user_func_handle );
- \#define SCOREP_USER_GLOBAL_REGION_DEFINE(handle) SCOREP_User_RegionHandle handle = SCOREP_USER_INVALID_REGION;
- \#define SCOREP_USER_GLOBAL_REGION_EXTERNAL(handle) extern SCOREP_User_RegionHandle handle;

Macros for parameter instrumentation

- \#define SCOREP_USER_PARAMETER_INT64(name, value)
- \#define SCOREP_USER_PARAMETER_UINT64(name, value)
- \#define SCOREP_USER_PARAMETER_STRING(name, value)
Macros to provide user metrics

- \#define SCOREP_USER_METRIC_LOCAL(metricHandle)
- \#define SCOREP_USER_METRIC_GLOBAL(metricHandle)
- \#define SCOREP_USER_METRIC_EXTERNAL(metricHandle) extern SCOREP_SamplingSetHandle metricHandle;
- \#define SCOREP_USER_METRIC_INIT(metricHandle, name, unit, type, context) SCOREP_User_InitMetric(
  &metricHandle, name, unit, type, context);
- \#define SCOREP_USER_METRIC_INT64(metricHandle, value)
- \#define SCOREP_USER_METRIC_UINT64(metricHandle, value)
- \#define SCOREP_USER_METRIC_DOUBLE(metricHandle, value)

Macros for creation of user topologies

- \#define SCOREP_USER_CARTESIAN_TOPOLOGY_CREATE(userTopology, name, nDims)
- \#define SCOREP_USER_CARTESIAN_TOPOLOGY_ADD_DIM(userTopology, size, periodic, name) SCOREP_User_CartTopologyAddDim( userTopology, size, periodic, name );
- \#define SCOREP_USER_CARTESIAN_TOPOLOGY_INIT(userTopology) SCOREP_User_CartTopologyInit( userTopology );
- \#define SCOREP_USER_CARTESIAN_TOPOLOGY_SET_COORDS(userTopology, nDims, ...) SCOREP_User_CartTopologySetCoords( userTopology, nDims, __VA_ARGS__); Aware of the potential for collisions with the previous macro with the same name.
- \#define SCOREP_USER_CARTESIAN_TOPOLOGY_DEFINE(userTopology)

C++ specific macros for region instrumentation

- \#define SCOREP_USER_REGION(name, type)

Macros for measurement control

- \#define SCOREP_RECORDING_ON() SCOREP_User_EnableRecording();
- \#define SCOREP_RECORDING_OFF() SCOREP_User_DisableRecording();
- \#define SCOREP_RECORDING_IS_ON() SCOREP_User_RecordingEnabled()

Region types

- \#define SCOREP_USER_REGION_TYPE_COMMON 0
- \#define SCOREP_USER_REGION_TYPE_FUNCTION 1
- \#define SCOREP_USER_REGION_TYPE_LOOP 2
- \#define SCOREP_USER_REGION_TYPE_DYNAMIC 4
- \#define SCOREP_USER_REGION_TYPE_PHASE 8

Metric types

- \#define SCOREP_USER_METRIC_TYPE_INT64 0
- \#define SCOREP_USER_METRIC_TYPE_UINT64 1
- \#define SCOREP_USER_METRIC_TYPE_DOUBLE 2
J.1 Score-P User Adapter

Metric contexts

- #define SCOREP_USER_METRIC_CONTEXT_GLOBAL 0
- #define SCOREP_USER_METRIC_CONTEXT_CALLPATH 1

J.1.1 Detailed Description

The user adapter provides a set of macros for user manual instrumentation. The macros are inserted in the source code and call functions of the Score-P runtime system. The user should avoid calling the Score-P runtime functions directly.

For every macro, two definitions are provided: The first one inserts calls to the Score-P runtime system, the second definitions resolve to nothing. Which implementation is used, depends on the definition of SCOREP_USER_ENABLE. If SCOREP_USER_ENABLE is defined, the macros resolve to calls to the Score-P runtime system. If SCOREP_USER_ENABLE is undefined, the user instrumentation is removed by the preprocessor. This flag SCOREP_USER_ENABLE should be set through the instrumentation wrapper tool automatically if user manual instrumentation is enabled.

Every source file which is instrumented must include a header file with the Score-P user instrumentation header. For C/C++ programs, the header file is 'scorep/SCOREP_User.h', for Fortran files, 'scorep/SCOREP_User.inc' must be included. Because the Fortran compilers cannot expand macros, the Fortran source code must be preprocessed by a C or C++ preprocessor, to include the headers and expand the macros. Which Fortran files are passed to the preprocessor depends on the suffix. Usually, suffixes .f and .f90 are not preprocessed, .F and .F90 files are preprocessed. However, this may depend on the used compiler.

J.1.2 Macro Definition Documentation

J.1.2.1 #define SCOREP_RECORDING_IS_ON( ) SCOREP_User_RecordEnabled()

In C/C++ it behaves like a function call which returns whether recording is enabled or not. It returns false if the recording of events is disabled, else it returns true.

C/C++ example:

```c
void foo()
{
    if (SCOREP_RECORDING_IS_ON())
    {
        // do something
    }
}
```

In Fortran, this macro has a different syntax. An integer variable must be specified as parameter, which is set to non-zero if recording is enabled, else the value is set to zero.

Fortran example:

```fortran
subroutine foo
    integer :: l
    SCOREP_RECORDING_IS_ON( l )
    if (l .eq. 0) then
        ! do something
    end if
end subroutine foo
```
J.1.2.2  \#define SCOREP_RECORDING_OFF() SCOREP_User_DisableRecording();

Disables recording of events. If already disabled, this command has no effect. The control is not restricted to events from the user adapter, but disables the recording of all events.

C/C++ example:

```
1 void foo()
2 {
3   SCOREP_RECORDING_OFF()
4   // do something
5   SCOREP_RECORDING_ON()
6 }
```

Fortran example:

```
1 subroutine foo
2     SCOREP_RECORDING_OFF()
3     ! do something
4     SCOREP_RECORDING_ON()
5     end subroutine foo
```

J.1.2.3  \#define SCOREP_RECORDING_ON() SCOREP_User_EnableRecording();

Enables recording of events. If already enabled, this command has no effect. The control is not restricted to events from the user adapter, but enables the recording of all events.

C/C++ example:

```
1 void foo()
2 {
3   SCOREP_RECORDING_OFF()
4   // do something
5   SCOREP_RECORDING_ON()
6 }
```

Fortran example:

```
1 subroutine foo
2     SCOREP_RECORDING_OFF()
3     ! do something
4     SCOREP_RECORDING_ON()
5     end subroutine foo
```

J.1.2.4  \#define SCOREP_USER_CARTESIAN_TOPOLOGY_ADD_DIM( userTopology, size, periodic, name )

This statement defines a dimension for the topology of the given handle.
J.1 Score-P User Adapter

Parameters

| userTopology | The handle that identifies the respective topology. |
| size         | Number of elements in the dimension.               |
| periodic     | The periodicity of the dimension; Bool values allowed. |
| name         | The name of the dimension.                         |

J.1.2.5 #define SCOREP_USER_CARTESIAN_TOPOLOGY_CREATE( userTopology, name, nDims )

Value:

SCOREP_User_CartesianTopologyHandle userTopology = SCOREP_USER_INVALID_CARTESIAN_TOPOLOGY; \
SCOREP_User_CartTopologyCreate( &userTopology, name, nDims );

This statement creates an user topology by the given name and initializes it based on name and number of expected dimensions.

Parameters

| userTopology | The handle that identifies the topology in subsequent calls. |
| name         | The unique name for the user topology.                   |
| nDims        | The number of dimensions.                               |

Note

The name of each user topology has to be unique to appear as a distinct topology!

J.1.2.6 #define SCOREP_USER_CARTESIAN_TOPOLOGY_DEFINE( userTopology )

This statement defines an user topology in the Fortran case. As a variable definition it has to be placed in the variable section.

Parameters

| userTopology | The handle that identifies the topology in subsequent calls. |

J.1.2.7 #define SCOREP_USER_CARTESIAN_TOPOLOGY_INIT( userTopology ) SCOREP_User_CartTopologyInit( userTopology );

Initialize the topology after all dimensions are set.

Parameters

| userTopology | The handle that identifies the respective topology. |

J.1.2.8 #define SCOREP_USER_CARTESIAN_TOPOLOGY_SET_COORDS( userTopology, nDims, ... ) SCOREP_User_CartTopologySetCoords( userTopology, nDims, __VA_ARGS__);

This statement defines the coordinates for the topology of the given handle. This call has to be done on the thread/process that should be associated with this set of coordinates, as the mapping will be done implicitly. The number of coordinate parameters in the variable array has to be the same as the number of dimensions for the topology.
Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>userTopology</code></td>
<td>The handle that identifies the respective topology.</td>
</tr>
<tr>
<td><code>nDims</code></td>
<td>The number of dimensions, which is the number of coordinate parameters in C and the length of the coordinate array in Fortran.</td>
</tr>
<tr>
<td><code>variable</code></td>
<td>array Coordinate information for each of the nDims dimensions.</td>
</tr>
</tbody>
</table>

The order of macro execution is important. All dimensions have to be added before the init call; the coordinates have to be added after the init call.

**Note**

For MPI programs, all calls to `SCOREP_USER_CARTESIAN_TOPOLOGY_SET_COORDS` have to happen after `MPI_Init`!

**C/C++ Example:**

```c
1  SCOREP_USER_CARTESIAN_TOPOLOGY_CREATE ( mytopo, "This is a new user topology", 2 );
2  SCOREP_USER_CARTESIAN_TOPOLOGY_ADD_DIM ( mytopo, 2 , 1, "dim1_2" );
3  SCOREP_USER_CARTESIAN_TOPOLOGY_ADD_DIM ( mytopo, ( numprocs + 1 ) / 2 , 1, "dim2_4" );
4  SCOREP_USER_CARTESIAN_TOPOLOGY_INIT ( mytopo );
5  SCOREP_USER_CARTESIAN_TOPOLOGY_SET_COORDS ( mytopo, 2, rank % 2, rank / 2 );
```

**Note** that `SCOREP_USER_CARTESIAN_TOPOLOGY_SET_COORDS` takes the location into account on which it is executed. To create coordinates on a thread level, use this macro inside an OpenMP parallel region or in a POSIX thread's start routine. It is possible to set all coordinates in a serial part of your program though.

**Note**, for Fortran the CREATE macro is split in a define and create step to allow its placement in the variable section.

**Fortran example:**

```fortran
1  program main
2    integer :: numprocs
3  SCOREP_USER_CARTESIAN_TOPOLOGY_DEFINE( mytopo )
4    integer, dimension(2) :: coords
5
6    !...
7
8  SCOREP_USER_CARTESIAN_TOPOLOGY_CREATE( mytopo, "This is a new user topology", 2 )
9  SCOREP_USER_CARTESIAN_TOPOLOGY_ADD_DIM( mytopo, 2 , 1, "dim1_2" )
10  SCOREP_USER_CARTESIAN_TOPOLOGY_ADD_DIM( mytopo, ( numprocs + 1 ) / 2 , 1, "dim2_4" )
11  SCOREP_USER_CARTESIAN_TOPOLOGY_INIT ( mytopo );
12  coords = (/ MOD( rank, 2 ), rank / 2 /)
13  SCOREP_USER_CARTESIAN_TOPOLOGY_SET_COORDS ( mytopo, 2, coords )
14  end program main
```

**J.1.2.9 #define SCOREP_USER_FUNC_BEGIN()**

**Value:**

```c
static SCOREP_User_RegionHandle
   \scorep_user_func_handle = SCOREP_USER_INVALID_REGION;
\SCOREP_User_RegionBegin ( &scorep_user_func_handle, &SCOREP_User_LastFileName, \      \&SCOREP_User_LastFileHandle, SCOREP_USER_FUNCTION_NAME, \      \&SCOREP_USER_REGION_TYPE_FUNCTION, __FILE__, \      \__LINE__   );
```

This macro marks the start of a function. It should be inserted at the beginning of the instrumented function. It will generate a region, with the function name.

The C/C++ version of this command takes no arguments. It contains a variable declaration and a function call. Compilers that require a strict separation between declaration block and execution block may fail if this macro is used.

In Fortran one argument is required for the name of the function. Furthermore, the handle must be declared explicitly in Fortran.
J.1 Score-P User Adapter

Parameters

| name | Fortran only: A string containing the name of the function. |

C/C++ example:

```
1 void myfunc()
2 {
3   // declarations
4   5 SCOREP_USER_FUNC_BEGIN()
6   7   // do something
8   9 SCOREP_USER_FUNC_END()
10 }
```

Fortran example:

```
1 subroutine myfunc
2   SCOREP_USER_FUNC_DEFINE()
3   ! more declarations
4   5 SCOREP_USER_FUNC_BEGIN( "myfunc" )
6   7   ! do something
8   9 SCOREP_USER_FUNC_END()
9 end subroutine myfunc
```

Note that in Fortran the function need to be declared using SCOREP_USER_FUNC_DEFINE before.

J.1.2.10 `#define SCOREP_USER_FUNC_DEFINE( )`

This macro is for Fortran only. It declares the handle for a function. Every function handle must be declared in the declaration part of the subroutine or function if the SCOREP_USER_FUNC_BEGIN and SCOREP_USER_FUNC_END macros are used.

Example:

```
1 subroutine myfunc
2   SCOREP_USER_FUNC_DEFINE()
3   ! more declarations
4   5 SCOREP_USER_FUNC_BEGIN( "myfunc" )
6   7   ! do something
8   9 SCOREP_USER_FUNC_END()
9 end subroutine myfunc
```

Note that in Fortran the function need to be declared using SCOREP_USER_FUNC_DEFINE before.

J.1.2.11 `#define SCOREP_USER_FUNC_END( ) SCOREP_User_RegionEnd( scorep_user_func_handle );`

This macro marks the end of a function. It should be inserted at every return point of the instrumented function.

C/C++ example:
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1 void myfunc()
2 {
3   // declarations
4   
5   SCOREP_USER_FUNC_BEGIN()
6   
7   // do something
8   if ( some_expression )
9   {
10      SCOREP_USER_FUNC_END()
11      return;
12   }
13   
14   SCOREP_USER_FUNC_END()
15 }

Fortran example:

1 subroutine myfunc
2 SCOREP_USER_FUNC_DEFINE()
3 ! more declarations
4 
5 SCOREP_USER_FUNC_BEGIN( "myfunc" )
6   ! do something
7 SCOREP_USER_FUNC_END()
8 
9 end subroutine myfunc

Note that in Fortran the function need to be declared using SCOREP_USER_FUNC_DEFINE before.

J.1.2.12 #define SCOREP_USER_GLOBAL_REGION_DEFINE( handle ) SCOREP_User_RegionHandle handle = SCOREP_USER_INVALID_REGION;

This macro defines a region handle in a global scope for usage in more than one code block. If a region is used in multiple source files, only one of them must contain the definition using SCOREP_USER_GLOBAL_REGION_DEFINE. All other files, in which the global handle is accessed, must only declare the global handle with SCOREP_USER_GLOBAL_REGION_EXTERNAL( handle ). It is possible to use the global handle in more than one code-block. However, code-blocks that share a handle, are handled as they were all the same region. Enter and exit events for global regions are created with SCOREP_USER_REGION_BEGIN and SCOREP_USER_REGION_END, respectively. Its name and type is determined at the first enter event and is not changed on later events, even if other code blocks contains a different name or type in their SCOREP_USER_REGION_BEGIN statement.

This macro is not available in Fortran.

Parameters

| handle | A unique name for the handle must be provided. This handle is declared in the macro. This handle is used in the SCOREP_USER_REGION_BEGIN and SCOREP_USER_REGION_END statements to specify which region is started, or ended. If you are using a Fortran version which has a limited length of code lines, the length of the handle parameter must be at most 4 characters, else the declaration line exceeds the allowed length. |

C/C++ example:

1 // In File1:
2 SCOREP_USER_GLOBAL_REGION_DEFINE( my_global_handle )
3 
4 void myfunc()
5 {
6   SCOREP_USER_REGION_BEGIN( my_global_handle, "my_global", SCOREP_USER_REGION_TYPE_PHASE )
7   // do something
8 
9   SCOREP_USER_REGION_END( my_global_handle )
10 }
J.1 Score-P User Adapter

1 // In File2:
2 SCOREP_USER_GLOBAL_EXTERNAL( my_global_handle )
3 void foo()
4 {
5   SCOREP_USER_REGION_BEGIN( my_global_handle, "my_global", SCOREP_USER_REGION_TYPE_PHASE )
6     // do something
7   SCOREP_USER_REGION_END( my_global_handle )
8 }

J.1.2.13 #define SCOREP_USER_GLOBAL_REGION_EXTERNAL(handle) extern SCOREP_User_RegionHandle handle;

This macro declares an externally defined global region. If a region is used in multiple source files, only one of them must contain the definition using SCOREP_USER_GLOBAL_REGION_DEFINE. All other files, in which the global handle is accessed, must only declare the global handle with SCOREP_USER_GLOBAL_REGION_EXTERNAL(handle). It is possible to use the global handle in more than one code-block. However, code-blocks that share a handle, are handled as they were all the same region. Enter and exit events for global regions are created with SCOREP_USER_REGION_BEGIN and SCOREP_USER_REGION_END, respectively. Its name and type is determined at the first enter event and is not changed on later events, even if other code blocks contains a different name or type in their SCOREP_USER_REGION_BEGIN statement.

This macro is not available in Fortran

Parameters

| handle | A name for a variable must be provided. This variable name must be the same like for the corresponding SCOREP_USER_GLOBAL_REGION_DEFINE statement. The handle is used in the SCOREP_USER_REGION_BEGIN and SCOREP_USER_REGION_END statements to specify which region is started, or ended. |

C/C++ example:

1 // In File 1
2 SCOREP_USER_GLOBAL_REGION_DEFINE( my_global_handle )
3 void myfunc()
4 {
5   SCOREP_USER_REGION_BEGIN( my_global_handle, "my_global", SCOREP_USER_REGION_TYPE_PHASE )
6     // do something
7   SCOREP_USER_REGION_END( my_global_handle )
8 }
9
1 // In File 2
2 SCOREP_USER_GLOBAL_EXTERNAL( my_global_handle )
3 void foo()
4 {
5   SCOREP_USER_REGION_BEGIN( my_global_handle, "my_global", SCOREP_USER_REGION_TYPE_PHASE )
6     // do something
7   SCOREP_USER_REGION_END( my_global_handle )
8 }

J.1.2.14 #define SCOREP_USER_METRIC_CONTEXT_CALLPATH 1

Indicates that a user counter is measured for every callpath.
#define SCOREP_USER_METRIC_CONTEXT_GLOBAL 0

Indicates that a user counter is measured for the global context.

#define SCOREP_USER_METRIC_DOUBLE( metricHandle, value )

Value:

SCOREP_User_TriggerMetricDouble( \n    metricHandle, value );

Triggers a new event for a user counter of a double precision floating point data type. Each user metric must be declared with SCOREP_USER_COUNTER_LOCAL, SCOREP_USER_COUNTER_GLOBAL, or SCOREP_USER_COUNTER_EXTERNAL and initialized with SCOREP_USER_COUNTER_INIT before it is triggered for the first time.

Parameters

<table>
<thead>
<tr>
<th>metricHandle</th>
<th>The handle of the metric for which a value is given in this statement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The value of the counter. It must be possible for implicit casts to cast it to a double.</td>
</tr>
</tbody>
</table>

Example:

1  SCOREP_USER_METRIC_LOCAL( my_local_metric )
2  int main()
3  { 
4 5      SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", \n6                      SCOREP_USER_METRIC_TYPE_DOUBLE, \n7                      SCOREP_USER_METRIC_CONTEXT_GLOBAL )
8  // do something
9  }
10  void foo()
11  { 
12    double my_double = get_some_double_value();
13   SCOREP_USER_METRIC_DOUBLE( my_local_metric, my_double )
14  }

Fortran example:

1  program myProg
2     SCOREP_USER_METRIC_LOCAL( my_local_metric )
3     real (kind=selected_int_kind(14,200)):: my_real = 24.5
4     ! more declarations
5 6     SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", \n7                      SCOREP_USER_METRIC_TYPE_DOUBLE, \n8                      SCOREP_USER_METRIC_CONTEXT_GLOBAL )
9     ! do something
10 11     SCOREP_USER_METRIC_DOUBLE( my_local_metric, my_real )
12 13  end program myProg
14

#define SCOREP_USER_METRIC_EXTERNAL( metricHandle ) extern SCOREP_SamplingSetHandle metricHandle;

Declares an externally defined handle for a user metric. Every global metric must be declared only in one file using SCOREP_USER_METRIC_GLOBAL. All other files in which this handle is accessed must declare it with SCOREP_USER_METRIC_EXTERNAL.

This macro is not available in Fortran.
J.1 Score-P User Adapter

Parameters

| metricHandle | The variable name of the handle. It must be the same name as used in the corresponding SCOREP_USER_METRIC_GLOBAL statement. |

C/C++ example:

```c
1 // In File 1
2 SCOREP_USER_METRIC_GLOBAL( my_global_metric )
3
4 int main()
5 {
6    SCOREP_USER_METRIC_INIT( my_global_metric, "My Global Metric", "seconds", 
7                              SCOREP_USER_METRIC_TYPE_UINT64, 
8                              SCOREP_USER_METRIC_CONTEXT_GLOBAL )
9    // do something
10 }
11 void foo()
12 {
13    uint64 my_int = get_some_int_value();
14    SCOREP_USER_METRIC_UINT64( my_global_metric, my_int )
15 }

1 // In File 2
2 SCOREP_USER_METRIC_EXTERNAL( my_global_metric )
3
4 void bar()
5 {
6    uint64 my_int = get_some_int_value();
7    SCOREP_USER_METRIC_UINT64( my_global_metric, my_int )
8 }
```

J.1.2.18 `#define SCOREP_USER_METRIC_GLOBAL( metricHandle )`

Value:

```c
SCOREP_SamplingSetHandle metricHandle = SCOREP_INVALID_SAMPLING_SET;
```

Declares a handle for a user metric as a global variable. It must be used if a metric handle is accessed in more than one file. Every global metric must be declared only in one file using `SCOREP_USER_METRIC_GLOBAL`. All other files in which this handle is accessed must declare it with `SCOREP_USER_METRIC_EXTERNAL`.

This macro is not available in Fortran.

Parameters

| metricHandle | The variable name for the handle. If you are using a Fortran version which has a limited length of code lines, the length of the handle parameter must be at most 4 characters, else the declaration line exceeds the allowed length. |

C/C++ example:

```c
1 // In File 1
2 SCOREP_USER_METRIC_GLOBAL( my_global_metric )
3
4 int main()
5 {
6    SCOREP_USER_METRIC_INIT( my_global_metric, "My Global Metric", "seconds", 
7                              SCOREP_USER_METRIC_TYPE_UINT64, 
8                              SCOREP_USER_METRIC_CONTEXT_GLOBAL )
9    // do something
10 }
11 void foo()
12 {
13    uint64 my_int = get_some_int_value();
14    SCOREP_USER_METRIC_UINT64( my_global_metric, my_int )
15 }

1 // In File 2
2 SCOREP_USER_METRIC_EXTERNAL( my_global_metric )
3
4 void bar()
5 {
6    uint64 my_int = get_some_int_value();
7    SCOREP_USER_METRIC_UINT64( my_global_metric, my_int )
8 }
```
J.1.2.19  

```c
#define SCOREP_USER_METRIC_INIT( metricHandle, name, unit, type, context )
SCOREP_User_InitMetric( &metricHandle, name, unit, type, context );
```

Initializes a new user counter. Each counter must be initialized before it is triggered the first time. The handle must be declared using SCOREP_USER_METRIC_LOCAL, SCOREP_USER_METRIC_GLOBAL, or SCOREP_USER_METRIC_EXTERNAL.

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>metricHandle</td>
<td>Provides a variable name of the variable to store the metric handle. The variable is declared by the macro.</td>
</tr>
<tr>
<td>name</td>
<td>A string containing a unique name for the counter.</td>
</tr>
<tr>
<td>unit</td>
<td>A string containing a unit of the data.</td>
</tr>
<tr>
<td>type</td>
<td>Specifies the data type of the counter. It must be one of the following: SCOREP_USER_METRIC_TYPE_INT64, SCOREP_USER_METRIC_TYPE_UINT64, SCOREP_USER_METRIC_TYPE_DOUBLE. In Fortran is SCOREP_USER_METRIC_TYPE_UINT64 not available.</td>
</tr>
<tr>
<td>context</td>
<td>Specifies the context for which the counter is measured. It must be one of the following: SCOREP_USER_METRIC_CONTEXT_GLOBAL, or SCOREP_USER_METRIC_CONTEXT_CALLPATH.</td>
</tr>
</tbody>
</table>

### C/C++ example:

```c
int main() {
  SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", SCOREP_USER_METRIC_TYPE_UINT64, SCOREP_USER_METRIC_CONTEXT_GLOBAL );
  // do something
}
```

### Fortran example:

```fortran
program myProg
  integer (kind=selected_int_kind(8)):: my_int = 19
  SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", &
                          SCOREP_USER_METRIC_TYPE_INT64, &
                          SCOREP_USER_METRIC_CONTEXT_GLOBAL );
  ! do something
end program myProg
```

J.1.2.20  

```c
#define SCOREP_USER_METRIC_INT64( metricHandle, value )

SCOREP_User_TriggerMetricInt64( metricHandle, value );
```

Triggers a new event for a user counter of a 64 bit integer data type. Each user metric must be declared with SCOREP_USER_COUNTER_LOCAL, SCOREP_USER_COUNTER_GLOBAL, or SCOREP_USER_COUNTER_EXTERNAL and initialized with SCOREP_USER_COUNTER_INIT before it is triggered for the first time.
J.1 Score-P User Adapter

Parameters

<table>
<thead>
<tr>
<th>metricHandle</th>
<th>The handle of the metric for which a value is given in this statement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The value of the counter. It must be possible for implicit casts to cast it to a 64 bit integer.</td>
</tr>
</tbody>
</table>

C/C++ example:

```c
1 SCOREP_USER_METRIC_LOCAL( my_local_metric )
2 int main()
3 {
4   SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", 
5       SCOREP_USER_METRIC_TYPE_UINT64, 
6       SCOREP_USER_METRIC_CONTEXT_GLOBAL )
7   // do something
8 }
9
go fo o()
10 {
11  int64 my_int = get_some_int_value();
12  SCOREP_USER_METRIC_UINT64( my_local_metric, my_int )
13 }
```

Fortran example:

```fortran
1 program myProg
2 SCOREP_USER_METRIC_LOCAL( my_local_metric )
3 integer (kind=selected_int_kind(8)):: my_int = 19
4 ! more declarations
5
go
6
go
7 SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", 
8       SCOREP_USER_METRIC_TYPE_UINT64, 
9       SCOREP_USER_METRIC_CONTEXT_GLOBAL )
10
11 ! do something
12
go
13 SCOREP_USER_METRIC_UINT64( my_local_metric, my_int )
14 end program myProg
```

J.1.2.21 #define SCOREP_USER_METRIC_LOCAL( metricHandle )

Value:

```c
static SCOREP_SamplingSetHandle \ 
   metricHandle = SCOREP_INVALID_SAMPLING_SET;
```

Declares a handle for a user metric. It defines a variable which must be in scope at all places where the metric is used. If it is used in more than one place it need to be a global definition.

Parameters

| metricHandle | The name of the variable which will be declared for storing the metric handle. |

C/C++ example:

```c
1 SCOREP_USER_METRIC_LOCAL( my_local_metric )
2 int main()
3 {
4   SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", 
5       SCOREP_USER_METRIC_TYPE_UINT64, 
6       SCOREP_USER_METRIC_CONTEXT_GLOBAL )
7   // do something
8 }
9
go fo o()
10 {
11  uint64 my_int = get_some_int_value();
12  SCOREP_USER_METRIC_UINT64( my_local_metric, my_int )
13 }
```

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Fortran example:

```fortran
1 program myProg
2  SCOREP_USER_METRIC_LOCAL( my_local_metric )
3  integer (kind=selected_int_kind(8)):: my_int = 19
4  ! more declarations
5
6  SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", &
7       SCOREP_USER_METRIC_TYPE_INT64, &
8       SCOREP_USER_METRIC_CONTEXT_GLOBAL )
9
11  ! do something
12  SCOREP_USER_METRIC_INT64( my_local_metric, my_int )
14 end program myProg
```

---

J.1.2.22 #define SCOREP_USER_METRIC_TYPE_DOUBLE 2

Indicates that a user counter is of data type double.

J.1.2.23 #define SCOREP_USER_METRIC_TYPE_INT64 0

Indicates that a user counter is of data type signed 64 bit integer.

J.1.2.24 #define SCOREP_USER_METRIC_TYPE_UINT64 1

Indicates that a user counter is of data type unsigned 64 bit integer.

J.1.2.25 #define SCOREP_USER_METRIC_UINT64( metricHandle, value )

Value:

```
SCOREP_User_TriggerMetricUint64( metricHandle, value );
```

Triggers a new event for a user counter of a 64 bit unsigned integer data type. Each user metric must be declared
with SCOREP_USER_COUNTER_LOCAL, SCOREP_USER_COUNTER_GLOBAL, or SCOREP_USER_COUNTER_EXTERNAL
and initialized with SCOREP_USER_COUNTER_INIT before it is triggered for the first time.

In Fortran is the unsigned integer type metric not available.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>metricHandle</code></td>
<td>The handle of the metric for which a value is given in this statement.</td>
</tr>
<tr>
<td><code>value</code></td>
<td>The value of the counter. It must be possible for implicit casts to cast it to a 64 bit unsigned integer.</td>
</tr>
</tbody>
</table>

Example:

```fortran
1 SCOREP_USER_METRIC_LOCAL( my_local_metric )
2
3 int main()
4 {
5  SCOREP_USER_METRIC_INIT( my_local_metric, "My Metric", "seconds", &
6       SCOREP_USER_METRIC_TYPE_UINT64, &
7       SCOREP_USER_METRIC_CONTEXT_GLOBAL )
8  // do something
9 }
11 void foo()
12 {
13  uint64 my_int = get_some_int_value();
14  SCOREP_USER_METRIC_UINT64( my_local_metric, my_int )
15 }
```
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J.1.2.26  

```c
#define SCOREP_USER_OA_PHASE_BEGIN( handle, name, type )
SCOREP_User_OaPhaseBegin( \
    handle, &SCOREP_User_LastFileName, &SCOREP_User_LastFileHandle, name, \
    type, __FILE__, __LINE__ );
```

This macro marks the start of a user defined Online Access phase region. The `SCOREP_USER_OA_PHASE_BEGIN` and `SCOREP_USER_OA_PHASE_END` must be correctly nested and be a potential global synchronization points, also it is recommended to mark the body of the application's main loop as a Online Access phase in order to utilize main loop iterations for iterative online analysis.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>handle</code></td>
<td>The handle of the associated user region, which will become a root of the profile call-tree. This handle must be declared using <code>SCOREP_USER_REGION_DEFINE</code> or <code>SCOREP_USER_GLOBAL_REGION_DEFINE</code> before.</td>
</tr>
<tr>
<td><code>name</code></td>
<td>A string containing the name of the new region. The name should be unique.</td>
</tr>
<tr>
<td><code>type</code></td>
<td>Specifies the type of the region. Possible values are <code>SCOREP_USER_REGION_TYPE_COMMON</code>, <code>SCOREP_USER_REGION_TYPE_FUNCTION</code>, <code>SCOREP_USER_REGION_TYPE_LOOP</code>, <code>SCOREP_USER_REGION_TYPE_DYNAMIC</code>, or a combination of them.</td>
</tr>
</tbody>
</table>

C/C++ example:

```c
1 void main() {
2    SCOREP_USER_REGION_DEFINE( my_region_handle )
3
4    // application initialization
5
6    for ( ) // main loop of the application
7       {
8        SCOREP_USER_OA_PHASE_BEGIN( my_region_handle, "main loop",SCOREP_USER_REGION_TYPE_COMMON )
9        // do something
10       }
11    SCOREP_USER_OA_PHASE_END( my_region_handle )
12
13    // application finalization
14 }
```

Fortran example:

```fortran
1 program myProg
2    SCOREP_USER_REGION_DEFINE( my_region_handle )
3
4    ! applications initialization
5
6    ! main loop of the application
7    do ... 
8    SCOREP_USER_OA_PHASE_BEGIN( my_region_handle, "main loop",SCOREP_USER_REGION_TYPE_COMMON )
9    ! do something
10   
11   SCOREP_USER_OA_PHASE_END( my_region_handle )
12
13 ! application finalization
14 end program myProg
```

J.1.2.27  

```c
#define SCOREP_USER_OA_PHASE_END( handle ) SCOREP_User_OaPhaseEnd( handle );
```

This macro marks the end of a user defined Online Access phase region. The `SCOREP_USER_OA_PHASE_BEGIN` and `SCOREP_USER_OA_PHASE_END` must be correctly nested and be a potential global synchronization points, also it is recommended to mark the body of the application's main loop as a Online Access phase in order to utilize main loop iterations for iterative online analysis.
### Parameters

| **handle** | The handle of the associated user region, which will become a root of the profile call-tree. This handle must be declared using `SCOREP_USER_REGION_DEFINE` or `SCOREP_USER_GLOBAL_REGION_DEFINE` before. C/C++ example:

```c
void main()
{
  SCOREP_USER_REGION_DEFINE( my_region_handle )

  for ( ) // main loop of the application
  {
    SCOREP_USER_OA_PHASE_BEGIN( my_region_handle, "main loop", SCOREP_USER_REGION_TYPE_COMMON )
    // do something
    SCOREP_USER_OA_PHASE_END( my_region_handle )
  }

  // application finalization
}
```

Fortran example:

```fortran
program myProg
SCOREP_USER_REGION_DEFINE( my_region_handle )
!
! applications initialization
!
! main loop of the application
!
SCOREP_USER_OA_PHASE_BEGIN( my_region_handle, "main loop", SCOREP_USER_REGION_TYPE_COMMON )
    ! do something
SCOREP_USER_OA_PHASE_END( my_region_handle )
enddo
!
! application finalization
end program myProg
```

J.1.2.28  

```c
#define SCOREP_USER_PARAMETER_INT64( name, value )

static SCOREP_User_ParameterHandle scorep_param = 
SCOREP_USER_INVALID_PARAMETER;
SCOREP_User_ParameterInt64( &scorep_param, name, value );
```

This statement adds a 64 bit signed integer type parameter for parameter-based profiling to the current region. The call-tree for the region is split according to the different values of the parameters with the same name. It is possible to add an arbitrary number of parameters to a region. Each parameter must have a unique name. However, it is not recommended to use more than 1 parameter per region.

| **name** | A string containing the name of the parameter. |
J.1 Score-P User Adapter

value | The value of the parameter. It must be possible for implicit casts to cast it to a 64 bit integer.

C/C++ example:

```c
1 void myfunc(int64 myint)
2 {
3   SCOREP_USER_REGION_DEFINE( my_region_handle )
4   SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region", SCOREP_USER_REGION_TYPE_COMMON )
5   SCOREP_USER_PARAMETER_INT64("A nice int",myint)
6     // do something
7   SCOREP_USER_REGION_END( my_region_handle )
8 }
9
```

J.1.2.29 #define SCOREP_USER_PARAMETER_STRING( name, value )

Value:

```c
1 \ static SCOREP_User_ParameterHandle scorep_param = 
2 \ SCOREP_USER_INVALID_PARAMETER; 
3 \ SCOREP_User_ParameterString( &scorep_param, name, value ); 
```

This statement adds a string type parameter for parameter-based profiling to the current region. The call-tree for
the region is split according to the different values of the parameters with the same name. It is possible to add
an arbitrary number of parameters to a region. Each parameter must have a unique name. However, it is not
recommended to use more than 1 parameter per region. During one visit it is not allowed to use the same name
twice for two different parameters.

Parameters

<table>
<thead>
<tr>
<th>name</th>
<th>A string containing the name of the parameter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The value of the parameter. It must be a pointer to a C-string (a NULL-terminated string).</td>
</tr>
</tbody>
</table>

C/C++ Example:

```c
1 void myfunc(char *mystring)
2 {
3   SCOREP_USER_REGION_DEFINE( my_region_handle )
4   SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region", SCOREP_USER_REGION_TYPE_COMMON )
5   SCOREP_USER_PARAMETER_STRING("A nice string",mystring)
6     // do something
7   SCOREP_USER_REGION_END( my_region_handle )
8 }
9
```

J.1.2.30 #define SCOREP_USER_PARAMETER_UINT64( name, value )

Value:

```c
1 \ static SCOREP_User_ParameterHandle scorep_param = 
2 \ SCOREP_USER_INVALID_PARAMETER; 
3 \ SCOREP_User_ParameterUint64( &scorep_param, name, value ); 
```

This statement adds a 64 bit unsigned integer type parameter for parameter-based profiling to the current region.
The call-tree for the region is split according to the different values of the parameters with the same name. It
is possible to add an arbitrary number of parameters to a region. Each parameter must have a unique name.
However, it is not recommended to use more than 1 parameter per region.
APPENDIX J. MODULE DOCUMENTATION

Parameters

<table>
<thead>
<tr>
<th>name</th>
<th>A string containing the name of the parameter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The value of the parameter. It must be possible for implicit casts to cast it to a 64 bit unsigned integer.</td>
</tr>
</tbody>
</table>

C/C++ example:

```c
void myfunc(uint64 myuint)
{
  SCOREP_USER_REGION_DEFINE( my_region_handle )
  SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region", SCOREP_USER_REGION_TYPE_COMMON )
  SCOREP_USER_PARAMETER_UINT64("A nice unsigned int", myuint)
  // do something
  SCOREP_USER_REGION_END( my_region_handle )
}
```

J.1.2.31 `#define SCOREP_USER_REGION( name, type )`

Instruments a code block as a region with the given name. It inserts a local variable of the type class SCOREP_User_Region. Its constructor generates the enter event and its destructor generates the exit event. Thus, only one statement is necessary to instrument the code block. This statement is only in C++ available.

Parameters

<table>
<thead>
<tr>
<th>name</th>
<th>A string containing the name of the new region. The name should be unique.</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>Specifies the type of the region. Possible values are SCOREP_USER_REGION_TYPE_COMMON, SCOREP_USER_REGION_TYPE_FUNCTION, SCOREP_USER_REGION_TYPE_LOOP, SCOREP_USER_REGION_TYPE_DYNAMIC, SCOREP_USER_REGION_TYPE_PHASE, or a combination of them.</td>
</tr>
</tbody>
</table>

Example:

```c
void myfunc()
{
  SCOREP_USER_REGION_( "myfunc", SCOREP_USER_REGION_TYPE_FUNCTION )
  // do something
}
```

J.1.2.32 `#define SCOREP_USER_REGION_BEGIN( handle, name, type )`

Value:

```c
SCOREP_User_RegionBegin( handle, &SCOREP_User_LastFileName, &SCOREP_User_LastFileHandle, name, type, __FILE__, __LINE__ );
```

This macro marks the start of a user defined region. The SCOREP_USER_REGION_BEGIN and SCOREP_USER_REGION_END calls of all regions must be correctly nested.

Parameters
### J.1 Score-P User Adapter

| handle | The handle of the region to be started. This handle must be declared using `SCOREP_USER_REGION_DEFINE` or `SCOREP_USER_GLOBAL_REGION_DEFINE` before. |
| name | A string containing the name of the new region. The name should be unique. |
| type | Specifies the type of the region. Possible values are `SCOREP_USER_REGION_TYPE_COMMON`, `SCOREP_USER_REGION_TYPE_FUNCTION`, `SCOREP_USER_REGION_TYPE_LOOP`, `SCOREP_USER_REGION_TYPE_DYNAMIC`, `SCOREP_USER_REGION_TYPE_PHASE`, or a combination of them. |

**C/C++ example:**
```c
void myfunc()
{
SCOREP_USER_REGION_DEFINE( my_region_handle )
// do something
SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region",SCOREP_USER_REGION_TYPE_COMMON )
// do something
SCOREP_USER_REGION_END( my_region_handle )
}
```

**Fortran example:**
```fortran
program myProg
SCOREP_USER_REGION_DEFINE( my_region_handle )
! more declarations
SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region",SCOREP_USER_REGION_TYPE_COMMON )
! do something
SCOREP_USER_REGION_END( my_region_handle )
end program myProg
```

### J.1.2.33

```c
#define SCOREP_USER_REGION_DEFINE( handle ) static SCOREP_User_RegionHandle handle = SCOREP_USER_INVALID_REGION;
```

This macro defines a user region handle in a local context. Every user handle must be defined, before it can be used.

**Parameters**

| handle | A unique name for the handle must be provided. This handle is declared in the macro. This handle is used in the `SCOREP_USER_REGION_BEGIN` and `SCOREP_USER_REGION_END` statements to specify which region is started, or ended. If you are using a Fortran version which has a limited length of code lines, the length of the `handle` parameter must be at most 4 characters, else the declaration line exceeds the allowed length. |

**C/C++ example:**
```c
void myfunc()
{
SCOREP_USER_REGION_DEFINE( my_region_handle )
// do something
SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region",SCOREP_USER_REGION_TYPE_COMMON )
// do something
SCOREP_USER_REGION_END( my_region_handle )
}
```

**Fortran example:**
```fortran
program myProg
SCOREP_USER_REGION_DEFINE( my_region_handle )
! more declarations
SCOREP_USER_REGION_BEGIN( my_region_handle, "my_region",SCOREP_USER_REGION_TYPE_COMMON )
! do something
SCOREP_USER_REGION_END( my_region_handle )
end program myProg
```
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J.1.2.34 #define SCOREP_USER_REGION_END( handle ) SCOREP_User_RegionEnd( handle );

This macro marks the end of a user defined region. The SCOREP_USER_REGION_BEGIN and SCOREP_USER_REGION_END calls of all regions must be correctly nested.

Parameters

| handle | The handle of the region which ended here. It must be the same handle which is used as the start of the region. |

C/C++ example:

```c
void myfunc()
{
    SCOREP_USER_REGION_DEFINE( my_region_handle )
    // do something
    SCOREP_USER_REGION_BEGIN( my_region_handle, *my_region*,SCOREP_USER_REGION_TYPE_COMMON )
    // do something
    SCOREP_USER_REGION_END( my_region_handle )
}
```

Fortran example:

```fortran
program myProg
    SCOREP_USER_REGION_DEFINE( my_region_handle )
    ! more declarations
    SCOREP_USER_REGION_BEGIN( my_region_handle, *my_region*,SCOREP_USER_REGION_TYPE_COMMON )
    ! do something
    SCOREP_USER_REGION_END( my_region_handle )
end program myProg
```

J.1.2.35 #define SCOREP_USER_REGION_ENTER( handle ) SCOREP_User_RegionEnter( handle );

This macro marks the beginning of a user defined and already initialized region. The SCOREP_USER_REGION_BEGIN/SCOREP_USER_REGION_ENTER and SCOREP_USER_REGION_END calls of all regions must be correctly nested. To initialize the region handle, SCOREP_USER_REGION_INIT or SCOREP_USER_REGION_BEGIN must be called before.

Parameters

| handle | The handle of the region which ended here. It must be the same handle which is used as the start of the region. |

C/C++ example:

```c
void myfunc()
{
    SCOREP_USER_REGION_DEFINE( my_region_handle )
    // do something
    SCOREP_USER_REGION_INIT( my_region_handle, *my_region*,SCOREP_USER_REGION_TYPE_COMMON )
    SCOREP_USER_REGION_ENTER( my_region_handle )
    // do something
    SCOREP_USER_REGION_END( my_region_handle )
}
```

Fortran example:

```fortran
program myProg
    SCOREP_USER_REGION_DEFINE( my_region_handle )
    ! more declarations
    SCOREP_USER_REGION_INIT( my_region_handle, *my_region*,SCOREP_USER_REGION_TYPE_COMMON )
    ! do something
    SCOREP_USER_REGION_ENTER( my_region_handle )
    ! do something
    SCOREP_USER_REGION_END( my_region_handle )
end program myProg
```
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J.1.2.36  

#define SCOREP_USER_REGION_INIT( handle, name, type )

Value:

SCOREP_UserRegionInit(
    handle, &SCOREP_User_LastFileName, &SCOREP_User_LastFileHandle, name, \
    type, __FILE__, __LINE__ );

This macro initializes a user defined region. If the region handle is already initialized, no operation is executed.

Parameters

<table>
<thead>
<tr>
<th>handle</th>
<th>The handle of the region to be started. This handle must be declared using SCOREP_USER_REGION_DEFINE or SCOREP_USER_GLOBAL_REGION_DEFINE before.</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>A string containing the name of the new region. The name should be unique.</td>
</tr>
<tr>
<td>type</td>
<td>Specifies the type of the region. Possible values are SCOREP_USER_REGION_TYPE_COMMON, SCOREP_USER_REGION_TYPE_FUNCTION, SCOREP_USER_REGION_TYPE_LOOP, SCOREP_USER_REGION_TYPE_DYNAMIC, SCOREP_USER_REGION_TYPE_PHASE, or a combination of them.</td>
</tr>
</tbody>
</table>

C/C++ example:

```c
1 void myfunc()
2 {
3    SCOREP_USER_REGION_DEFINE( my_region_handle )
4    // do something
5    SCOREP_USER_REGION_INIT( my_region_handle, "my_region",SCOREP_USER_REGION_TYPE_COMMON )
6    SCOREP_USER_REGION_ENTER( my_region_handle )
7    // do something
8    SCOREP_USER_REGION_END( my_region_handle )
9}
```

Fortran example:

```fortran
1 program myProg
2    SCOREP_USER_REGION_DEFINE( my_region_handle )
3    ! more declarations
4    SCOREP_USER_REGION_INIT( my_region_handle, "my_region",SCOREP_USER_REGION_TYPE_COMMON )
5    SCOREP_USER_REGION_ENTER( my_region_handle )
6    ! do something
7    SCOREP_USER_REGION_END( my_region_handle )
8 end program myProg
```

J.1.2.37  

#define SCOREP_USER_REGION_TYPE_COMMON 0

Region without any specific type.

J.1.2.38  

#define SCOREP_USER_REGION_TYPE_DYNAMIC 4

Marks the regions as dynamic.
J.1.2.39 #define SCOREP_USER_REGION_TYPE_FUNCTION 1

Marks the region as being the codeblock of a function.

J.1.2.40 #define SCOREP_USER_REGION_TYPE_LOOP 2

Marks the region as being the codeblock of a loop with the same number of iterations on all processes.

J.1.2.41 #define SCOREP_USER_REGION_TYPE_PHASE 8

Marks the region as being a root node of a phase.
Macros

- `#define SCOREP_ALL_TARGET_RANKS -1`
- `#define SCOREP_INVALID_EXIT_STATUS ((int64_t)((~(~(uint64_t)0u)) >> 1))`
- `#define SCOREP_INVALID_LINE_NO 0`
- `#define SCOREP_INVALID_METRIC SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_PARADIGM SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_PID 0`
- `#define SCOREP_INVALID_REGION SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_ROOT_RANK -1`
- `#define SCOREP_INVALID_SAMPLING_SET SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_SOURCE_FILE SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_TID 0`
- `#define SCOREP_IO_UNKNOWN_OFFSET UINT64_MAX`
- `#define SCOREP_LOCATION_TYPES`
- `#define SCOREP_MOVABLE_NULL 0`

Typedefs

- `typedef uint32_t SCOREP_Allocator_MovableMemory`
- `typedef SCOREP_Allocator_MovableMemory SCOREP_AnyHandle`
- `typedef int64_t SCOREP_ExitStatus`
- `typedef uint32_t SCOREP_LineNo`
- `typedef SCOREP_AnyHandle SCOREP_MetricHandle`
- `typedef int SCOREP_MpiRank`
- `typedef uint64_t SCOREP_MpiRequestId`
- `typedef SCOREP_AnyHandle SCOREP_ParadigmHandle`
- `typedef SCOREP_AnyHandle SCOREP_RegionHandle`
- `typedef SCOREP_AnyHandle SCOREP_SamplingSetHandle`
- `typedef SCOREP_AnyHandle SCOREP_SourceFileHandle`
- `typedef struct SCOREP_Task SCOREP_TaskHandle`
Enumerations

• enum SCOREP_CollectiveType {
    SCOREP_COLLECTIVE_BARRIER,
    SCOREP_COLLECTIVE_BROADCAST,
    SCOREP_COLLECTIVE_GATHER,
    SCOREP_COLLECTIVE_GATHERV,
    SCOREP_COLLECTIVE_SCATTER,
    SCOREP_COLLECTIVE_SCATTERV,
    SCOREP_COLLECTIVE_ALLGATHER,
    SCOREP_COLLECTIVE_ALLGATHERV,
    SCOREP_COLLECTIVE_ALLTOALL,
    SCOREP_COLLECTIVE_ALLTOALLV,
    SCOREP_COLLECTIVE_ALLTOALLW,
    SCOREP_COLLECTIVE_ALLREDUCE,
    SCOREP_COLLECTIVE_REDUCE,
    SCOREP_COLLECTIVE_REDUCE_SCATTER,
    SCOREP_COLLECTIVE_REDUCE_SCATTER_BLOCK,
    SCOREP_COLLECTIVE_SCAN,
    SCOREP_COLLECTIVE_EXSCAN,
    SCOREP_COLLECTIVE_CREATE_HANDLE,
    SCOREP_COLLECTIVE_DESTROY_HANDLE,
    SCOREP_COLLECTIVE_ALLOCATE,
    SCOREP_COLLECTIVE DEALLOCATE,
    SCOREP_COLLECTIVE_CREATE_HANDLE_AND_ALLOCATE,
    SCOREP_COLLECTIVE_DESTROY_HANDLE_AND_DEALLOCATE
}

Types to specify the used collectives in calls to SCOREP_MpiCollectiveBegin and SCOREP_RmaCollectiveBegin.

• enum SCOREP_IoAccessMode {
    SCOREP_IO_ACCESS_MODE_NONE = 0,
    SCOREP_IO_ACCESS_MODE_READ_ONLY,
    SCOREP_IO_ACCESS_MODE_WRITE_ONLY,
    SCOREP_IO_ACCESS_MODE_READ_WRITE,
    SCOREP_IO_ACCESS_MODE_EXECUTE_ONLY,
    SCOREP_IO_ACCESS_MODE_SEARCH_ONLY
}

• enum SCOREP_IoCreationFlag {
    SCOREP_IO_CREATION_FLAG_NONE = 0,
    SCOREP_IO_CREATION_FLAG_CREATE = (1 << 0),
    SCOREP_IO_CREATION_FLAG_TRUNCATE = (1 << 1),
    SCOREP_IO_CREATION_FLAG_DIRECTORY = (1 << 2),
    SCOREP_IO_CREATION_FLAG_EXCLUSIVE = (1 << 3),
    SCOREP_IO_CREATION_FLAG_NO_CONTROLLING_TERMINAL = (1 << 4),
    SCOREP_IO_CREATION_FLAG_NO_FOLLOW = (1 << 5),
    SCOREP_IO_CREATION_FLAG_PATH = (1 << 6),
    SCOREP_IO_CREATION_FLAG_TEMPORARY_FILE = (1 << 7),
    SCOREP_IO_CREATION_FLAG_LARGEFILE = (1 << 8),
    SCOREP_IO_CREATION_FLAG_NO_SEEK = (1 << 9),
    SCOREP_IO_CREATION_FLAG_UNIQUE = (1 << 10)
}

• enum SCOREP_IoOperationFlag {
    SCOREP_IO_OPERATION_FLAG_NONE = 0,
    SCOREP_IO_OPERATION_FLAG_BLOCKING = 0,
    SCOREP_IO_OPERATION_FLAG_NON_BLOCKING = (1 << 0),
    SCOREP_IO_OPERATION_FLAG_COLLECTIVE = (1 << 1),
    SCOREP_IO_OPERATION_FLAG_NON_COLLECTIVE = 0
}

• enum SCOREP_IoOperationMode {
    SCOREP_IO_OPERATION_MODE_READ = 0,
    SCOREP_IO_OPERATION_MODE_WRITE,
    SCOREP_IO_OPERATION_MODE_FLUSH
}

• enum SCOREP_IoParadigmType
• enum SCOREP_IoSeekOption{
    SCOREP_IO_SEEK_FROM_START = 0,
    SCOREP_IO_SEEK_FROM_CURRENT,
    SCOREP_IO_SEEK_FROM_END,
    SCOREP_IO_SEEK_DATA,
    SCOREP_IO_SEEK_HOLE,
    SCOREP_IO_SEEK_INVALID }

• enum SCOREP_IoStatusFlag {
    SCOREP_IO_STATUS_FLAG_NONE = 0,
    SCOREP_IO_STATUS_FLAG_CLOSE_ON_EXEC = (1 << 0),
    SCOREP_IO_STATUS_FLAG_APPEND = (1 << 1),
    SCOREP_IO_STATUS_FLAG_NON_BLOCKING = (1 << 2),
    SCOREP_IO_STATUS_FLAG_ASYNC = (1 << 3),
    SCOREP_IO_STATUS_FLAG.Sync = (1 << 4),
    SCOREP_IO_STATUS_FLAG_DATA_SYNC = (1 << 5),
    SCOREP_IO_STATUS_FLAG_AVOID_CACHING = (1 << 6),
    SCOREP_IO_STATUS_FLAG_NO_ACCESS_TIME = (1 << 7),
    SCOREP_IO_STATUS_FLAG_DELETE_ON_CLOSE = (1 << 8) }

• enum SCOREP_Ipc_Datatype
  specifies an inter process communication data types

• enum SCOREP_Ipc_Operation
  specifies an inter process communication operation for reduce function

• enum SCOREP_LocationType { , SCOREP_INVALID_LOCATION_TYPE }

• enum SCOREP_LockType {
    SCOREP_LOCK_EXCLUSIVE,
    SCOREP_LOCK_SHARED,
    SCOREP_INVALID_LOCK_TYPE }

• enum SCOREP_MetricOccurrence {
    SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS_STRICT = 0,
    SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS = 1,
    SCOREP_METRIC_OCCURRENCE_ASYNCHRONOUS = 2,
    SCOREP_INVALID_METRIC_OCCURRENCE }
  Types to be used in defining the occurrence of a sampling set.

• enum SCOREP_MetricScope {
    SCOREP_METRIC_SCOPE_LOCATION = 0,
    SCOREP_METRIC_SCOPE_LOCATION_GROUP = 1,
    SCOREP_METRIC_SCOPE_SYSTEM_TREE_NODE = 2,
    SCOREP_METRIC_SCOPE_GROUP = 3,
    SCOREP_INVALID_METRIC_SCOPE }
  Types to be used in defining the scope of a scoped sampling set.

• enum SCOREP_ParadigmClass { SCOREP_INVALID_PARADIGM_CLASS }
  defines classes of paradigms that are monitored Types:

• enum SCOREP_ParadigmType { SCOREP_INVALID_PARADIGM_TYPE }
  defines paradigms that are be monitored

• enum SCOREP_ParameterType {
    SCOREP_PARAMETER_INT64,
    SCOREP_PARAMETER_UINT64,
    SCOREP_PARAMETER_STRING,
    SCOREP_INVALID_PARAMETER_TYPE }
  defines types to be used in defining a parameter for parameter based profiling (SCOREP_Definitions_NewParameter()).

• enum SCOREP_RegionType { , SCOREP_INVALID_REGION_TYPE }
  specifies a Region

• enum SCOREP_RmaAtomicType
  specifies a RMA Atomic Operation Type.
• `enum SCOREP_RmaSyncLevel`
  specifies a RMA synchronization level, used by RMA records to be passed to `SCOREP_Rma()` functions.

• `enum SCOREP_RmaSyncType { SCOREP_INVALID_RMA_SYNC_TYPE }`
  Type of direct RMA synchronization call.

• `enum SCOREP_SamplingSetClass {
    SCOREP_SAMPLING_SET_ABSTRACT,
    SCOREP_SAMPLING_SET_CPU,
    SCOREP_SAMPLING_SET_GPU
}`
  Class of locations which recorded a sampling set.

• `enum SCOREP_Substrates_RequirementFlag {
    SCOREP_SUBSTRATES_REQUIREMENT_CREATE_EXPERIMENT_DIRECTORY,
    SCOREP_SUBSTRATES_REQUIREMENT_PREVENT_ASYNC_METRICS,
    SCOREP_SUBSTRATES_REQUIREMENT_PREVENT_PER_HOST_AND_ONCE_METRICS,
    SCOREP_SUBSTRATES_NUM_REQUIREMENTS
}"

### J.2.1 Detailed Description

### J.2.2 Macro Definition Documentation

#### J.2.2.1 `#define SCOREP_ALL_TARGET_RANKS -1`
Symbolic constant representing an invalid or inapplicable target rank for a lock event.

See also

`SCOREP_RmaAcquireLock()` and similar calls.

#### J.2.2.2 `#define SCOREP_INVALID_EXIT_STATUS ( ( int64_t )(( ~(( ( uint64_t )0u ) ) >> 1 ) ) )`
Symbolic constant representing an invalid or unknown exit status. Do not use INT64_C here, as this maybe accessed by C++

#### J.2.2.3 `#define SCOREP_INVALID_LINE_NO 0`
Symbolic constant representing an invalid or unknown line number.

See also

`SCOREP_Definitions_NewRegion()`

#### J.2.2.4 `#define SCOREP_INVALID_METRIC SCOREP_MOVABLE_NULL`
Symbolic constant representing an invalid or unknown metric definition.

#### J.2.2.5 `#define SCOREP_INVALID_PARADIGM SCOREP_MOVABLE_NULL`
Symbolic constant representing an invalid or unknown paradigm definition.
J.2 Public type definitions and enums used in Score-P

J.2.2.6 #define SCOREP_INVALID_PID 0
Symbolic constant representing an invalid or unknown process identifier.

J.2.2.7 #define SCOREP_INVALID_REGION SCOREP_MOVABLE_NULL
Symbolic constant representing an invalid or unknown region definition.

J.2.2.8 #define SCOREP_INVALID_ROOT_RANK -1
Symbolic constant representing an invalid or unknown rank.

See also
SCOREP_MpiCollective()

J.2.2.9 #define SCOREP_INVALID_SAMPLING_SET SCOREP_MOVABLE_NULL
Symbolic constant representing an invalid or unknown metric class definition.

J.2.2.10 #define SCOREP_INVALID_SOURCE_FILE SCOREP_MOVABLE_NULL
Symbolic constant representing an invalid or unknown source file definition.

J.2.2.11 #define SCOREP_INVALID_TID 0
Symbolic constant representing an invalid or unknown thread identifier.

J.2.2.12 #define SCOREP_IO_UNKNOWN_OFFSET UINT64_MAX
Symbolic constant representing the offset that is unknown.

J.2.2.13 #define SCOREP_LOCATION_TYPES

Value:

SCOREP_LOCATION_TYPE( CPU_THREAD, "CPU thread" ) \ 
SCOREP_LOCATION_TYPE( GPU, "GPU" ) \ 
SCOREP_LOCATION_TYPE( METRIC, "metric location" ) \ 

Types to be used in defining a location (SCOREP_Definitions_NewLocation()).
J.2.2.14  
#define SCOREP_MOVABLE_NULL 0

Symbolic constant representing an invalid or NULL handle of type SCOREP_Allocator_MovableMemory.

J.2.3  Typedef Documentation

J.2.3.1  
typedef uint32_t SCOREP_Allocator_MovableMemory

Opaque handle to memory that can be easily moved between processes. Used for definitions as they have to be moved during unification.

J.2.3.2  
typedef SCOREP_Allocator_MovableMemory SCOREP_AnyHandle

Type of a opaque handle to any definition.

J.2.3.3  
typedef int64_t SCOREP_ExitStatus

Type used in specify the exit status of the program.

See also
  ProgramEnd event

J.2.3.4  
typedef uint32_t SCOREP_LineNo

Type used in specifying line numbers.

See also
  SCOREP_Definitions_NewRegion()

J.2.3.5  
typedef SCOREP_AnyHandle SCOREP_MetricHandle

Type of a opaque handle to a metric definition.

See also
  SCOREP_Definitions_NewMetric()

J.2.3.6  
typedef int SCOREP_MpiRank

Type of MPI Ranks. Type of MPI ranks always int.
J.2 Public type definitions and enums used in Score-P

J.2.3.7 typedef uint64_t SCOREP_MpiRequestId

Type of a MPI Non-blocking communication request id.

J.2.3.8 typedef SCOREP_AnyHandle SCOREP_ParadigmHandle

Type of a opaque handle to a paradigm definition.

See also
SCOREP_Definitions_NewParadigm()

J.2.3.9 typedef SCOREP_AnyHandle SCOREP_RegionHandle

Type of a opaque handle to a region definition.

See also
SCOREP_Definitions_NewRegion()

J.2.3.10 typedef SCOREP_AnyHandle SCOREP_SamplingSetHandle

Type of a opaque handle to a sampling set definition.

See also
SCOREP_Definitions_NewSamplingSet()

J.2.3.11 typedef SCOREP_AnyHandle SCOREP_SourceFileHandle

Type of a opaque handle to a source file definition.

See also
SCOREP_Definitions_NewSourceFile()

J.2.3.12 typedef struct SCOREP_Task * SCOREP_TaskHandle

Task Handle
J.2.4 Enumeration Type Documentation

J.2.4.1 enum SCOREP_CollectiveType

Types to specify the used collectives in calls to SCOREP_MpiCollectiveBegin and SCOREP_RmaCollectiveBegin.

Enumerator

- **SCOREP_COLLECTIVE_BARRIER** The collective is a barrier, e.g., MPI_Barrier(...), shmem_barrier(...), or shmem_barrier_all(...)
- **SCOREP_COLLECTIVE_BROADCAST** The collective is a barrier, e.g., MPI_Bcast(...), or shmem_broadcast32(...)
- **SCOREP_COLLECTIVE_GATHER** The collective is a simple gather operation, e.g., MPI_Gather(...)
- **SCOREP_COLLECTIVE_GATHERV** The collective is a complex gather operation, e.g., MPI_Gatherv(...)
- **SCOREP_COLLECTIVE_SCATTER** The collective is a simple scatter operation, e.g., MPI_Scatter(...)
- **SCOREP_COLLECTIVE_SCATTERV** The collective is a complex scatter operation, e.g., MPI_Scatterv(...)
- **SCOREP_COLLECTIVE_ALLGATHER** The collective is a simple allgather operation, e.g., MPI_Allgather(...), or shmem_collect64(...)
- **SCOREP_COLLECTIVE_ALLGATHERV** The collective is a complex allgather operation, e.g., MPI_Allgatherv(...)
- **SCOREP_COLLECTIVE_ALLTOALL** The collective is a simple all-to-all communication, e.g., MPI_Alltoall(...)
- **SCOREP_COLLECTIVE_ALLTOALLV** The collective is a all-to-all communication with more options for sizes and displacements, e.g., MPI_Alltoallv(...)
- **SCOREP_COLLECTIVE_ALLTOALLW** The collective is a generalized all-to-all communication, e.g., MPI_Alltoallw(...)
- **SCOREP_COLLECTIVE_ALLREDUCE** The collective is an allreduce operation, e.g., MPI_Allreduce(...)
- **SCOREP_COLLECTIVE_REDUCE** The collective is a reduce operation, e.g., MPI_Reduce(...), or shmem_longlong_max_to_all(...)
- **SCOREP_COLLECTIVE_REDUCE_SCATTER** The collective is a reduce-scatter operation, which combines some values and scatters the results, e.g., MPI_Reduce_scatter(...)
- **SCOREP_COLLECTIVE_REDUCE_SCATTER_BLOCK** The collective is a reduce scatter block operation, e.g., MPI_Reduce_scatter_block(...)
- **SCOREP_COLLECTIVE_SCAN** The collective is a scan operation, where partial reductions of data is computed, e.g., MPI_Scan(...)
- **SCOREP_COLLECTIVE_EXSCAN** The collective is an exclusive scan operation, e.g., MPI_Exscan(...)
- **SCOREP_COLLECTIVE_CREATE_HANDLE** This is used by the tracing substrate to work together with OTF2
- **SCOREP_COLLECTIVE_DESTROY_HANDLE** This is used by the tracing substrate to work together with OTF2
- **SCOREP_COLLECTIVE_ALLOCATE** This is used by the tracing substrate to work together with OTF2
- **SCOREP_COLLECTIVE_DEALLOCATE** This is used by the tracing substrate to work together with OTF2
- **SCOREP_COLLECTIVE_CREATE_HANDLE_AND_ALLOCATE** This is used by the tracing substrate to work together with OTF2
- **SCOREP_COLLECTIVE_DESTROY_HANDLE_AND_DEALLOCATE** This is used by the tracing substrate to work together with OTF2
J.2 Public type definitions and enums used in Score-P

J.2.4.2 enum SCOREP_IoAccessMode

Access mode of an I/O handle in subsequent I/O operations.

Enumerator

- `SCOREP_IO_ACCESS_MODE_NONE` Unspecified access mode.
- `SCOREP_IO_ACCESS_MODE_READ_ONLY` Read-only access.
- `SCOREP_IO_ACCESS_MODE_WRITE_ONLY` Write-only access.
- `SCOREP_IO_ACCESS_MODE_READ_WRITE` Read-write access.
- `SCOREP_IO_ACCESS_MODE_EXECUTE_ONLY` Execute-only access.
- `SCOREP_IO_ACCESS_MODE_SEARCH_ONLY` Search-only access.

J.2.4.3 enum SCOREP_IoCreationFlag

Additional flags specified while creation of an I/O handle.

Enumerator

- `SCOREP_IO_CREATION_FLAG_NONE` No flag is set.
- `SCOREP_IO_CREATION_FLAG_CREATE` If the file does not exist, it will be created.
- `SCOREP_IO_CREATION_FLAG_TRUNCATE` Truncate file to length 0 if possible.
- `SCOREP_IO_CREATION_FLAG_DIRECTORY` Open operation will fail if pathname is not a directory.
- `SCOREP_IO_CREATION_FLAG_EXCLUSIVE` Ensure that this call creates the file.
- `SCOREP_IO_CREATION_FLAG_NO_CONTROLLING TERMINAL` File is a terminal device and should not be promoted to a controlling terminal, if none existed before.
- `SCOREP_IO_CREATION_FLAG_NO_FOLLOW` If pathname is a symbolic link, then the open operation will fail.
- `SCOREP_IO_CREATION_FLAG_PATH` File is only a location in the filesystem tree and is not suitable for reading and writing.
- `SCOREP_IO_CREATION_FLAG_TEMPORARY_FILE` Create an unnamed temporary file.
- `SCOREP_IO_CREATION_FLAG_LARGEFILE` Ensure that the file size can be represented by a 64-bit datatype.
- `SCOREP_IO_CREATION_FLAG_NO_SEEK` Gives the advice that no reposition will happen on this I/O handle. E.g., no seek operation or similar, only sequential read or write operations.
- `SCOREP_IO_CREATION_FLAG_UNIQUE` Gives the advice that this will be the only active {IoHandle} of the {IoParadigmType} which will operate on the referenced {IoFile} at any time. E.g., no other {IoHandle} of the same {IoParadigmType} and the same {IoFile} will be active.

J.2.4.4 enum SCOREP_IoOperationFlag

Flags for I/O operations to indicate specific semantics of the operation. Per default any I/O operation is assumed as blocking and non-collective. You can set appropriate flag bits to indicate a deviation from this default semantic.

Enumerator

- `SCOREP_IO_OPERATION_FLAG_NONE` No special semantics.
- `SCOREP_IO_OPERATION_FLAG_BLOCKING` The I/O operation was performed in a blocking mode (default).
- `SCOREP_IO_OPERATION_FLAG_NON_BLOCKING` The I/O operation was performed in a non-blocking mode.
- `SCOREP_IO_OPERATION_FLAG_COLLECTIVE` The I/O operation was performed collectively over the communicator of the referenced (IoHandle) handle.
- `SCOREP_IO_OPERATION_FLAG_NON_COLLECTIVE` The I/O operation was performed in a non-collective mode. (default)
J.2.4.5 enum SCOREP_IoOperationMode

Mode of an I/O operation.

Enumerator

- **SCOREP_IO_OPERATION_MODE_READ** Read operation.
- **SCOREP_IO_OPERATION_MODE_WRITE** Write operation.
- **SCOREP_IO_OPERATION_MODE_FLUSH** Synchronization/flush operation (request and completion).

J.2.4.6 enum SCOREP_IoParadigmType

I/O paradigm types.

J.2.4.7 enum SCOREP_IoSeekOption

Options for repositioning a file offset with file seek operations.

Enumerator

- **SCOREP_IO_SEEK_FROM_START** The offset is set to offset bytes.
- **SCOREP_IO_SEEK_FROM_CURRENT** The offset is set to its current location plus offset bytes.
- **SCOREP_IO_SEEK_FROM_END** The offset is set to the size of the file plus offset bytes.
- **SCOREP_IO_SEEK_DATA** The offset is set to the next location in the file greater than or equal to offset containing data.
- **SCOREP_IO_SEEK_HOLE** The offset is set to the next hole in the file greater than or equal to offset.
- **SCOREP_IO_SEEK_INVALID** NON-ABI, for internal use only.

J.2.4.8 enum SCOREP_IoStatusFlag

Additional status flags of an I/O handle. Status flags can be set when an I/O handle is created and changed during its lifetime.

Enumerator

- **SCOREP_IO_STATUS_FLAG_NONE** No flag is set.
- **SCOREP_IO_STATUS_FLAG_CLOSE_ON_EXEC** Enable close-on-exec flag.
- **SCOREP_IO_STATUS_FLAG_APPEND** Open file in append mode which means I/O write operations are automatically performed at the end of the file.
- **SCOREP_IO_STATUS_FLAG_NON_BLOCKING** I/O operations (including the creation) will fail if they would block the issuing process.
- **SCOREP_IO_STATUS_FLAG_ASYNC** Enable signal-driven I/O.
- **SCOREP_IO_STATUS_FLAG_SYNC** Write operations on the file will complete according to the requirements of synchronized I/O file integrity completion (data and metadata)
- **SCOREP_IO_STATUS_FLAG_DATA_SYNC** Write operations on the file will complete according to the requirements of synchronized I/O data integrity completion.
- **SCOREP_IO_STATUS_FLAG_AVOID_CACHING** Instruct I/O operations to reduce caching effects, e.g., direct file I/O.
- **SCOREP_IO_STATUS_FLAG_NO_ACCESS_TIME** Read access to a file won't update its last access time.
- **SCOREP_IO_STATUS_FLAG_DELETE_ON_CLOSE** Delete the file when closing the {IoHandle}.
J.2 Public type definitions and enums used in Score-P

J.2.4.9 enum SCOREP_Ipc_Datatype

specifies an inter process communication data types
Types:

• SCOREP_IPC_BYTE byte
• SCOREP_IPC_CHAR char
• SCOREP_IPC_UNSIGNED_CHAR unsigned char
• SCOREP_IPC_INT int
• SCOREP_IPC_UNSIGNED unsigned int
• SCOREP_IPC_INT32_T int32_t
• SCOREP_IPC_UINT32_T uint32_t
• SCOREP_IPC_INT64_T int64_t
• SCOREP_IPC_UINT64_T uint64_t
• SCOREP_IPC_DOUBLE double

J.2.4.10 enum SCOREP_Ipc_Operation

specifies an inter process communication operation for reduce function
Types:

• SCOREP_IPC_BAND binary and
• SCOREP_IPC_BOR binary or
• SCOREP_IPC_MIN minimum
• SCOREP_IPC_MAX maximum
• SCOREP_IPC_SUM sum

J.2.4.11 enum SCOREP_LocationType

Enumerator

SCOREP_INVALID_LOCATION_TYPE For internal use only.

J.2.4.12 enum SCOREP_LockType

General Lock Type.

Enumerator

SCOREP_LOCK_EXCLUSIVE Exclusive lock. No other lock will be granted.
SCOREP_LOCK_SHARED Shared lock. Other shared locks will be granted, but no exclusive locks.
SCOREP_INVALID_LOCK_TYPE For internal use only.
J.2.4.13  enum SCOREP_MetricOccurrence

Types to be used in defining the occurrence of a sampling set.

Enumerator

  SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS_STRICT  Metric occurs at every region enter and leave.

  SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS  Metric occurs only at a region enter and leave, but does not need to occur at every enter/leave.

  SCOREP_METRIC_OCCURRENCEASYNCHRONOUS  Metric can occur at any place i.e. it is not related to region enter and leaves.

  SCOREP_INVALID_METRIC_OCCURRENCE  For internal use only.

J.2.4.14  enum SCOREP_MetricScope

Types to be used in defining the scope of a scoped sampling set.

Enumerator

  SCOREP_METRIC_SCOPE_LOCATION  Scope of a metric is another location.

  SCOREP_METRIC_SCOPE_LOCATION_GROUP  Scope of a metric is a location group.

  SCOREP_METRIC_SCOPE_SYSTEM_TREE_NODE  Scope of a metric is a system tree node.

  SCOREP_METRIC_SCOPE_GROUP  Scope of a metric is a generic group of locations.

  SCOREP_INVALID_METRIC_SCOPE  For internal use only.

J.2.4.15  enum SCOREP_ParadigmClass

defines classes of paradigms that are monitored Types:

Types to be used in defining a region (SCOREP_Definitions_NewRegion()). In order to track the origin of a region definition, the adapter needs to provide his type.

-  SCOREP_PARADIGM_CLASS_MPP refers to any multi processing based paradigms (e.g., MPI, SHMEM)
-  SCOREP_PARADIGM_CLASS_THREAD_FORK_JOIN refers to any thread parallel fork-join based paradigms (e.g., OpenMP)
-  SCOREP_PARADIGM_CLASS_THREAD_CREATE_WAIT refers to any thread parallel create wait based paradigms (e.g., PThreads)
-  SCOREP_PARADIGM_CLASS_ACCELERATOR refers to any accelerator based paradigms
-  SCOREP_INVALID_PARADIGM_CLASS for internal use only

Enumerator

  SCOREP_INVALID_PARADIGM_CLASS  For internal use only.
J.2 Public type definitions and enums used in Score-P

J.2.4.16 enum SCOREP_ParadigmType

defines paradigms that are be monitored

Types:

  - SCOREP_PARADIGM_MEASUREMENT refers to Score-P internals
  - SCOREP_PARADIGM_USER refers to user instrumentation
  - SCOREP_PARADIGM_COMPILER refers to compiler instrumentation
  - SCOREP_PARADIGM_SAMPLING refers to sampling
  - SCOREP_PARADIGM_MEMORY refers to a memory region (malloc/realloc/...)
  - SCOREP_PARADIGM_LIBWRAP refers to region instrumented by user library wrapping
  - SCOREP_PARADIGM_MPI refers to MPI instrumentation
  - SCOREP_PARADIGM_SHMEM refers to SHMEM instrumentation
  - SCOREP_PARADIGM_OPENMP refers to OpenMP instrumentation
  - SCOREP_PARADIGM_PTHREAD refers to Pthread instrumentation
  - SCOREP_PARADIGM_ORPHAN_THREAD refers to Pthreads that are not instrumented
  - SCOREP_PARADIGM_CUDA refers to CUDA instrumentation
  - SCOREP_PARADIGM_OPENCL refers to OpenCL instrumentation
  - SCOREP_PARADIGM_OPENACC refers to OpenACC instrumentation
  - SCOREP_PARADIGM_IO refers to I/O instrumentation
  - SCOREP_INVALID_PARADIGM_TYPE for internal use only

Enumerator

  SCOREP_INVALID_PARADIGM_TYPE  For internal use only.

J.2.4.17 enum SCOREP_ParameterType

defines types to be used in defining a parameter for parameter based profiling (SCOREP_Definitions_NewParameter(i)).

Enumerator

  SCOREP_PARAMETER_INT64  The parameter is an int64_t
  SCOREP_PARAMETER_UINT64  The parameter is an uint64_t
  SCOREP_PARAMETER_STRING  The parameter is a string
  SCOREP_INVALID_PARAMETER_TYPE  For internal use only.
J.2.4.18 enum SCOREP_RegionType

specifies a Region

Types to be used in defining a region (SCOREP_Definitions_NewRegion()). These types are currently not used inside the measurement system. This may change in future if we are going to implement phases/dynamic regions etc. inside the measurement system as opposed to inside the adapters or as a postprocessing step. The names should be self explanatory; most of them are already used (with a different prefix) in VampiTrace and Scalasca.

Types:

- SCOREP_REGION_UNKNOWN The type of the region is unknown / not defined
- SCOREP_REGION_FUNCTION The region is defined by compiler instrumentation/sampling and defines a code function
- SCOREP_REGION_LOOP The region represents a loop in the source code (used by Opapi)
- SCOREP_REGION_USER The region is a user region, e.g., an Opapi user region
- SCOREP_REGION_CODE The region represents a code region
- SCOREP_REGION_PHASE (Currently not used)
- SCOREP_REGION_DYNAMIC (Currently not used)
- SCOREP_REGION_DYNAMIC_PHASE (Currently not used)
- SCOREP_REGION_DYNAMIC_LOOP (Currently not used)
- SCOREP_REGION_DYNAMIC_FUNCTION (Currently not used)
- SCOREP_REGION_DYNAMIC_LOOP_PHASE (Currently not used)
- SCOREP_REGION_COLL_ONE2ALL Represents a collective communication region with one2all communication
- SCOREP_REGION_COLL_ALL2ONE Represents a collective communication region with all2one communication
- SCOREP_REGION_COLL_ALL2ALL Represents a collective communication region with all2all communication
- SCOREP_REGION_COLL_OTHER Represents a collective communication region that is neither one2all, nor all2one, nor all2all
- SCOREP_REGION_POINT2POINT Represents a point2point communication region
- SCOREP_REGION_PARALLEL Represents an (OpenMP) parallel region
- SCOREP_REGION_SECTIONS Represents an (OpenMP) sections region
- SCOREP_REGION_SECTION Represents an (OpenMP) section region
- SCOREP_REGION_WORKSHARE Represents an (OpenMP) workshare region
- SCOREP_REGION_SINGLE Represents an (OpenMP) single region
- SCOREP_REGION_MASTER Represents an (OpenMP) master region
- SCOREP_REGION_CRITICAL Represents an (OpenMP) critical region
- SCOREP_REGION_ATOMIC Represents an atomic region
- SCOREP_REGION_BARRIER Represents a barrier
J.2 Public type definitions and enums used in Score-P

- SCOREP_REGION_IMPLICIT_BARRIER Represents an implicit barrier (that is implicitly given but not explicitly defined)
- SCOREP_REGION_FLUSH Represents an (OpenMP) flush region
- SCOREP_REGION_CRITICAL_SBLOCK Represents an sblock within a (OpenMP) critical region
- SCOREP_REGION_SINGLE_SBLOCK Represents an sblock within a (OpenMP) single region
- SCOREP_REGION_WRAPPER Represents a wrapper region (e.g., from interpositioning)
- SCOREP_REGION_TASK Represents a (OpenMP) task region, within SCOREP_REGION_TASK_CREATE
- SCOREP_REGION_TASK_UNTIED Represents a (OpenMP) untied task region
- SCOREP_REGION_TASK_WAIT Represents a (OpenMP) taskwait region
- SCOREP_REGION_TASK_CREATE Represents a created (OpenMP) task region
- SCOREP_REGION_ORDERED Represents an (OpenMP) ordered region
- SCOREP_REGION_ORDERED_SBLOCK Represents an sblock within a (OpenMP) ordered region
- SCOREP_REGION_ARTIFICIAL Represents an artificial region
- SCOREP_REGION_RMA Represents an RMA region
- SCOREP_REGION_THREAD_CREATE Represents the creation of a thread
- SCOREP_REGION_THREAD_WAIT Represents the creation of a thread
- SCOREP_REGION_ALLOCATE Represents a region where memory is allocated, e.g., MPI_Alloc_mem
- SCOREP_REGION DEALLOCATE Represents a region where memory is deallocated
- SCOREP_REGION_REALLOCATE Represents a region where memory is reallocated
- SCOREP_REGION_FILE_IO Represents an I/O data operation region
- SCOREP_REGION_FILE_IO_METADATA Represents an I/O metadata operation region (e.g., seek)

Enumerator

SCOREP_INVALID_REGION_TYPE For internal use only.

J.2.4.19 enum SCOREP_RmaAtomicType

specifies a RMA Atomic Operation Type.

Types:

- SCOREP_RMA_ATOMIC_TYPE_ACCUMULATE accumulate
- SCOREP_RMA_ATOMIC_TYPE_INCREMENT increment
- SCOREP_RMA_ATOMIC_TYPE_TEST_AND_SET test and set
- SCOREP_RMA_ATOMIC_TYPE_COMPARE_AND_SWAP compare and swap
- SCOREP_RMA_ATOMIC_TYPE_SWAP swap
- SCOREP_RMA_ATOMIC_TYPE_FETCH_AND_ADD fetch and add
- SCOREP_RMA_ATOMIC_TYPE_FETCH_AND_INCREMENT fetch and increment
- SCOREP_RMA_ATOMIC_TYPE_ADD add
- SCOREP_INVALID_RMA_ATOMIC_TYPE for internal use only
J.2.4.20 enum SCOREP_RmaSyncLevel

specifies a RMA synchronization level, used by RMA records to be passed to SCOREP_Rma∗() functions.

Types:

- SCOREP_RMA_SYNC_LEVEL_NONE No process synchronization or access completion (e.g., ∗ MPI_← Win_post)
- SCOREP_RMA_SYNC_LEVEL_PROCESS Synchronize processes (e.g., MPI_Win_create/free)
- SCOREP_RMA_SYNC_LEVEL_MEMORY Complete memory accesses (e.g., MPI_Win_complete, MPI← Win_wait)
- SCOREP_RMA_SYNC_LEVELS for internal use only

J.2.4.21 enum SCOREP_RmaSyncType

Type of direct RMA synchronization call.

Types:

- SCOREP_RMA_SYNC_TYPE_MEMORY Synchronize memory copy.
- SCOREP_RMA_SYNC_TYPE_NOTIFY_IN Incoming remote notification.
- SCOREP_RMA_SYNC_TYPE_NOTIFY_OUT Outgoing remote notification
- SCOREP_INVALID_RMA_SYNC_TYPE for internal use only

Enumerator

SCOREP_INVALID_RMA_SYNC_TYPE For internal use only.

J.2.4.22 enum SCOREP_SamplingSetClass

Class of locations which recorded a sampling set.

Enumerator

SCOREP_SAMPLING_SET_ABSTRACT The sampling set is more complicated, e.g., refers to a number of locations.
SCOREP_SAMPLING_SET_CPU The sampling set refers to a CPU.
SCOREP_SAMPLING_SET_GPU The sampling set refers to a GPU.

J.2.4.23 enum SCOREP_Substrates_RequirementFlag

Enumerator

SCOREP_SUBSTRATES_REQUIREMENT_CREATE_experiment_DIRECTORY Return true on this feature if your substrate needs the experiment directory. There will be no directory nor configuration log file if no substrate requests it.
SCOREP_SUBSTRATES_REQUIREMENT_PREVENT_async_metrics Return true on this feature if your substrate can't handle asynchronous metrics. No asynchronous metrics will be recorded if at least on substrate prevents it.
SCOREP_SUBSTRATES_REQUIREMENT_PREVENT_PER_HOST_and_ONCE_metrics Return true on this feature if your substrate can't handle PER_HOST or ONCE metrics. No PER_HOST or ONCE metrics will be recorded if at least on substrate prevents it.
SCOREP_SUBSTRATES_NUM_REQUIREMENTS Non-ABI used internally
Appendix K

Data Structure Documentation

K.1  SCOREP_Metric_Plugin_Info Struct Reference

#include <SCOREP_MetricPlugins.h>

Data Fields

- int32_t(* add_counter)(char *metric_name)
- void(* finalize )()
- uint64_t(* get_all_values ) (int32_t id, SCOREP_MetricTimeValuePair **time_value_list)
- uint64_t(* get_current_value ) (int32_t id)
- SCOREP_Metric_Plugin_MetricProperties *(+ get_event_info ) (char *token)
- bool(* get_optional_value ) (int32_t id, uint64_t *value)
- int32_t(* initialize )()
- uint64_t plugin_version
- uint64_t reserved [92]
- SCOREP_MetricPer run_per
- void(* set_clock_function ) (uint64_t(* clock_time) (void))
- SCOREP_MetricSynchronicity sync
- void(* synchronize ) (bool is_responsible, SCOREP_MetricSynchronizationMode sync_mode)

K.1.1  Detailed Description

Information on that defines the plugin. All values that are not explicitly defined should be set to 0

K.1.2  Field Documentation

K.1.2.1  int32_t(* SCOREP_Metric_Plugin_Info::add_counter)(char *metric_name)

Depending on run_per, this function is called per thread, per process, per host, or only on a single thread. Further
it is called for each metric as returned by the calls to get_event_info.

The function sets up the measurement for the requested metric and returns a non-negative unique ID which is from
now on used to refer to this metric.
APPENDIX K. DATA STRUCTURE DOCUMENTATION

Parameters

| metric_name | Name of an individual metric |

Returns

- non-negative ID of requested metric or negative value in case of failure

K.1.2.2 uint64_t SCOREP_Metric_Plugin_Info::delta_t

Set a specific interval for reading metric values. Score-P will request metric values of a plugin, at the earliest, after \( \delta_t \) ticks after it was last read. NOTE: This is only a lower limit for the time between two reads

- there is no upper limit. This setting is used by plugins of synchronicity type \( \text{SCOREP\_METRIC\_SYNC}, \text{SCOREP\_METRIC\_ASYNC\_EVENT}, \text{and SCOREP\_METRIC\_ASYNC} \). In combination with \( \text{SCOREP\_METRIC\_SYNC} \), it can be used for metrics that update at known intervals and therefore reduce the overhead of reading unchanged values. In combination with \( \text{SCOREP\_METRIC\_ASYNC\_EVENT} \) it can be used similarly. This value is ignored for \( \text{SCOREP\_METRIC\_STRICTLY\_SYNC} \) metrics.

K.1.2.3 void(\* SCOREP_Metric_Plugin_Info::finalize)(void)

This function is called once per process to clean up all resources used by the metric plugin.

K.1.2.4 uint64_t(\* SCOREP_Metric_Plugin_Info::get_all_values)(int32_t id, SCOREP_MetricTimeValuePair \*\* time_value_list)

This function provides the recorded value of the selected metric. It must be implemented by asynchronous metric plugins. The timestamps in the returned list should correspond to the clock provided by \( \text{set\_clock\_function} \). Further, all values (timestamps) should lie within the following interval: \( \text{synchronize(SCOREP\_METRIC\_SYNCHRONIZATION\_MODE\_BEGIN)} | \text{SCOREP\_METRIC\_SYNCHRONIZATION\_MODE\_BEGIN\_MPP)} \), \( \text{synchronize(SCOREP\_METRIC\_SYNCHRONIZATION\_MODE\_END)} \). Score-P takes ownership of the \( \text{time\_value\_list} \) memory. Make sure the memory remains valid and is never modified by the plugin. Score-P will release the memory using \( \text{free} \). The pointer must be created directly by \( \text{malloc/calloc} \) etc. directly. Do not use a memory pool / pointer with offset into a larger memory etc.

Parameters

<table>
<thead>
<tr>
<th>id</th>
<th>Metric id (see \text{add_counter}).</th>
</tr>
</thead>
<tbody>
<tr>
<td>out</td>
<td>\text{time_value_list}</td>
</tr>
</tbody>
</table>

See also

\( \text{SCOREP\_MetricSynchronizationMode} \)

Returns

- \( \text{Number of elements within } \text{time\_value\_list} \)

K.1.2.5 uint64_t(\* SCOREP_Metric_Plugin_Info::get_current_value)(int32_t id)

This function shall provide the current value of a metric. It must be implemented by strictly synchronous metric plugins. It is called according to the \( \text{run\_per} \) specification.
K.1 SCOREP_Metric_Plugin_Info Struct Reference

Parameters

| id | Metric id (see add_counter). |

Returns

Current value of requested metric. For metrics of value_type other than UINT64, the data should be reinterpreted to a UINT64 using a union.

K.1.2.6 SCOREP_Metric_Plugin_MetricProperties *( *SCOREP_Metric_Plugin_Info::get_event_info) (char *token)

A user specifies a SCOREP_METRIC_EXAMPLE_PLUGIN=token1,token2,... This function is called once per process and token. Each token can result in any number of metrics (wildcards). The function shall provide the properties of the metrics for this token.

The total list of metrics returned by the calls for all tokens comprises the metrics that will be recorded by the plugin.

Note: The properties-array must contain an additional end entry with name = NULL.

Note: The properties-array memory and all indirect pointers are managed by Score-P now. Make sure the memory remains valid and unmodified. All memory may be released with free by Score-P. Make sure that all provided pointers are created by malloc/strdup/....

Parameters

| token | String that describes one or multiple metrics. |

Returns

properties Meta data about the metrics available for this token.

K.1.2.7 bool( *SCOREP_Metric_Plugin_Info::get_optional_value) (int32_t id, uint64_t *value)

This function provides the current value of a metric if available. It must be implemented by synchronous metric plugins. It is called according to the run_per specification.

Parameters

| id | Metric id (see add_counter). |
| out | value | Current value of requested metric. For metrics of value_type other than UINT64, the data should be reinterpreted to a UINT64 using a union. |

Returns

True if value of requested metric was written, otherwise false.

K.1.2.8 int32_t ( *SCOREP_Metric_Plugin_Info::initialize) (void)

This function is called once per process. It should check that all requirements are met (e.g., are special libraries needed and available, has the user appropriate rights to access implemented metrics). If all requirements are met, data structures used by the plugin can be initialized within this function.

Returns

0 if successful, error code if failure
K.1.2.9 uint32_t SCOREP_Metric_Plugin_Info::plugin_version

Should be set to SCOREP_METRIC_PLUGIN_VERSION (needed for back- and forward compatibility)

K.1.2.10 uint64_t SCOREP_Metric_Plugin_Info::reserved[92]

Reserved space for future features, should be zeroed

K.1.2.11 SCOREP_MetricPer SCOREP_Metric_Plugin_Info::run_per

Defines how many threads should record the metrics of a plugin. For the available options see SCOREP_MetricPer.

K.1.2.12 void(∗SCOREP_Metric_Plugin_Info::set_clock_function)(uint64_t(∗clock_time)(void))

When this callback is implemented, Score-P calls it once to provide a clock function that allows the plugin to read the current time in Score-P ticks. This should be used by asynchronous metric plugins.

Note: This function is called before initialize.

Parameters

| clock_time | Function pointer to Score-P's clock function. |

K.1.2.13 SCOREP_MetricSynchronicity SCOREP_Metric_Plugin_Info::sync

Defines how metrics are measured over time and how they are collected by Score-P. This setting influences when and which callback functions are called by Score-P. For the available options see SCOREP_MetricSynchronicity.

K.1.2.14 void(∗SCOREP_Metric_Plugin_Info::synchronize)(bool is_responsible, SCOREP_MetricSynchronizationMode sync_mode)

This callback is used for stating and stopping the measurement of asynchronous metrics and can also be used for time synchronization purposes. This function is called for all threads in the application, but the threads that handle the metric plugin according to run_per will be marked as is_responsible. The function will be called approximately at the same time for all threads:

- Once the beginning with SCOREP_METRIC_SYNCHRONIZATION_MODE_BEGIN or SCOREP_METRIC_C_SYNCHRONIZATION_MODE_BEGIN_MPP for (non-)MPI programs respectively.
- Once at the end with SCOREP_METRIC_SYNCHRONIZATION_MODE_END For asynchronous metrics, starting and stopping a measurement should be done in this function, not in add_counter.
K.2 SCOREP_Metric_Plugin_MetricProperties Struct Reference

Properties describing a metric. Provided by the get_event_info function.

#include <SCOREP_MetricPlugins.h>

Data Fields

- SCOREP_MetricBase base
- char * description
- int64_t exponent
- SCOREP_MetricMode mode
- char * name
- char * unit
- SCOREP_MetricValueType value_type

K.2.1 Detailed Description

Properties describing a metric. Provided by the get_event_info function.

K.2.2 Field Documentation

K.2.2.1 SCOREP_MetricBase SCOREP_Metric_Plugin_MetricProperties::base

Base of metric: decimal, binary

K.2.2.2 char* SCOREP_Metric_Plugin_MetricProperties::description

Additional information about the metric
K.2.2.3 int64_t SCOREP_Metric_Plugin_MetricProperties::exponent

Exponent to scale metric: e.g., 3 for kilo

K.2.2.4 SCOREP_MetricMode SCOREP_Metric_Plugin_MetricProperties::mode

Metric mode: valid combination of ACCUMULATED|ABSOLUTE|RELATIVE + POINT|START|LAST|NEXT

See also
SCOREP_MetricMode

K.2.2.5 char* SCOREP_Metric_Plugin_MetricProperties::name

Plugin name

K.2.2.6 char* SCOREP_Metric_Plugin_MetricProperties::unit

Unit string of recorded metric

K.2.2.7 SCOREP_MetricValueType SCOREP_Metric_Plugin_MetricProperties::value_type

Value type: signed 64 bit integer, unsigned 64 bit integer, double

The documentation for this struct was generated from the following file:

- SCOREP_MetricPlugins.h

K.3 SCOREP_Metric_Properties Struct Reference

#include <SCOREP_MetricTypes.h>

Data Fields

- SCOREP_MetricBase base
- const char* description
- int64_t exponent
- SCOREP_MetricMode mode
- const char* name
- SCOREP_MetricProfilingType profiling_type
- SCOREP_MetricSourceType source_type
- const char* unit
- SCOREP_MetricValueType value_type
K.3 SCOREP_Metric_Properties Struct Reference

K.3.1 Detailed Description

Properties describing a metric.

K.3.2 Field Documentation

K.3.2.1 SCOREP_MetricBase SCOREP_Metric_Properties::base

Base of metric values (DECIMAL or BINARY).

K.3.2.2 const char* SCOREP_Metric_Properties::description

Long description of the metric.

K.3.2.3 int64_t SCOREP_Metric_Properties::exponent

Exponent to scale metric values (metric_value = value * base^exponent).

K.3.2.4 SCOREP_MetricMode SCOREP_Metric_Properties::mode

Metric mode (valid combination of ACCUMULATED|ABSOLUTE|RELATIVE and POINT|START|LAST|NEXT).

K.3.2.5 const char* SCOREP_Metric_Properties::name

Name of the metric.

K.3.2.6 SCOREP_MetricProfilingType SCOREP_Metric_Properties::profiling_type

Profiling type of the metric.

K.3.2.7 SCOREP_MetricSourceType SCOREP_Metric_Properties::source_type

Type of the metric source (e.g. PAPI).

K.3.2.8 const char* SCOREP_Metric_Properties::unit

Unit of the metric.
K.3.9 SCOREP_MetricValueType SCOREP_Metric_Properties::value_type

Type of the metric value (INT64, UINT64, or DOUBLE).

The documentation for this struct was generated from the following file:

• SCOREP_MetricTypes.h

K.4 SCOREP_MetricTimeValuePair Struct Reference

#include <SCOREP_MetricTypes.h>

Data Fields

• uint64_t timestamp
• uint64_t value

K.4.1 Detailed Description

Pair of Score-P timestamp and corresponding metric value (used by asynchronous metrics).

K.4.2 Field Documentation

K.4.2.1 uint64_t SCOREP_MetricTimeValuePair::timestamp

Timestamp in Score-P time!

K.4.2.2 uint64_t SCOREP_MetricTimeValuePair::value

Current metric value

The documentation for this struct was generated from the following file:

• SCOREP_MetricTypes.h

K.5 SCOREP_SubstratePluginCallbacks Struct Reference

#include <SCOREP_SubstratePlugins.h>
K.5 SCOREP_SubstratePluginCallbacks Struct Reference

Data Fields

- SCOREP_CallingContextHandle:(SCOREP_CallingContextHandle_GetParent)(SCOREP_CallingContextHandle handle)
- SCOREP_RegionHandle:(SCOREP_CallingContextHandle_GetRegion)(SCOREP_CallingContextHandle handle)
- void(SCOREP_ConfigManifestSectionEntry)(FILE *out, const char *fileName, const char *description\n  FormatString,...)
  Create formatted entry in the manifest file consisting out of a name and a description, the latter in printf style and terminated with a period.
- void(SCOREP_ConfigManifestSectionHeader)(FILE *out, const char *section)
  Create formatted header in the manifest file.
- const char *(SCOREP_GetExperimentDirName)(void)
- int(SCOREP_Ipc_Allgather)(const void *sendbuf, void *recvbuf, int count, SCOREP_Ipc_Datatype datatype)
- int(SCOREP_Ipc_Allreduce)(const void *sendbuf, void *recvbuf, int count, SCOREP_Ipc_Datatype datatype, SCOREP_Ipc_Operation operation)
- int(SCOREP_Ipc_BARRIER)(void)
- int(SCOREP_Ipc_Bcast)(void *buf, int count, SCOREP_Ipc_Datatype datatype, int root)
- int(SCOREP_Ipc_Gather)(const void *sendbuf, void *recvbuf, int count, SCOREP_Ipc_Datatype datatype, int root)
- int(SCOREP_Ipc_Gatherv)(const void *sendbuf, int sendcount, void *recvbuf, const int *recvcnts, SCOREP_Ipc_Datatype datatype, int root)
- int(SCOREP_Ipc_GetRank)(void)
- int(SCOREP_IpcGetSize)(void)
- int(SCOREP_Ipc_Send)(const void *buf, int count, SCOREP_Ipc_Datatype datatype, int dest)
- void(SCOREP_Location_GetData)(const struct SCOREP_Location *locationData, size_t plugin_id)
- uint64_t(SCOREP_Location_GetGlobalId)(const struct SCOREP_Location *locationData)
- uint32_t(SCOREP_Location_GetId)(const struct SCOREP_Location *locationData)
- const char *(SCOREP_Location_GetName)(const struct SCOREP_Location *locationData)
- SCOREP_LocationType(SCOREP_LocationGetType)(const struct SCOREP_Location *locationData)
- void(SCOREP_Location_SetData)(const struct SCOREP_Location *locationData, size_t plugin_id, void *data)
- void(SCOREP_Metric_WriteAsynchronousMetrics)(struct SCOREP_Location *location, SCOREP_Substrates_WriteMetricsCb cb)
  Tell Score-P to write the current asynchronous metrics to cb.
- void(SCOREP_Metric_WriteStrictlySynchronousMetrics)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_Substrates_WriteMetricsCb cb)
  Tell Score-P to write the current strictly synchronous metrics to cb.
- void(SCOREP_Metric_WriteSynchronousMetrics)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_Substrates_WriteMetricsCb cb)
  Tell Score-P to write the current synchronous metrics to cb.

- SCOREP_MetricMode(SCOREP_MetricHandle_GetMode)(SCOREP_MetricHandle handle)
- const char *(SCOREP_MetricHandleGetName)(SCOREP_MetricHandle handle)
- SCOREP_MetricProfilingType(SCOREP_MetricHandleGetProfilingType)(SCOREP_MetricHandle handle)
- SCOREP_MetricSourceType(SCOREP_MetricHandleGetSourceType)(SCOREP_MetricHandle handle)
- SCOREP_MetricValueType(SCOREP_MetricHandleGetValueType)(SCOREP_MetricHandle handle)
• SCOREP_ParadigmClass(* SCOREP_ParadigmHandle_GetClass )(SCOREP_ParadigmHandle handle)
• const char *(+ SCOREP_ParadigmHandle_GetName )(SCOREP_ParadigmHandle handle)
• SCOREP_ParadigmType(+ SCOREP_ParadigmHandle_GetType )(SCOREP_ParadigmHandle handle)
• const char *(+ SCOREP_ParameterHandle_GetName )(SCOREP_ParameterHandle handle)
• SCOREP_ParameterType(+ SCOREP_ParameterHandle_GetType )(SCOREP_ParameterHandle handle)
• SCOREP_LineNo(+ SCOREP_RegionHandle_GetBeginLine )(SCOREP_RegionHandle handle)
• const char *(+ SCOREP_RegionHandle_GetCanonicalName )(SCOREP_RegionHandle handle)
• SCOREP_LineNo(+ SCOREP_RegionHandle_GetEndLine )(SCOREP_RegionHandle handle)
• const char *(+ SCOREP_RegionHandle_GetFileName )(SCOREP_RegionHandle handle)
• uint32_t(* SCOREP_RegionHandle_GetId )(SCOREP_RegionHandle handle)
• const char *(+ SCOREP_RegionHandle_GetName )(SCOREP_RegionHandle handle)
• SCOREP_ParadigmType(+ SCOREP_RegionHandle_GetParadigmType )(SCOREP_RegionHandle handle)
• SCOREP_RegionType(+ SCOREP_RegionHandle_GetType )(SCOREP_RegionHandle handle)
• const SCOREP_MetricHandle *(+ SCOREP_SamplingSetHandle_GetMetricHandles )(SCOREP_SamplingSetHandle handle)
• SCOREP_MetricOccurrence(* SCOREP_SamplingSetHandle_GetMetricOccurrence )(SCOREP_SamplingSetHandle handle)
• uint8_t(+ SCOREP_SamplingSetHandle_GetNumberOfMetrics )(SCOREP_SamplingSetHandle handle)
• SCOREP_SamplingSetClass(+ SCOREP_SamplingSetHandle_GetSamplingSetClass )(SCOREP_SamplingSetHandle handle)
• SCOREP_MetricScope(* SCOREP_SamplingSetHandle_GetScope )(SCOREP_SamplingSetHandle handle)
• bool(+ SCOREP_SamplingSetHandle_IsScoped )(SCOREP_SamplingSetHandle handle)
• const char *(+ SCOREP_SourceFileHandle_GetName )(SCOREP_SourceFileHandle handle)
• const char *(+ SCOREP_StringHandle_Get )(SCOREP_StringHandle handle)

K.5.1 Detailed Description

Callbacks that are passed to Substrate plugins via the set_callbacks(...) call. These callbacks can be used by the plugins to access Score-P internal data and functionality.

Developer notice: New functions should be appended at the end of this struct. When extending this list, increase SCOREP_SUBSTRATE_PLUGIN_VERSION

K.5.2 Field Documentation

K.5.2.1 SCOREP_CallingContextHandle( + SCOREP_SubstratePluginCallbacks::SCOREP_CallingContextHandle_GetParent)(SCOREP_CallingContextHandle handle)

Returns the parent of a calling context node.

Parameters

| handle | handle of the calling context node |

Returns

parent handle

K.5.2.2 SCOREP_RegionHandle( + SCOREP_SubstratePluginCallbacks::SCOREP_CallingContextHandle_GetRegion)(SCOREP_CallingContextHandle handle)

Returns the region of a calling context node. (see SCOREP_PublicTypes.h)
K.5 SCOREP_SubstratePluginCallbacks Struct Reference

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>handle</td>
<td>handle of the calling context node</td>
</tr>
</tbody>
</table>

Returns

handle to the region that holds the node

K.5.2.3 const char* (SCOREP_SubstratePluginCallbacks::SCOREP_GetExperimentDirName) (void)

Returns the Score-P experiment directory. This should be used to write debug/performance data and is available at and after init_mpp is called. Data should be placed under SCOREP_GetExperimentDirName/(plugin-name)/. Per location data should be placed under SCOREP_GetExperimentDirName/(plugin-name)/(prefix)(SCOREP_Location_GetGlobalId(location))(suffix). If you want to use the experiment directory, you have to set the SCOREP_SUBSTRATES_REQUIREMENT_EXPERIMENT_DIRECTORY flag in the requirements, see SCOREP_SubstratePluginInfo.get_requirement The name is temporary and the directory might be renamed in the finalization stage.

K.5.2.4 int (SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Allgather) (const void* sendbuf, void* recvbuf, int count, SCOREP_Ipc_Datatype datatype)

Gathers data from every process with an equal amount of sent and received data from each process and distributes it to all processes. Can be called after Plugin receives init_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendbuf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>recvbuf</td>
<td>pointer to buffer there the received data should be stored data is stored in rank order size of the buffer should be big enough for the data of all processes</td>
</tr>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.5 int (SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Allreduce) (const void* sendbuf, void* recvbuf, int count, SCOREP_Ipc_Datatype datatype, SCOREP_Ipc_Operation operation)

Perform a reduce operation (such as sum, max, logical AND, etc.) with the combined data from every process and distributes the result to all processes. Can be called after Plugin receives init_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendbuf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>recvbuf</td>
<td>pointer to buffer there the evaluated data should be stored</td>
</tr>
</tbody>
</table>
APPENDIX K. DATA STRUCTURE DOCUMENTATION

<table>
<thead>
<tr>
<th>count</th>
<th>number of elements in buffer</th>
</tr>
</thead>
<tbody>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>operation</td>
<td>operation that should be performed</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.6 int* SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Barrier (void)

Wait until every process that is part of the MPP paradigm entered the barrier, otherwise return. Can be called after Plugin receives init_mpp() call.

Returns

return zero on success and something else if an error occurred

K.5.2.7 int* SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Bcast (void *buf, int count, SCOREP_Ipc_Datatype datatype, int root)

Send data to every process within the MPP paradigm (if MPP paradigm is used), including self. Can be called after Plugin receives init_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>buf</th>
<th>pointer to the buffer of the data that should be sent</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>root</td>
<td>rank of the source process</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.8 int* SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Gather (const void *sendbuf, void *recvbuf, int count, SCOREP_Ipc_Datatype datatype, int root)

Gathers data from every process within the MPP paradigm (if MPP paradigm is used), root included, with an equal amount of sent for each process.

Can be called after Plugin receives init_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>sendbuf</th>
<th>pointer to the buffer of the data that should be sent</th>
</tr>
</thead>
</table>
recvbuf | pointer to buffer there the received data should be stored data is stored in rank order size of the buffer should be big enough for the data of all processes (SCOREP_IpcGetSize()∗sizeof(type(datatype)))
count | number of elements in buffer
datatype | type of data
root | rank of the process, that should receive all the data

Returns
return zero on success and something else if an error occurred

K.5.2.9 int( * SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Gatherv) (const void * sendbuf, int sendcount, void * recvbuf, const int * recvcnts, SCOREP_Ipc_Datatype datatype, int root)

Gathers data from every process, root included, with varying amount of sent data from each process. Can be called after Plugin receives init_mpp() call.

Parameters
sendbuf | pointer to the buffer of the data that should be sent
sendcount | number of elements in sent buffer
recvbuf | pointer to buffer there the received data should be stored data is stored in rank order size of the buffer should be big enough for the data of all processes
recvcnts | array with the number of elements that should be received from each process length should be the number of process
datatype | type of data
root | rank of the process, that should receive all the data

Returns
return zero on success and something else if an error occurred

K.5.2.10 int( * SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_GetRank) (void)

Get the rank of the process. Can be called after Plugin receives init_mpp() call.

Returns
If MPP paradigm is used get an identifier within the MPP paradigm (e.g., an MPI rank). If no MPP paradigm is used return 0

K.5.2.11 int( * SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_GetSize) (void)

Get the number of processes in this parallel program. Can be called after Plugin receives init_mpp() call.

Returns
If MPP paradigm is used we get the total number of processes that participate in the MPP paradigm, if no MPP paradigm is used return 1

K.5.2.12 int( * SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Recv) (void * buf, int count, SCOREP_Ipc_Datatype datatype, int source)

Receive data from a specific process (blocking) Can be called after Plugin receives init_mpp() call. Should not be called if no MPP paradigm is used.
APPENDIX K. DATA STRUCTURE DOCUMENTATION

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>buf</td>
<td>pointer to buffer where the received data should be stored</td>
</tr>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>source</td>
<td>rank of the source process (must be smaller than \texttt{SCOREP_Ipc_GetSize()} and different from \texttt{SCOREP_Ipc_GetRank()} )</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.13 \texttt{int( + SCOREP\_SubstratePluginCallbacks::SCOREP\_Ipc\_Reduce) (const void *sendbuf, void *recvbuf, int count, SCOREP\_Ipc\_Datatype datatype, SCOREP\_Ipc\_Operation operation, int root)}

Perform a reduce operation (such as sum, max, logical AND, etc.) with the combined data from every process. Can be called after Plugin receives init\_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendbuf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>recvbuf</td>
<td>pointer to buffer where the evaluated data should be stored</td>
</tr>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>operation</td>
<td>operation that should be performed</td>
</tr>
<tr>
<td>root</td>
<td>rank of the process, that should receive the evaluated data</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.14 \texttt{int( + SCOREP\_SubstratePluginCallbacks::SCOREP\_Ipc\_Scatter) (const void *sendbuf, void *recvbuf, int count, SCOREP\_Ipc\_Datatype datatype, int root)}

Send data to each process, root included with an equal amount of received data for each process. Can be called after Plugin receives init\_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendbuf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>recvbuf</td>
<td>pointer to buffer where the received data should be stored</td>
</tr>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>root</td>
<td>rank of the source process</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.15 \texttt{int( + SCOREP\_SubstratePluginCallbacks::SCOREP\_Ipc\_Scatterv) (const void *sendbuf, const int *sendcounts, void *recvbuf, int recvcount, SCOREP\_Ipc\_Datatype datatype, int root)}

Send data in parts to each process, root included with a varying amount of received data for each process. Can be called after Plugin receives init\_mpp() call.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendbuf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>recvbuf</td>
<td>pointer to buffer where the received data should be stored</td>
</tr>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>root</td>
<td>rank of the source process</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred
K.5 SCOREP_SubstratePluginCallbacks Struct Reference

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sendbuf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>sendcounts</td>
<td>array with the number of elements that should be sent to each process length should be the number of process</td>
</tr>
<tr>
<td>recvbuf</td>
<td>pointer to buffer there the received data should be stored</td>
</tr>
<tr>
<td>recvcount</td>
<td>number of elements in received buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>root</td>
<td>rank of the source process</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.16 int(*SCOREP_SubstratePluginCallbacks::SCOREP_Ipc_Send)(const void *buf, int count, SCOREP_Ipc_Datatype datatype, int dest)

Send data do a specific process (blocking) within the MPP paradigm. Can be called after Plugin receives init_mpp() call. Should not be called if no MPP paradigm is used.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>buf</td>
<td>pointer to the buffer of the data that should be sent</td>
</tr>
<tr>
<td>count</td>
<td>number of elements in buffer</td>
</tr>
<tr>
<td>datatype</td>
<td>type of data</td>
</tr>
<tr>
<td>dest</td>
<td>rank of the receiver process (must be smaller than SCOREP_IpcGetSize() and different from SCOREP_IpcGetRank() )</td>
</tr>
</tbody>
</table>

Returns

return zero on success and something else if an error occurred

K.5.2.17 void(*SCOREP_SubstratePluginCallbacks::SCOREP_Location.GetData)(const struct SCOREP_Location *locationData, size_t plugin_id)

Get location private data for a specific location (see SCOREP_Location_SetData) It is save to use it after the location is created (SCOREP_SubstratePluginInfo.create_location) and before the location is deleted (SCOREP_SubstratePluginInfo.delete_location)

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>handle of the location</td>
</tr>
<tr>
<td>plugin_id</td>
<td>the id assigned by assign_id</td>
</tr>
</tbody>
</table>

Returns

the data for this location and this plugin

K.5.2.18 uint64_t(*SCOREP_SubstratePluginCallbacks::SCOREP_Location.GetGlobalId)(const struct SCOREP_Location *locationData)

Get a unique global id of a location This is only to be used after init_mpp() is called.
APPENDIX K. DATA STRUCTURE DOCUMENTATION

Parameters

| location | location given from an event |

Returns

global location id

K.5.2.19  uint32_t(∗SCOREP_SubstratePluginCallbacks::SCOREP_Location_GetId) (const struct SCOREP_Location ∗locationData)

Returns the LOCAL id of the location. (see also SCOREP_Location_GetGlobalId)

Parameters

| location | location given from an event, or a location function from SCOREP_SubstratePluginInfo |

Returns

ID that is unique within the process

K.5.2.20  const char ∗(∗SCOREP_SubstratePluginCallbacks::SCOREP_Location_GetName) (const struct SCOREP_Location ∗locationData)

Get the name of a location

Parameters

| location | handle |

Returns

location name

K.5.2.21  SCOREP_LocationType(∗SCOREP_SubstratePluginCallbacks::SCOREP_Location_GetType) (const struct SCOREP_Location ∗locationData)

Returns the type of the location.

Returns

K.5.2.22  void(∗SCOREP_SubstratePluginCallbacks::SCOREP_Location_SetData) (const struct SCOREP_Location ∗locationData, size_t plugin_id, void ∗data)

Set location private data for a specific location (see SCOREP_Location_GetData) It is safe to use it after the location is created (SCOREP_SubstratePluginInfo.create_location) and before the location is deleted (SCOREP←_SubstratePluginInfo.delete_location)
## K.5 SCOREP_SubstratePluginCallbacks Struct Reference

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>handle of the location</td>
</tr>
<tr>
<td>plugin_id</td>
<td>the id assigned by assign_id</td>
</tr>
<tr>
<td>the</td>
<td>data for this location and this plugin</td>
</tr>
</tbody>
</table>

### K.5.2.23 void(SCOREP_SubstratePluginCallbacks::SCOREP_Metric_WriteAsynchronousMetrics)(struct SCOREP_Location* location, SCOREP_Substrates_WriteMetricsCb cb)

Tell Score-P to write the current asynchronous metrics to cb.

This function shall only be called while processing enters, exits, and samples. The callback might be called multiple times if multiple asynchronous sampling sets are present.

#### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>the location of the runtime event, this is reported back via cb</td>
</tr>
<tr>
<td>cb</td>
<td>a callback that processes the asynchronous metrics</td>
</tr>
</tbody>
</table>

### K.5.2.24 void(SCOREP_SubstratePluginCallbacks::SCOREP_Metric_WriteStrictlySynchronousMetrics)(struct SCOREP_Location* location, uint64_t timestamp, SCOREP_Substrates_WriteMetricsCb cb)

Tell Score-P to write the current strictly synchronous metrics to cb.

This function shall only be called while processing enters, exits, and samples.

#### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>the location of the runtime event, this is reported back via cb</td>
</tr>
<tr>
<td>timestamp</td>
<td>the timestamp of the runtime event, this is reported back via cb</td>
</tr>
<tr>
<td>cb</td>
<td>a callback that processes the strictly synchronous metrics</td>
</tr>
</tbody>
</table>

### K.5.2.25 void(SCOREP_SubstratePluginCallbacks::SCOREP_Metric_WriteSynchronousMetrics)(struct SCOREP_Location* location, uint64_t timestamp, SCOREP_Substrates_WriteMetricsCb cb)

Tell Score-P to write the current synchronous metrics to cb.

This function shall only be called while processing enters, exits, and samples. The callback might be called multiple times if multiple synchronous sampling sets are present.

#### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>the location of the runtime event, this is reported back via cb</td>
</tr>
<tr>
<td>timestamp</td>
<td>the timestamp of the runtime event, this is reported back via cb</td>
</tr>
<tr>
<td>cb</td>
<td>a callback that processes the synchronous metrics</td>
</tr>
</tbody>
</table>

### K.5.2.26 SCOREP_MetricMode(SCOREP_SubstratePluginCallbacks::SCOREP_MetricHandle_GetMode)(SCOREP_MetricHandle handle)

Returns the mode of a metric.
APPENDIX K. DATA STRUCTURE DOCUMENTATION

Parameters

| handle | handle of the local metric definition. |

Returns

mode of a metric.

See also

SCOREP_MetricTypes.h

K.5.2.27 const char∗( ∗SCOREP_SubstratePluginCallbacks::SCOREP_MetricHandle_GetName) (SCOREP_MetricHandle handle)

Returns the name of a metric.

Parameters

| handle | handle of the local metric definition. |

Returns

name of a metric.

K.5.2.28 SCOREP_MetricProfilingType( ∗SCOREP_SubstratePluginCallbacks::SCOREP_MetricHandle_GetProfilingType) (SCOREP_MetricHandle handle)

Returns the profiling type of a metric.

Parameters

| handle | handle of the local metric definition. |

Returns

profiling type of a metric.

See also

SCOREP_MetricTypes.h

K.5.2.29 SCOREP_MetricSourceType( ∗SCOREP_SubstratePluginCallbacks::SCOREP_MetricHandle_GetSourceType) (SCOREP_MetricHandle handle)

Returns the source type of a metric.
K.5 SCOREP_SubstratePluginCallbacks Struct Reference

Parameters

| handle | handle of the local metric definition. |

Returns

source type of a metric.

See also

SCOREP_MetricTypes.h

K.5.2.30  SCOREP_MetricValueType *(SCOREP_SubstratePluginCallbacks::SCOREP_MetricHandle_GetValueType)(SCOREP_MetricHandle handle)

Returns the value type of a metric.

Parameters

| handle | handle of the local metric definition. |

Returns

value type of a metric.

See also

SCOREP_MetricTypes.h

K.5.2.31  SCOREP_ParadigmClass *(SCOREP_SubstratePluginCallbacks::SCOREP_ParadigmHandle_GetClass)(SCOREP_ParadigmHandle handle)

Returns paradigm class

Parameters

| handle | handle of the paradigm |

Returns

class (e.g. SCOREP_PARADIGM_CLASS_MPP for MPI paradigm)

See also

SCOREP_PublicTypes.h

K.5.2.32  const char *(SCOREP_SubstratePluginCallbacks::SCOREP_ParadigmHandle_GetName)(SCOREP_ParadigmHandle handle)

Returns paradigm name
### Parameters

| handle          | handle of the paradigm |

### Returns

name (e.g., "MPI")

#### K.5.2.33

```c
SCOREP_ParadigmType(∗SCOREP_SubstratePluginCallbacks::SCOREP_ParadigmHandle_GetType)(SCOREP_ParadigmHandle handle)
```

Returns paradigm type

| handle          | handle of the paradigm |

### Returns

type (e.g. SCOREP_PARADIGM_MPI for MPI)

#### See also

`SCOREP_PublicTypes.h`

#### K.5.2.34

```c
const char∗(∗SCOREP_SubstratePluginCallbacks::SCOREP_ParameterHandle_GetName)(SCOREP_ParameterHandle handle)
```

Returns the name of a parameter

| handle          | handle of the parameter |

### Returns

name

#### K.5.2.35

```c
SCOREP_ParameterType(∗SCOREP_SubstratePluginCallbacks::SCOREP_ParameterHandle_GetType)(SCOREP_ParameterHandle handle)
```

Returns parameter type

### Parameters
K.5 SCOREP_SubstratePluginCallbacks Struct Reference

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>handle</td>
<td>handle of the parameter</td>
</tr>
</tbody>
</table>

Returns
type of parameter

See also
SCOREP_PublicTypes.h

K.5.2.36 SCOREP_LineNo( *SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetBeginLine) (SCOREP_RegionHandle handle)

Returns begin line of a function within the source file

Parameters
| handle   | handle of the region |

Returns
begin line

K.5.2.37 const char*( *SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetCanonicalName) (SCOREP_RegionHandle handle)

Returns regions mangled canonical name

Parameters
| handle   | of the region |

Returns
mangled region name

K.5.2.38 SCOREP_LineNo( *SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetEndLine) (SCOREP_RegionHandle handle)

Returns end line of a function within the source file

Parameters
| handle   | handle of the region |

Returns
deep line

K.5.2.39 const char*( *SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetFileName) (SCOREP_RegionHandle handle)

Returns file name where region is defined
## Appendix K. Data Structure Documentation

### Parameters

<table>
<thead>
<tr>
<th>handle</th>
<th>handle of the region</th>
</tr>
</thead>
</table>

### Returns

- **file name**

### K.5.2.40

`uint32_t(∗SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetId)(SCOREP_RegionHandle handle)`

Retrieves parameter id

<table>
<thead>
<tr>
<th>handle</th>
<th>handle of the parameter</th>
</tr>
</thead>
</table>

### Returns

- **id of parameter**

### K.5.2.41

`const char ∗(∗SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetName)(SCOREP_RegionHandle handle)`

Retrieves region demangled name

<table>
<thead>
<tr>
<th>handle</th>
<th>handle of the region</th>
</tr>
</thead>
</table>

### Returns

- **demangled region name**

### K.5.2.42

`SCOREP_ParadigmType(∗SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetParadigmType)(SCOREP_RegionHandle handle)`

Retrieves region paradigm

<table>
<thead>
<tr>
<th>handle</th>
<th>handle of the region</th>
</tr>
</thead>
</table>

### Returns

- **paradigm** (e.g. `SCOREP_PARADIGM_MPI` for MPI regions)

See also

- `SCOREP_PublicTypes.h`

### K.5.2.43

`SCOREP_RegionType(∗SCOREP_SubstratePluginCallbacks::SCOREP_RegionHandle_GetType)(SCOREP_RegionHandle handle)`

Retrieves region type
K.5 SCOREP_SubstratePluginCallbacks Struct Reference

Parameters

| handle | handle of the region |

Returns

type (e.g. SCOREP_REGION_USER for user regions)

See also

SCOREP_PublicTypes.h

K.5.2.44 const SCOREP_MetricHandle *( *SCOREP_SubstratePluginCallbacks::SCOREP_SamplingSetHandle_GetMetricHandles)(SCOREP_SamplingSetHandle handle)

Get the metric handles in a sampling set.

Parameters

| handle | the handle of the the existing sampling set |

Returns

a list of associated metrics. get the length of the list with SCOREP_SamplingSet_GetNunmberOfMetrics

K.5.2.45 SCOREP_MetricOccurrence( *SCOREP_SubstratePluginCallbacks::SCOREP_SamplingSetHandle_GetMetricOccurrence)(SCOREP_SamplingSetHandle handle)

Get the metric occurrence of a sampling set.

Parameters

| handle | the handle of the the existing sampling set |

Returns

the occurrence of handle.

K.5.2.46 uint8_t( *SCOREP_SubstratePluginCallbacks::SCOREP_SamplingSetHandle_GetNumberOfMetrics)(SCOREP_SamplingSetHandle handle)

Get the number of metrics in a sampling set.

Parameters
<table>
<thead>
<tr>
<th>Function Description</th>
<th>Parameters</th>
<th>Return Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>handle of the existing sampling set</td>
<td>handle</td>
<td>Returns the number of associated metrics</td>
</tr>
<tr>
<td>SCOREP_SamplingSetClass</td>
<td>handle</td>
<td>Returns the class of the sampling set</td>
</tr>
<tr>
<td>SCOREP_MetricScope</td>
<td>handle</td>
<td>Returns the scope of the sampling set or SCOREP_INVALID_METRIC_SCOPE if sampling set is not scoped</td>
</tr>
<tr>
<td>SCOREP_SamplingSetHandle_IsScoped</td>
<td>handle</td>
<td>Check whether a sampling set is scoped (belongs to a number of locations).</td>
</tr>
<tr>
<td>SCOREP_SourceFileHandle_GetName</td>
<td>handle</td>
<td>Returns name of a source file</td>
</tr>
</tbody>
</table>
K.6 SCOREP_SubstratePluginInfo Struct Reference

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>handle</td>
<td>handle of the source file</td>
</tr>
</tbody>
</table>

Returns

name

K.5.2.51 const char* (SCOREP_SubstratePluginCallbacks::SCOREP_StringHandle_Get) (SCOREP_StringHandle handle)

Resolve string handle

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>handle</td>
<td>handle of string</td>
</tr>
</tbody>
</table>

Returns

string

The documentation for this struct was generated from the following file:

- SCOREP_SubstratePlugins.h

K.6 SCOREP_SubstratePluginInfo Struct Reference

#include <SCOREP_SubstratePlugins.h>

Data Fields

- void(* activate_cpu_location)(const struct SCOREP_Location *location, const struct SCOREP_Location *parentLocation, uint32_t forkSequenceCount)
- void(* assign_id)(size_t pluginId)
- void(* core_task_complete)(const struct SCOREP_Location *location, SCOREP_TaskHandle taskHandle)
- void(* core_task_create)(const struct SCOREP_Location *location, SCOREP_TaskHandle taskHandle)
- void(* create_location)(const struct SCOREP_Location *location, const struct SCOREP_Location *parentLocation)
- void(* deactivate_cpu_location)(const struct SCOREP_Location *location, const struct SCOREP_Location *parentLocation)
- void(* delete_location)(const struct SCOREP_Location *location)
- void(* dump_manifest)(FILE *manifestFile, const char *relativeSourceDir, const char *targetDir)
- void(* finalize)(void)
- uint32_t(* get_event_functions)(SCOREP_Substrates_Mode mode, SCOREP_Substrates_Callback **functions)
- bool(* get_requirement)(SCOREP_Substrates_RequirementFlag flag)
- int(* init)(void)
- void(* init_mpp)(void)
- void(* new_definition_handle)(SCOREP_AnyHandle handle, SCOREP_HandleType type)
- uint32_t plugin_version
- void(* pre_unify)(void)
- void(* set_callbacks)(const SCOREP_SubstratePluginCallbacks *callbacks, size_t size)
- void(* undeclared[SCOREP_SUBSTRATE_PLUGIN_UNDEFINED_MANAGEMENTFUNCTIONS])(void)
- void(* write_data)(void)
K.6.1 Detailed Description

Describes a Substrate plugin. The plugin definition should be done using the SCOREP_SUBSTRATE_PLUGIN_ENTRY macro. The call order of these functions is:

- Called per process

1. (...Score-P initialization part 1, e.g. environment variables...)
2. resolving of SCOREP_SUBSTRATE_PLUGIN_ENTRY, e.g., for SCOREP_SUBSTRATE_PLUGIN(plugin_name)
   check whether there is a library called libscorep_substrate_plugin_name.so that provides a SCOREP_SUBSTRATE_PLUGIN_ENTRY(plugin_name) / holds the function SCOREP_SubstratePlugin_plugin_name_get_info
3. init()
4. set_callbacks()
5. get_event_functions() with mode == SCOREP_SUBSTRATES_RECORDING_ENABLED
6. get_event_functions() with mode == SCOREP_SUBSTRATES_RECORDING_DISABLED
7. From now on at any point in time there can be new definitions created via new_definition_handle(). Definitions are unique in a process context. Thus, two different locations within a process can use the same definitions and there are no handles that are only valid for a specific location. Plugins should care for thread safeness when registering handles in internal data structures.
8. From now on at any point in time there can be calls to get_requirement()
9. (...Score-P initialization part 2...)
10. assign_id()
11. create_location() for the main thread
12. As soon as the MPP paradigm is initialized, init_mpp() is called. If the program does not use MPP paradigms, init_mpp() will also be called
13. (...Score-P initialization part 3...)
14. Called for each location (e.g., thread)
   (a) create_location() (Only new locations, remember that the main thread location is already created earlier!)
   (b) if it is a CPU location: activate_cpu_location()
   (c) Now there is a sequence of these events
      - if it is a CPU location:
        * (optional) calls to deactivate_cpu_location() followed by calls to activate_cpu_location()
        * (optional) core_task_create(), possibly followed by runtime events, followed by core_task_complete()
      - (optional) runtime events
   (d) if it is a CPU location: deactivate_cpu_location()
   (e) delete_location()
15. pre_unify()
16. write_data()
17. finalize()

Not implemented functions MUST point to NULL, e.g., info.assign_id = NULL;

Developer notice: When a new function is necessary, append it after the functions, but before undeclared. For each new function, decrease SCOREP_SUBSTRATE_PLUGIN_UNDEFINED_MANAGEMENT_FUNCTIONS by one. If this happens, increase SCOREP_PLUGIN_VERSION.
K.6.2 Field Documentation

K.6.2.1 void(∗SCOREP_SubstratePluginInfo::activate_cpu_location)(const struct SCOREP_Location∗location, const struct SCOREP_Location∗parentLocation, uint32_t forkSequenceCount)

This function is called whenever a location is activated.

See also
  create_location
  deactivate_cpu_location
  delete_location

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which is activated</th>
</tr>
</thead>
<tbody>
<tr>
<td>parentLocation</td>
<td>parent of location. May be equal locationData.</td>
</tr>
<tr>
<td>forkSequence Count</td>
<td>an increasing number which defines the current fork from parentLocation. At each fork (or omp parallel) this increases by 1.</td>
</tr>
</tbody>
</table>

K.6.2.2 void(∗SCOREP_SubstratePluginInfo::assign_id)(size_t pluginId)

This function assigns a specific ID to the plugin that can be used for accessing thread local storage. However, most of the internal functionality is not available at the time this function is called. Therefore, only the id should be stored for now.

The function might be called multiple times when the Online Access interface is used and re-initializes Score-P.

Parameters

| plugin_id | a specific ID that is assigned to the plugin and can be used to access thread local storages. (see also SCOREP_Location_SetData and SCOREP_Location_GetData) This ID is only valid for the current Score-P run. |

K.6.2.3 void(∗SCOREP_SubstratePluginInfo::core_task_complete)(const struct SCOREP_Location∗location, SCOREP_TaskHandle taskHandle)

Called when a task (e.g., an OpenMP task) is completed The taskHandle is not defined via define_handle and can not be converted to SCOREP_AnyHandle

Parameters

| location | the location that completes the task |
| taskHandle | the completed created task |

K.6.2.4 void(∗SCOREP_SubstratePluginInfo::core_task_create)(const struct SCOREP_Location∗location, SCOREP_TaskHandle taskHandle)

Called when a task (e.g., an OpenMP task) is creates The taskHandle is not defined via define_handle and can not be converted to SCOREP_AnyHandle
APPENDIX K. DATA STRUCTURE DOCUMENTATION

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>location</code></td>
<td>the location that created the task</td>
</tr>
<tr>
<td><code>taskHandle</code></td>
<td>the newly created task</td>
</tr>
</tbody>
</table>

K.6.2.5  void( *SCOREP_SubstratePluginInfo::create_location) (const struct SCOREP_Location *location, const struct SCOREP_Location *parentLocation)

The location callbacks notify the subsystem about the lifetime of a location. For CPU locations:

- **create_location**
  - initial `activate_cpu_location()`
  - (optional) interim `deactivate_cpu_location()`, followed by `activate_cpu_location()`
  - final `deactivate_cpu_location()`

- **delete_location**

For none-CPU locations:

1. **create_location**
2. **delete_location** This function is called whenever a new location is created, e.g. whenever a new OpenMP thread is created.

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>location</code></td>
<td>location which is created</td>
</tr>
<tr>
<td><code>parentLocation</code></td>
<td>location that created this location</td>
</tr>
</tbody>
</table>

K.6.2.6  void( *SCOREP_SubstratePluginInfo::deactivate_cpu_location) (const struct SCOREP_Location *location, const struct SCOREP_Location *parentLocation)

This function is called whenever a location is deactivated

See also
- `create_location`
- `activate_cpu_location`

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>location</code></td>
<td>location which is deactivated</td>
</tr>
<tr>
<td><code>parentLocation</code></td>
<td>parent of location. May be equal locationData.</td>
</tr>
</tbody>
</table>

K.6.2.7  void( *SCOREP_SubstratePluginInfo::delete_location) (const struct SCOREP_Location *location)

This function is called whenever a location is deleted

See also
- `create_location`

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K.6 SCOREP_SubstratePluginInfo Struct Reference

Parameters

| location         | location which is deleted |

K.6.2.8 void(SCOREP_SubstratePluginInfo::dump_manifest)(FILE *manifestFile, const char *relativeSourceDir, const char *targetDir)

This function is called during experiment directory creation and allows to write information about involved files to the Manifest file and initiate file copies if needed.

K.6.2.9 void(SCOREP_SubstratePluginInfo::finalize)(void)

This function is called when the Score-P run finished

K.6.2.10 uint32_t(SCOREP_SubstratePluginInfo::get_event_functions)(SCOREP_Substrates_Mode mode, SCOREP_Substrates_Callback **functions)

Get all functions for events, attributed to their SCOREP_Substrates_EventType

Parameters

<table>
<thead>
<tr>
<th>mode</th>
<th>defines which function set should be returned either for disabled or enabled recording.</th>
</tr>
</thead>
<tbody>
<tr>
<td>functions</td>
<td>a pointer to the functions that are assigned to the types. The returned array MUST hold SCOREP_SUBSTRATES_NUM_EVENTS elements. Not-implemented functions should be set to NULL. The array will NOT be free’d by Score-P.</td>
</tr>
</tbody>
</table>

Returns

MUST return SCOREP_SUBSTRATES_NUM_EVENTS (see SCOREP_SubstrateEvents.h)

K.6.2.11 bool(SCOREP_SubstratePluginInfo::get_requirement)(SCOREP_Substrates_RequirementFlag flag)

Provide Score-P with additional information about requirements, see SCOREP_SubstratesRequirementFlag for details. If this function is not implemented, the default is assumed (0). This can be called at any time by any thread depending on the flag that is queried. Plugins must take care that they return 0 if flag is greater than SCORE_P_SUBSTRATES_NUM_REQUIREMENT Plugins must always return the same value for a given flag during one execution.

Parameters

| flag                  | the requirement flag that is queried |

Returns

the setting for the requirement flag, which highly depends on the type of flag
K.6.2.12 int(* SCOREP_SubstratePluginInfo::init) (void)

This function is called before most internal Score-P data is initialized. The plugin should be initialized here and dependencies should be checked.

Returns

0 if initialization succeeded, otherwise !=0

K.6.2.13 void(* SCOREP_SubstratePluginInfo::init_mpp) (void)

This function is called after MPP paradigms are initialized. If the program does not use MPP paradigms this function is also called. To detect used paradigms check for calls to new_definition_handle with type == SCOREP_HAND←LE_TYPE_PARADIGM.

K.6.2.14 void(* SCOREP_SubstratePluginInfo::new_definition_handle) (SCOREP_AnyHandle handle, SCOREP_HandleType type)

This function will be called whenever a new definition is created. Plugins can filter the processing of definitions according to the given type. Plugins should use the callbacks passed by set_callbacks, SCOREP_PublicHandles.h, and SCOREP_PublicTypes.h to make sense from the handle, (e.g., to get the name of a region).

The handles can be unique for every process and are not necessarily comparable. It might be that this is called within a locked region. Therefore your implementation should be as lightweight as possible.

Parameters

<table>
<thead>
<tr>
<th>handle</th>
<th>a handle to the newly created object</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>the type of the handle</td>
</tr>
</tbody>
</table>

K.6.2.15 uint32_t SCOREP_SubstratePluginInfo::plugin_version

Must be set to SCOREP_SUBSTRATE_PLUGIN_VERSION (needed for back- and forward compatibility)

K.6.2.16 void(* SCOREP_SubstratePluginInfo::pre_unify) (void)

This function is called before the data about different threads and MPI processes is collected and unified, i.e. when definitions are synchronized.

K.6.2.17 void(* SCOREP_SubstratePluginInfo::set_callbacks) (const SCOREP_SubstratePluginCallbacks *callbacks, size_t size)

Provide plugins with pointers to functions that can be used to get meta data about handles.
K.6 SCOREP_SubstratePluginInfo Struct Reference

Parameters

<table>
<thead>
<tr>
<th>callbacks</th>
<th>the provided function callbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>sizeof(SCOREP_SubstrateCallbacks)</td>
<td>The plugin should care that its version of SCOREP_SubstrateCallbacks is smaller or equal size</td>
</tr>
</tbody>
</table>

K.6.2.18  void( + SCOREP_SubstratePluginInfo::undeclared[ SCOREP_SUBSTRATE_PLUGIN_UNDEFINED_MANAGEMENT_FUNCTIONS ])(void)

for future extensions Plugins must set all entries of this list to 0 (e.g., via memset)

When a new function is added in Score-P, SCOREP_SUBSTRATE_PLUGIN_UNDEFINED_MANAGEMENT_FUNCTIONS should be decreased by 1. Score-P should check for an appropriate plugin_version before calling the new function. Otherwise, Score-P is not able to check whether this is set to 0 but might use an invalid function. This can be avoided by enforcing a correct plugin_version.

K.6.2.19  void( + SCOREP_SubstratePluginInfo::write_data) (void)

This function is called after the unification process when traces/profiles are written - right before finalize. This should be used to flush recorded data.

The documentation for this struct was generated from the following file:

- SCOREP_SubstratePlugins.h
Appendix L

File Documentation

L.1 SCOREP_MetricPlugins.h File Reference

Description of the metric plugin header. For information on how to use metric plugins, please refer to 'Metric Plugins'.

#include <stdbool.h>
#include <scorep/SCOREP_MetricTypes.h>

Data Structures

• struct SCOREP_Metric_Plugin_Info
• struct SCOREP_Metric_Plugin_MetricProperties

Properties describing a metric. Provided by the get_event_info function.

Macros

• #define SCOREP_METRIC_PLUGIN_ENTRY(_name)
• #define SCOREP_METRIC_PLUGIN_VERSION 1

L.1.1 Detailed Description

Description of the metric plugin header. For information on how to use metric plugins, please refer to 'Metric Plugins'.

L.1.2 Macro Definition Documentation

L.1.2.1 #define SCOREP_METRIC_PLUGIN_ENTRY( _name )

Value:

EXTERN SCOREP_Metric_Plugin_Info \
SCOREP_MetricPlugin_ ## _name ## _get_info( void )

Macro used for implementation of the 'get_info' function
L.1.2.2 #define SCOREP_METRIC_PLUGIN_VERSION 1

The developer of a metric plugin should provide a README file which explains how to compile, install and use the plugin. In particular, the supported metrics should be described in the README file.

Each metric plugin has to include `SCOREP_MetricPlugins.h` and implement a ‘get_info’ function. Therefore, use the `SCOREP_METRIC_PLUGIN_ENTRY` macro and provide the name of the plugin library as the argument. For example, the metric plugin `libexample_plugin.so` should use `SCOREP_METRIC_PLUGIN_ENTRY(example_plugin).`  

It is encouraged to use the "_plugin" suffix on the name to avoid conflicts with existing libraries, e.g., `libsensors_plugin.so` using the existing `libsensors.so`.

L.1.3 Mandatory functions

See each function for details.

initialize
Check requirements and initialize the plugin.

get_event_info
A user specifies a `SCOREP_METRIC_EXAMPLE_PLUGIN=token1,token2,...` This function provides information about the metric(s) corresponding to this token. The total list of metrics returned for all tokens will then be recorded by the plugin.

add_counter
The function is called for and sets each of the metrics to be recorded by the plugin. It provides a unique ID for each metric.

finalize
Clean up the resources used by the metric plugin.

L.1.4 Mandatory variables

run_per
Defines how many threads should record the metrics of a plugin.

sync
Defines synchronicity type of a metric plugin. A metric plugin can

- provide a metric value for each event (`SCOREP_METRIC_STRICTLY_SYNC`)  
- optionally provide a metric value for each Score-P event (`SCOREP_METRIC_SYNC`)  
- measure metric values independently of Score-P events, but collect them in Score-p during a Score-P event (`SCOREP_METRIC_ASYNC_EVENT`)  
- measure all metric values independently of events and collect them once at the very end of execution (`SCOREP_METRIC_ASYNC`)  

plugin_version
Should be set to `SCOREP_METRIC_PLUGIN_VERSION`

Depending on the plugin's synchronicity type there are some optional functions and variables.
L.1.5 Optional functions

get_current_value

Used by strictly synchronous metric plugins only. Returns value of requested metric.

get_optional_value

Used by synchronous metric plugins, but not by strictly synchronous ones. This function requests current value of a metric, but it is valid that no value is returned (read: no update for this metric available).

get_all_values

Used by asynchronous metric plugins. This function is used to request values of a asynchronous metric. The metric will return an arbitrary number of timestamp-value-pairs.

set_clock_function

Used by asynchronous metric plugins. This function passes a function to the plugin, which can be used by the plugin to get a Score-P valid timestamp.

L.1.6 Optional variables

delta_t

Defines interval between two calls to update metric value. Ignored for strictly synchronous plugins. Current version of Score-P metric plugin interface.

L.2 SCOREP_MetricTypes.h File Reference

Types used by metric service.

#include <stdint.h>

Data Structures

- struct SCOREP_Metric_Properties
- struct SCOREP_MetricTimeValuePair
Enumerations

- enum SCOREP_MetricBase {
  SCOREP_METRIC_BASE_BINARY = 0,
  SCOREP_METRIC_BASE_DECIMAL = 1,
  SCOREP_INVALID_METRIC_BASE
}

- enum SCOREP_MetricMode {
  SCOREP_METRIC_MODE_ACCUMULATED_START = 0,
  SCOREP_METRIC_MODE_ACCUMULATED_POINT = 1,
  SCOREP_METRIC_MODE_ACCUMULATED_LAST = 2,
  SCOREP_METRIC_MODE_ACCUMULATED_NEXT = 3,
  SCOREP_METRIC_MODE_ABSOLUTE_POINT = 4,
  SCOREP_METRIC_MODE_ABSOLUTE_LAST = 5,
  SCOREP_METRIC_MODE_ABSOLUTE_NEXT = 6,
  SCOREP_METRIC_MODE_RELATIVE_POINT = 7,
  SCOREP_METRIC_MODE_RELATIVE_LAST = 8,
  SCOREP_METRIC_MODE_RELATIVE_NEXT = 9
}

- enum SCOREP_MetricPer {
  SCOREP_METRIC_PER_THREAD = 0,
  SCOREP_METRIC_PER_PROCESS,
  SCOREP_METRIC_PER_HOST,
  SCOREP_METRIC_ONCE
}

- enum SCOREP_MetricProfilingType {
  SCOREP_METRIC_PROFILING_TYPE_EXCLUSIVE = 0,
  SCOREP_METRIC_PROFILING_TYPE_INCLUSIVE = 1,
  SCOREP_METRIC_PROFILING_TYPE_SIMPLE = 2,
  SCOREP_METRIC_PROFILING_TYPE_MAX = 3,
  SCOREP_METRIC_PROFILING_TYPE_MIN = 4
}

- enum SCOREP_MetricSourceType {
  SCOREP_METRIC_SOURCE_TYPE_PAPI = 0,
  SCOREP_METRIC_SOURCE_TYPE_RUSAGE = 1,
  SCOREP_METRIC_SOURCE_TYPE_USER = 2,
  SCOREP_METRIC_SOURCE_TYPE_OTHER = 3,
  SCOREP_METRIC_SOURCE_TYPE_TASK = 4,
  SCOREP_METRIC_SOURCE_TYPE_PLUGIN = 5,
  SCOREP_METRIC_SOURCE_TYPE_PERF = 6
}

- enum SCOREP_MetricSynchronicity {
  SCOREP_METRIC_STRICTLY_SYNC = 0,
  SCOREP_METRIC_SYNC,
  SCOREP_METRIC_ASYNC_EVENT,
  SCOREP_METRIC_ASYNC
}

- enum SCOREP_MetricSynchronizationMode {
  SCOREP_METRIC_SYNCHRONIZATION_MODE_BEGIN,
  SCOREP_METRIC_SYNCHRONIZATION_MODE_BEGIN_MPP,
  SCOREP_METRIC_SYNCHRONIZATION_MODE_END
}

- enum SCOREP_MetricValueType {
  SCOREP_METRIC_VALUE_INT64,
  SCOREP_METRIC_VALUE_UINT64,
  SCOREP_METRIC_VALUE_DOUBLE
}

L.2.1 Detailed Description

Types used by metric service.
L.2.2 Enumeration Type Documentation

L.2.2.1 enum SCOREP_MetricBase

Types to be used in defining metric base (SCOREP_Definitions_NewMetric()).

Enumerator

SCOREP_METRIC_BASE_BINARY  Binary base.
SCOREP_METRIC_BASE_DECIMAL  Decimal base.
SCOREP_INVALID_METRIC_BASE For

L.2.2.2 enum SCOREP_MetricMode

Types to be used in defining metric mode (SCOREP_Definitions_NewMetric()). The mode consists of a timing and a value semantic. The possible value semantics are:

- Accumulated for classic counters, e.g. number of floating point operations. While they are stored monotonically increasing in the trace, they are often differentiated as rate over time.
- Absolute values, e.g. temperature. They are stored as is in the trace and typically also displayed as is.
- Relative values.

The possible timing semantics are:

- Start: The value is valid for the interval from the beginning of the trace to the associated timestamp.
- Point: The value is only valid for the point in time given by the timestamp.
- Last: The value is valid for the interval from the previous to the current timestamp.
- Next: The value is valid for the interval from the current to the next timestamp.

Enumerator

SCOREP_METRIC_MODE_ACCUMULATED_START  Accumulated metric, ‘START’ timing.
SCOREP_METRIC_MODE_ACCUMULATED_POINT   Accumulated metric, ‘POINT’ timing.
SCOREP_METRIC_MODE_ACCUMULATED_LAST     Accumulated metric, ‘LAST’ timing.
SCOREP_METRIC_MODE_ACCUMULATED_NEXT     Accumulated metric, ‘NEXT’ timing.
SCOREP_METRIC_MODE_ABSOLUTE_POINT       Absolute metric, ‘POINT’ timing.
SCOREP_METRIC_MODE_ABSOLUTE_LAST        Absolute metric, ‘LAST’ timing.
SCOREP_METRIC_MODE_ABSOLUTE_NEXT        Absolute metric, ‘NEXT’ timing.
SCOREP_METRIC_MODE_RELATIVE_POINT       Relative metric, ‘POINT’ timing.
SCOREP_METRIC_MODE_RELATIVE_LAST        Relative metric, ‘LAST’ timing.
SCOREP_METRIC_MODE_RELATIVE_NEXT        Relative metric, ‘NEXT’ timing.
L.2.2.3 enum SCOREP_MetricPer

Enumeration to define how many threads should record the metrics of a plugin. Used by `SCOREP_Metric_PluginInfo::run_per`.

**Enumerator**

- **SCOREP_METRIC_PER_THREAD**: Metric values are recorded on all threads of all processes.
- **SCOREP_METRIC_PER_PROCESS**: If processes use multiple threads, the metric is recorded on the main thread of each process.
- **SCOREP_METRIC_PER_HOST**: Metric values are recorded on a single thread of each node in a parallel program running on multiple nodes (hosts). Nodes are determined by the platform-specific Score-P node identifier.
- **SCOREP_METRIC_ONCE**: Metric values recorded once within the parallel program. They are recorded on the first node, first process, first thread.

L.2.2.4 enum SCOREP_MetricProfilingType

Types used to define type of profiling.

**Enumerator**

- **SCOREP_METRIC_PROFILING_TYPE_EXCLUSIVE**: Exclusive values (excludes values from subordinated items).
- **SCOREP_METRIC_PROFILING_TYPE_INCLUSIVE**: Inclusive values (sum including values from subordinated items).
- **SCOREP_METRIC_PROFILING_TYPE_SIMPLE**: Single value.
- **SCOREP_METRIC_PROFILING_TYPE_MAX**: Maximum values.
- **SCOREP_METRIC_PROFILING_TYPE_MIN**: Minimum values.

L.2.2.5 enum SCOREP_MetricSourceType

Metric sources to be used in defining a metric member (`SCOREP_Definitions_NewMetric()`).

**Enumerator**

- **SCOREP_METRIC_SOURCE_TYPE_PAPI**: PAPI counter.
- **SCOREP_METRIC_SOURCE_TYPE_RUSAGE**: Resource usage counter.
- **SCOREP_METRIC_SOURCE_TYPE_USER**: User metrics.
- **SCOREP_METRIC_SOURCE_TYPE_OTHER**: Any other metrics.
- **SCOREP_METRIC_SOURCE_TYPE_TASK**: Generated by task profiling.
- **SCOREP_METRIC_SOURCE_TYPE_PLUGIN**: Plugin metrics.
- **SCOREP_METRIC_SOURCE_TYPE_PERF**: Linux perf metrics.
### L.2.2.6 enum SCOREP_MetricSynchronicity

Enumeration to define the synchronicity type of a metric. Used by `SCOREP_Metric_Plugin_Info::sync`.

**Enumerator**

- **SCOREP_METRIC_STRICTLY_SYNC** The current value of each metric is queried by Score-P whenever an enter/leave event occurs via `get_current_value`. The plugin must always be able to provide a current value. The plugin provides the value itself, the timestamp is provided by Score-P. This setting is used for metrics that can be measured with minimal runtime costs and updated very frequently.

- **SCOREP_METRIC_SYNC** The current value of each metric is queried by Score-P whenever an enter/leave event occurs via `get_optional_value`. Providing a value is optional in case no new value is available in the plugin. The plugin provides the value itself, the timestamp is provided by Score-P. This setting is used for metrics that can be measured with minimal runtime costs but do not necessarily always change.

- **SCOREP_METRIC_ASYNC_EVENT** Metric values are measured at arbitrary points in time, but are collected at enter/leave events. Whenever an enter/leave event occurs, Score-P queries the plugin via `get_all_values` for a list of timestamp-value-pairs. This setting can be used for some special cases, `SCOREP_METRIC_ASYNC` is usually easier to implement.

- **SCOREP_METRIC_ASYNC** Metric values are measured at arbitrary points in time. All values are collected once at the very end of the execution. Score-P collects the values and associated timestamps via `get_all_values`. This setting is used for metrics that are recorded on external systems or within a separate thread. While it does require additional memory buffers to store the measurement, it usually reduces the overhead by decoupling the measurement from collection. It is also called post-mortem processing.

### L.2.2.7 enum SCOREP_MetricSynchronizationMode

Possible modes of a synchronization point. Express the time when a synchronization happens.

**Enumerator**

- **SCOREP_METRIC_SYNCHRONIZATION_MODE_BEGIN** Synchronization at the beginning of the measurement
- **SCOREP_METRIC_SYNCHRONIZATION_MODE_BEGIN_MPP** Synchronization at the initialization of a multi-process paradigm (e.g., MPI)
- **SCOREP_METRIC_SYNCHRONIZATION_MODE_END** Synchronization at the end of the measurement

### L.2.2.8 enum SCOREP_MetricValueType

Types to be used in defining type of metric values (`SCOREP_Definitions_NewMetric()`). The interface uses `UINT64` for all values, the other types should be reinterpreted using a union.

**Enumerator**

- **SCOREP_METRIC_VALUE_INT64** 64 bit integer
- **SCOREP_METRIC_VALUE_UINT64** 64 bit unsigned integer
- **SCOREP_METRIC_VALUE_DOUBLE** double precision floating point
L.3 SCOREP_PublicHandles.h File Reference

Description of definition handles. This header defines an enumeration to map SCOREP_AnyHandle to specific handles. It also contains some of these handle definitions.

#include <scorep/SCOREP_PublicTypes.h>

Enumerations

- enum SCOREP_HandleType {
  SCOREP_HANDLE_TYPE_CALLING_CONTEXT,
  SCOREP_HANDLE_TYPE_GROUP,
  SCOREP_HANDLE_TYPE_INTERIM_COMMUNICATOR,
  SCOREP_HANDLE_TYPE_INTERRUPT_GENERATOR,
  SCOREP_HANDLE_TYPE_LOCATION,
  SCOREP_HANDLE_TYPE_LOCATION_GROUP,
  SCOREP_HANDLE_TYPE_LOCATION_PROPERTY,
  SCOREP_HANDLE_TYPE_METRIC,
  SCOREP_HANDLE_TYPE_PARADIGM,
  SCOREP_HANDLE_TYPE_PARAMETER,
  SCOREP_HANDLE_TYPE_REGION,
  SCOREP_HANDLE_TYPE_RMA_WINDOW,
  SCOREP_HANDLE_TYPE_SAMPLING_SET,
  SCOREP_HANDLE_TYPE_SAMPLING_SET_RECORDER,
  SCOREP_HANDLE_TYPE_SOURCE_CODE_LOCATION,
  SCOREP_HANDLE_TYPE_SOURCE_FILE,
  SCOREP_HANDLE_TYPE_STRING,
  SCOREP_HANDLE_TYPE_SYSTEM_TREE_NODE,
  SCOREP_HANDLE_TYPE_SYSTEM_TREE_NODE_PROPERTY,
  SCOREP_HANDLE_TYPE_CARTESIAN_TOPOLOGY,
  SCOREP_HANDLE_TYPE_CARTESIAN_COORDS,
  SCOREP_HANDLE_TYPE_IO_FILE,
  SCOREP_HANDLE_TYPE_IO_FILE_PROPERTY,
  SCOREP_HANDLE_TYPE_IO_HANDLE,
  SCOREP_HANDLE_TYPE_IO_PARADIGM,
  SCOREP_HANDLE_TYPE_NUM_HANDLES
};

L.3.1 Detailed Description

Description of definition handles. This header defines an enumeration to map SCOREP_AnyHandle to specific handles. It also contains some of these handle definitions.

L.3.2 Enumeration Type Documentation

L.3.2.1 enum SCOREP_HandleType

handle types, lists all handle types that are supported.

Enumerator

SCOREP_HANDLE_TYPE_CALLINGCONTEXT The handle type is not defined/invalid
SCOREP_HANDLE_TYPE_GROUP  The handle type is SCOREP_CallingContextHandle
SCOREP_HANDLE_TYPE_INTERIM_COMMUNICATOR  The handle type is SCOREP_GroupHandle
SCOREP_HANDLE_TYPE_INTERRUPT_GENERATOR  The handle type is SCOREP_InterimCommunicatorHandle
SCOREP_HANDLE_TYPE_LOCATION  The handle type is SCOREP INTERRUPT GENERATOR Handle
SCOREP_HANDLE_TYPE_LOCATION_GROUP  The handle type is SCOREP_LocationGroupHandle
SCOREP_HANDLE_TYPE_INTERRUPT_GENERATOR  The handle type is SCOREP_LocationPropertyHandle
SCOREP_HANDLE_TYPE_PARADIGM  The handle type is SCOREP_MetricHandle (defined in SCOREP_PublicTypes.h)
SCOREP_HANDLE_TYPE_PARAMETER  The handle type is SCOREP_ParadigmHandle (defined in SCOREP_PublicTypes.h)
SCOREP_HANDLE_TYPE_REGION  The handle type is SCOREP_ParameterHandle
SCOREP_HANDLE_TYPE_RMA_WINDOW  The handle type is SCOREP_RegionHandle (defined in SCOREP_PublicTypes.h)
SCOREP_HANDLE_TYPE_SAMPLING_SET  The handle type is SCOREP_RmaWindowHandle
SCOREP_HANDLE_TYPE_SAMPLING_SET_RECORDER  The handle type is SCOREP_SamplingSetHandle (defined in SCOREP_PublicTypes.h)
SCOREP_HANDLE_TYPE_SOURCE_CODE_LOCATION  The handle type is SCOREP_SamplingSetRecorderHandle
SCOREP_HANDLE_TYPE_SOURCE_FILE  The handle type is SCOREP_SourceCodeLocationHandle
SCOREP_HANDLE_TYPE_STRING  The handle type is SCOREP_SourceFileHandle (defined in SCOREP_PublicTypes.h)
SCOREP_HANDLE_TYPE_SYSTEM_TREE_NODE  The handle type is SCOREP_StringHandle
SCOREP_HANDLE_TYPE_SYSTEM_TREE_NODE_PROPERTY  The handle type is SCOREP_SystemTreeNodeHandle
SCOREP_HANDLE_TYPE_CARTESIAN_TOPOLOGY  The handle type is SCOREP_CartesianTopologyHandle
SCOREP_HANDLE_TYPE_CARTESIAN_COORDS  The handle type is SCOREP_CartesianCoordsHandle
SCOREP_HANDLE_TYPE_IO_FILE  The handle type is SCOREP_CartesianFileHandle
SCOREP_HANDLE_TYPE_IO_FILE_PROPERTY  The handle type is SCOREP_CartesianFilePropertyHandle
SCOREP_HANDLE_TYPE_IO_HANDLE  The handle type is SCOREP_CartesianHandleHandle
SCOREP_HANDLE_TYPE_IO_PARADIGM  The handle type is SCOREP_IoParadigmHandle Not ABI

L.4 SCOREP_PublicTypes.h File Reference

Defines public definitions that are used internally and externally (e.g., by metric plugins, user functions, substrate plugins)

#include <stdint.h>
Macros

- `#define SCOREP_ALL_TARGET_RANKS -1`
- `#define SCOREP_INVALID_EXIT_STATUS ((int64_t)(~(~(~(uint64_t)0u) «> 1)))`
- `#define SCOREP_INVALID_LINE_NO 0`
- `#define SCOREP_INVALID_METRIC SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_PARADIGM SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_PID 0`
- `#define SCOREP_INVALID_REGION SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_ROOT_RANK -1`
- `#define SCOREP_INVALID_SAMPLING_SET SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_SOURCE_FILE SCOREP_MOVABLE_NULL`
- `#define SCOREP_INVALID_TID 0`
- `#define SCOREP_IO_UNKNOWN_OFFSET UINT64_MAX`
- `#define SCOREP_LOCATION_TYPES`
- `#define SCOREP_MOVABLE_NULL 0`

Typedefs

- `typedef uint32_t SCOREP_Allocator_MovableMemory`
- `typedef SCOREP_Allocator_MovableMemory SCOREP_AnyHandle`
- `typedef int64_t SCOREP_ExitStatus`
- `typedef uint32_t SCOREP_LineNo`
- `typedef SCOREP_AnyHandle SCOREP_MetricHandle`
- `typedef int SCOREP_MpiRank`
- `typedef uint64_t SCOREP_MpiRequestId`
- `typedef SCOREP_AnyHandle SCOREP_ParadigmHandle`
- `typedef SCOREP_AnyHandle SCOREP_RegionHandle`
- `typedef SCOREP_AnyHandle SCOREP_SamplingSetHandle`
- `typedef SCOREP_AnyHandle SCOREP_SourceFileHandle`
- `typedef struct SCOREP_Task* SCOREP_TaskHandle`

Enumerations

- `enum SCOREP_CollectiveType {
  SCOREP_COLLECTIVE_BARRIER,
  SCOREP_COLLECTIVE_BROADCAST,
  SCOREP_COLLECTIVE_GATHER,
  SCOREP_COLLECTIVE_GATHERV,
  SCOREP_COLLECTIVE_SCATTER,
  SCOREP_COLLECTIVE_SCATTERV,
  SCOREP_COLLECTIVE_ALLGATHER,
  SCOREP_COLLECTIVE_ALLGATHERV,
  SCOREP_COLLECTIVE_ALLTOALL,
  SCOREP_COLLECTIVE_ALLTOALLV,
  SCOREP_COLLECTIVE_ALLTOALLW,
  SCOREP_COLLECTIVE_ALLREDUCE,
  SCOREP_COLLECTIVE_REDUCE,
  SCOREP_COLLECTIVE_REDUCE_SCATTER,
  SCOREP_COLLECTIVE_REDUCE_SCATTER_BLOCK,
  SCOREP_COLLECTIVE_SCAN,
  SCOREP_COLLECTIVE_EXSCAN,
  SCOREP_COLLECTIVE_CREATE_HANDLE,
  SCOREP_COLLECTIVE_DESTROY_HANDLE,
  SCOREP_COLLECTIVE_ALLOCATE,
  SCOREP_COLLECTIVE_DEALLOCATE,
  SCOREP_COLLECTIVE_CREATE_HANDLE_AND_ALLOCATE,
  SCOREP_COLLECTIVE_DESTROY_HANDLE_AND_DEALLOCATE
}`
Types to specify the used collectives in calls to SCOREP_MpiCollectiveBegin and SCOREP_RmaCollectiveBegin.

- enum SCOREP_IoAccessMode {
  SCOREP_IO_ACCESS_MODE_NONE = 0,
  SCOREP_IO_ACCESS_MODE_READ_ONLY,
  SCOREP_IO_ACCESS_MODE_WRITE_ONLY,
  SCOREP_IO_ACCESS_MODE_READ_WRITE,
  SCOREP_IO_ACCESS_MODE_EXECUTE_ONLY,
  SCOREP_IO_ACCESS_MODE_SEARCH_ONLY
}

- enum SCOREP_IoCreationFlag {
  SCOREP_IO_CREATION_FLAG_NONE = 0,
  SCOREP_IO_CREATION_FLAG_CREATE = (1 << 0),
  SCOREP_IO_CREATION_FLAG_TRUNCATE = (1 << 1),
  SCOREP_IO_CREATION_FLAG_DIRECTORY = (1 << 2),
  SCOREP_IO_CREATION_FLAG_EXCLUSIVE = (1 << 3),
  SCOREP_IO_CREATION_FLAG_NO_CONTROLLING_TERMINAL = (1 << 4),
  SCOREP_IO_CREATION_FLAG_NO_FOLLOW = (1 << 5),
  SCOREP_IO_CREATION_FLAG_PATH = (1 << 6),
  SCOREP_IO_CREATION_FLAG_TEMPORARY_FILE = (1 << 7),
  SCOREP_IO_CREATION_FLAG_LARGEFILE = (1 << 8),
  SCOREP_IO_CREATION_FLAG_NO_SEEK = (1 << 9),
  SCOREP_IO_CREATION_FLAG_UNIQUE = (1 << 10)
}

- enum SCOREP_IoOperationFlag {
  SCOREP_IO_OPERATION_FLAG_NONE = 0,
  SCOREP_IO_OPERATION_FLAG_BLOCKING = 0,
  SCOREP_IO_OPERATION_FLAG_NON_BLOCKING = (1 << 0),
  SCOREP_IO_OPERATION_FLAG_COLLECTIVE = (1 << 1),
  SCOREP_IO_OPERATION_FLAG_NON_COLLECTIVE = 0
}

- enum SCOREP_IoOperationMode {
  SCOREP_IO_OPERATION_MODE_READ = 0,
  SCOREP_IO_OPERATION_MODE_WRITE,
  SCOREP_IO_OPERATION_MODE_FLUSH
}

- enum SCOREP_IoParadigmType

- enum SCOREP_IoSeekOption {
  SCOREP_IO.Seek_FROM_START = 0,
  SCOREP_IO.Seek_FROM_CURRENT,
  SCOREP_IO.Seek_FROM_END,
  SCOREP_IO.Seek_DATA,
  SCOREP_IO.Seek_HOLE,
  SCOREP_IO.Seek_INVALID
}

- enum SCOREP_IoStatusFlag {
  SCOREP_IO>Status_FLAG_NONE = 0,
  SCOREP_IO_STATUS_FLAG_CLOSE_ON_EXEC = (1 << 0),
  SCOREP_IO_STATUS_FLAG_APPEND = (1 << 1),
  SCOREP_IO_STATUS_FLAG_NON_BLOCKING = (1 << 2),
  SCOREP_IO_STATUS_FLAG_ASYNC = (1 << 3),
  SCOREP_IO_STATUS_FLAG_SYNC = (1 << 4),
  SCOREP_IO_STATUS_FLAG_DATA_SYNC = (1 << 5),
  SCOREP_IO_STATUS_FLAG_AVOID_CACHING = (1 << 6),
  SCOREP_IO_STATUS_FLAG_NO_ACCESS_TIME = (1 << 7),
  SCOREP_IO_STATUS_FLAG_DELETE_ON_CLOSE = (1 << 8)
}

- enum SCOREP_Ipc_Datatype

specifies an inter process communication data types

- enum SCOREP_Ipc_Operation

specifies an inter process communication operation for reduce function

- enum SCOREP_LocationType { , SCOREP_INVALID_LOCATION_TYPE }
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• enum SCOREP_LockType {
  SCOREP_LOCK_EXCLUSIVE,
  SCOREP_LOCK_SHARED,
  SCOREP_INVALID_LOCK_TYPE }

• enum SCOREP_MetricOccurrence {
  SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS_STRICT = 0,
  SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS = 1,
  SCOREP_METRIC_OCCURRENCE_ASYNCHRONOUS = 2,
  SCOREP_INVALID_METRIC_OCCURRENCE }

  Types to be used in defining the occurrence of a sampling set.

• enum SCOREP_MetricScope {
  SCOREP_METRIC_SCOPE_LOCATION = 0,
  SCOREP_METRIC_SCOPE_LOCATION_GROUP = 1,
  SCOREP_METRIC_SCOPE_SYSTEM_TREE_NODE = 2,
  SCOREP_METRIC_SCOPE_GROUP = 3,
  SCOREP_INVALID_METRIC_SCOPE }

  Types to be used in defining the scope of a scoped sampling set.

• enum SCOREP_ParadigmClass { SCOREP_INVALID_PARADIGM_CLASS }

  defines classes of paradigms that are monitored.

• enum SCOREP_ParadigmType { SCOREP_INVALID_PARADIGM_TYPE }

  defines paradigms that are be monitored.

• enum SCOREP_ParameterType {
  SCOREP_PARAMETER_INT64,
  SCOREP_PARAMETER_UINT64,
  SCOREP_PARAMETER_STRING,
  SCOREP_INVALID_PARAMETER_TYPE }

  defines types to be used in defining a parameter for parameter based profiling (SCOREP_Definitions_NewParameter()).

• enum SCOREP_RegionType { , SCOREP_INVALID_REGION_TYPE }

  specifies a Region.

• enum SCOREP_RmaAtomicType

  specifies a RMA Atomic Operation Type.

• enum SCOREP_RmaSyncLevel

  specifies a RMA synchronization level, used by RMA records to be passed to SCOREP_Rma() functions.

• enum SCOREP_RmaSyncType { SCOREP_INVALID_RMA_SYNC_TYPE }

  Type of direct RMA synchronization call.

• enum SCOREP_SamplingSetClass {
  SCOREP_SAMPLING_SET_ABSTRACT,
  SCOREP_SAMPLING_SET_CPU,
  SCOREP_SAMPLING_SET_GPU }

  Class of locations which recorded a sampling set.

• enum SCOREP_Substrates_RequirementFlag {
  SCOREP_SUBSTRATES_REQUIREMENT_CREATE_EXPERIMENT_DIRECTORY,
  SCOREP_SUBSTRATES_REQUIREMENT_PREVENT_ASYNC_METRICS,
  SCOREP_SUBSTRATES_REQUIREMENT_PREVENT_PER_HOST_AND_ONCE_METRICS,
  SCOREP_SUBSTRATES_NUM_REQUIREMENTS }

L.4.1 Detailed Description

Defines public definitions that are used internally and externally (e.g., by metric plugins, user functions, substrate plugins)
Description of the substrate plugin events header. For information on how to use substrate plugins, please refer to section 'Substrate Plugins'.

```c
#include <stdbool.h>
#include <stddef.h>
#include <scorep/SCOREP_MetricTypes.h>
#include <scorep/SCOREP_PublicTypes.h>
#include <scorep/SCOREP_PublicHandles.h>
```

### Typedefs

- typedef void(\*SCOREP_Substrates_Callback) (void)
- typedef void(\*SCOREP_Substrates_CallingContextEnterCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_CallingContextHandle callingContext, SCOREP_CallingContextHandle previousCallingContext, uint32_t unwindDistance, uint64_t metricValues)
- typedef void(\*SCOREP_Substrates_CallingContextExitCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_CallingContextHandle callingContext, SCOREP_CallingContextHandle previousCallingContext, uint32_t unwindDistance, uint64_t metricValues)
- typedef void(\*SCOREP_Substrates_DisableRecordingCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t \*metricValues)
- typedef void(\*SCOREP_Substrates_EnableRecordingCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t \*metricValues)
- typedef void(\*SCOREP_Substrates_EnterRegionCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t \*metricValues)
- typedef void(\*SCOREP_Substrates_EnterRewindRegionCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RegionHandle regionHandle)
- typedef void(\*SCOREP_Substrates_ExitRegionCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t \*metricValues)
- typedef void(\*SCOREP_Substrates_ExitRewindRegionCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, bool doRewind)
- typedef void(\*SCOREP_Substrates_IoChangeStatusFlagsCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoStatusFlag statusFlags)
- typedef void(\*SCOREP_Substrates_IoCreateHandleCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoAccessMode mode, SCOREP_IoCreationFlag creationFlags, SCOREP_IoStatusFlag statusFlags)
- typedef void(\*SCOREP_Substrates_IoDeleteFileCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoParadigmType ioParadigm, SCOREP_IoFileHandle ioFile)
- typedef void(\*SCOREP_Substrates_IoDestroyHandleCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle oldHandle, SCOREP_IoHandleHandle newHandle, SCOREP_IoStatusFlag statusFlags)
- typedef void(\*SCOREP_Substrates_IoOperationBeginCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoOperationMode mode, SCOREP_IoOperationFlag operationFlags, uint64_t bytesRequest, uint64_t matchingId, uint64_t offset)
- typedef void(\*SCOREP_Substrates_IoOperationCancelledCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle handle, uint64_t matchingId)
- typedef void(\*SCOREP_Substrates_IoOperationCompleteCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoOperationMode mode, uint64_t bytesResult, uint64_t matchingId)
- typedef void(\*SCOREP_Substrates_IoOperationIssuedCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_IoHandleHandle handle, uint64_t matchingId)
typedef void(SCOREP_Substrates_IoOperationTestCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, uint64_t matchingId);

typedef void(SCOREP_Substrates_IoSeekCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, int64_t offsetRequest, SCOREP_IoSeekOption whence, uint64_t offsetResult);

typedef void(SCOREP_Substrates_MpiCollectiveBeginCb) (struct SCOREP_Location *location, uint64_t timestamp);

typedef void(SCOREP_Substrates_MpiCollectiveEndCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_InterimCommunicatorHandle communicatorHandle, SCOREP_CollectiveType collectiveType, uint64_t bytesSent, uint64_t bytesReceived);

typedef void(SCOREP_Substrates_MpiIrecvCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiIrecvCompleteCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiIsendCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRank destinationRank, SCOREP_InterimCommunicatorHandle communicatorHandle, uint32_t tag, uint64_t bytesSent, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiIsendCompleteCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiRecvCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRank sourceRank, SCOREP_InterimCommunicatorHandle communicatorHandle, uint32_t tag, uint64_t bytesReceived, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiRecvRequestCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiRequestCancelledCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_MpiRequestTestedCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId);

typedef void(SCOREP_Substrates_RmaAcquireLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, SCOREP_InterimCommunicatorHandle communicatorHandle, uint64_t bytesSent, uint64_t bytesReceived, SCOREP_RmaAtomicType type, SCOREP_RmaWindowHandle windowHandle, uint32_t root, uint64_t lockId, SCOREP_RmaAtomicLockType lockType);

typedef void(SCOREP_Substrates_RmaReleaseLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, SCOREP_RmaAtomicType type, uint64_t bytesSent, uint64_t bytesReceived, uint64_t matchingId);

typedef void(SCOREP_Substrates_RmaAtomicCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, SCOREP_RmaAtomicType type, uint64_t bytesSent, uint64_t bytesReceived, uint64_t matchingId);

typedef void(SCOREP_Substrates_RmaCollectiveBeginCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaCollectiveEndCb)

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typedef void(SCOREP_Substrates_RmaOpTestCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint64_t matchingId);

typedef void(SCOREP_Substrates_RmaReleaseLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId);

typedef void(SCOREP_Substrates_RmaRequestLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId, SCOREP_LockType lockType);

typedef void(SCOREP_Substrates_RmaSyncCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, SCOREP_RmaSyncType syncType);

typedef void(SCOREP_Substrates_RmaTryLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId, SCOREP_LockType lockType);

typedef void(SCOREP_Substrates_RmaWaitChangeCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle);

typedef void(SCOREP_Substrates_RmaWinCreateCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle);

typedef void(SCOREP_Substrates_RmaWinDestroyCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle);

typedef void(SCOREP_Substrates_SampleCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_CallingContextHandle callingContext, SCOREP_CallingContextHandle previousCallingContext, uint32_t unwindDistance, SCOREP_InterruptGeneratorHandle interruptGeneratorHandle, uint64_t *metricValues);

typedef void(SCOREP_Substrates_ThreadForkJoinForkCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, uint32_t nRequestedThreads, uint32_t forkSequenceCount);

typedef void(SCOREP_Substrates_ThreadForkJoinJoinCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm);

typedef void(SCOREP_Substrates_ThreadForkJoinTaskCreateCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t threadId, uint32_t generationNumber);

typedef void(SCOREP_Substrates_ThreadForkJoinTaskSwitchCb) (struct SCOREP_Location *location, uint64_t timestamp, uint64_t *metricValues, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t threadId, uint32_t generationNumber, SCOREP_TaskHandle taskHandle);

typedef void(SCOREP_Substrates_TrackAllocCb) (struct SCOREP_Location *location, uint64_t timestamp, uint64_t addrAllocated, size_t bytesAllocated, void *substrateData[], size_t bytesAllocatedMetric, size_t bytesAllocatedProcess);

typedef void(SCOREP_Substrates_TrackFreeCb) (struct SCOREP_Location *location, uint64_t timestamp, uint64_t addrFreed, size_t bytesFreed, void *substrateData[], size_t bytesAllocatedMetric, size_t bytesAllocatedProcess);

typedef void(SCOREP_Substrates_TrackReallocCb) (struct SCOREP_Location *location, uint64_t timestamp, uint64_t oldAddr, size_t oldBytesAllocated, void *oldSubstrateData[], uint64_t newAddr, size_t newBytesAllocated, void *newSubstrateData[], size_t bytesAllocatedMetric, size_t bytesAllocatedProcess);

typedef void(SCOREP_Substrates_TriggerParameterStringCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParameterHandle parameterHandle, SCOREP_StringHandle string_handle);

typedef void(SCOREP_Substrates_WriteMetricsCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_SamplingSetHandle samplingSet, const uint64_t *metricValues);

typedef void(SCOREP_Substrates_RmaPutCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t bytes, uint64_t matchingId);

typedef void(SCOREP_Substrates_RmaOpCompleteBlockingCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint64_t matchingId);

typedef void(SCOREP_Substrates_ThreadAcquireLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, uint32_t lockId, uint32_t acquisitionOrder);
• typedef void(\* SCOREP_Substrates_TriggerCounterInt64Cb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_SamplingSetHandle counterHandle, int64_t value)

• typedef void(\* SCOREP_Substrates_TriggerParameterInt64Cb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParameterHandle parameterHandle, int64_t value)

• typedef void(\* SCOREP_Substrates_ThreadForkJoinTeamBeginCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint64_t threadId)

• typedef void(\* SCOREP_Substrates_ThreadForkJoinTaskBeginCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t *metricValues, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t threadId, uint32_t generationNumber, SCOREP_TaskHandle taskHandle)

• typedef void(\* SCOREP_Substrates_ThreadCreateWaitCreateCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t createSequenceCount)

• typedef void(\* SCOREP_Substrates_IoAcquireLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_LockType lockType)
Enumerations

- enum SCOREP_Substrates_EventType {
  SCOREP_EVENT_ENABLE_RECORDING = 0,
  SCOREP_EVENT_DISABLE_RECORDING,
  SCOREP_EVENT_ON_TRACING_BUFFER_FLUSH_BEGIN,
  SCOREP_EVENT_ON_TRACING_BUFFER_FLUSH_END,
  SCOREP_EVENT_ENTER_REGION,
  SCOREP_EVENT_EXIT_REGION,
  SCOREP_EVENT_SAMPLE,
  SCOREP_EVENT_CALLING_CONTEXT_ENTER,
  SCOREP_EVENT_CALLING_CONTEXT_EXIT,
  SCOREP_EVENT_ENTER_REWIND_REGION,
  SCOREP_EVENT_EXIT_REWIND_REGION,
  SCOREP_EVENT_MPI_SEND,
  SCOREP_EVENT_MPI_RECV,
  SCOREP_EVENT_MPI_COLLECTIVE_BEGIN,
  SCOREP_EVENT_MPI_COLLECTIVE_END,
  SCOREP_EVENT_MPI_ISEND_COMPLETE,
  SCOREP_EVENT_MPI_IRECV_REQUEST,
  SCOREP_EVENT_MPI_REQUEST_TESTED,
  SCOREP_EVENT_MPI_REQUEST_CANCELLED,
  SCOREP_EVENT_MPI_ISEND,
  SCOREP_EVENT_MPI_IRECV,
  SCOREP_EVENT_RMA_WIN_CREATE,
  SCOREP_EVENT_RMA_WIN_DESTROY,
  SCOREP_EVENT_RMA_COLLECTIVE_BEGIN,
  SCOREP_EVENT_RMA_COLLECTIVE_END,
  SCOREP_EVENT_RMA_TRY_LOCK,
  SCOREP_EVENT_RMA_ACQUIRE_LOCK,
  SCOREP_EVENT_RMA_REQUEST_LOCK,
  SCOREP_EVENT_RMA_RELEASE_LOCK,
  SCOREP_EVENT_RMA_SYNC,
  SCOREP_EVENT_RMA_GROUP_SYNC,
  SCOREP_EVENT_RMA_PUT,
  SCOREP_EVENT_RMA_GET,
  SCOREP_EVENT_RMA_ATOMIC,
  SCOREP_EVENT_RMA_WAIT_CHANGE,
  SCOREP_EVENT_RMA_OP_COMPLETE_BLOCKING,
  SCOREP_EVENT_RMA_OP_COMPLETE_NON_BLOCKING,
  SCOREP_EVENT_RMA_OP_TEST,
  SCOREP_EVENT_RMA_OP_COMPLETE_REMOTE,
  SCOREP_EVENT_THREAD_ACQUIRE_LOCK,
  SCOREP_EVENT_THREAD_RELEASE_LOCK,
  SCOREP_EVENT_TRIGGER_COUNTER_INT64,
  SCOREP_EVENT_TRIGGER_COUNTER_UINT64,
  SCOREP_EVENT_TRIGGER_COUNTER_DOUBLE,
  SCOREP_EVENT_TRIGGER_PARAMETER_INT64,
  SCOREP_EVENT_TRIGGER_PARAMETER_UINT64,
  SCOREP_EVENT_TRIGGER_PARAMETER_STRING,
  SCOREP_EVENT_THREAD_FORK_JOIN_FORK,
  SCOREP_EVENT_THREAD_FORK_JOIN_JOIN,
  SCOREP_EVENT_THREAD_FORK_JOIN_TEAM_BEGIN,
  SCOREP_EVENT_THREAD_FORK_JOIN_TEAM_END,
  SCOREP_EVENT_THREAD_FORK_JOIN_TASK_CREATE,
  SCOREP_EVENT_THREAD_FORK_JOIN_TASK_SWITCH,
  SCOREP_EVENT_THREAD_FORK_JOIN_TASK_BEGIN,
  SCOREP_EVENT_THREAD_FORK_JOIN_TASK_END,
  SCOREP_EVENT_THREAD_CREATE_WAIT_CREATE,
  SCOREP_EVENT_THREAD_CREATE_WAIT_WAIT,
  SCOREP_EVENT_THREAD_CREATE_WAIT_BEGIN,
  SCOREP_EVENT_THREAD_CREATE_WAIT_END,
  SCOREP_EVENT_TRACK_ALLOC,
  SCOREP_EVENT_TRACK_REALLOC,
  SCOREP_EVENT_TRACK_FREE,
}

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SCOREP_SUBSTRATES_NUM_EVENTS }

Substrate events. Lists every event that is going to be used by the substrate mechanism. More details can be found in the respective functions. To maintain API stability, new events need to be added at the end of the enum.

- enum SCOREP_Substrates_Mode {
  SCOREP_SUBSTRATES_RECORDING_ENABLED = 0,
  SCOREP_SUBSTRATES_RECORDING_DISABLED,
  SCOREP_SUBSTRATES_NUM_MODES }

L.5.1 Detailed Description

Description of the substrate plugin events header. For information on how to use substrate plugins, please refer to section 'Substrate Plugins'.

L.5.2 Typedef Documentation

L.5.2.1 typedef void(∗SCOREP_Substrates_Callback) (void)

L.5.3 Advice

Do not include this file directly, but include SCOREP_SubstratePlugins.h Generic void function pointer for substrate functions.

L.5.3.1 typedef void(∗SCOREP_Substrates_CallingContextEnterCb) (struct SCOREP_Location ∗location, uint64_t timestamp,
SCOREP_CallingContextHandle callingContext, SCOREP_CallingContextHandle previousCallingContext, uint32_t
unwindDistance, uint64_t ∗metricValues)
called when entering a region via a instrumentation adapter and Score-P is recording calling contexts (i.e., unwinding is enabled), alternative to SCOREP_Substrates_EnterRegionCb

Parameters

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>callingContext</td>
<td>callstack at timestamp</td>
</tr>
<tr>
<td>previouscallingContext</td>
<td>calling context of the last SCOREP_Substrates_SampleCb</td>
</tr>
<tr>
<td>unwindDistance</td>
<td>number of stack levels changed since the last sample</td>
</tr>
<tr>
<td>metricValues</td>
<td>synchronous metrics at timestamp The synchronous metric belong to the last sampling set definition whose metric occurrence is SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS and whose class is SCOREP_SAMPLING_SET_CPU</td>
</tr>
</tbody>
</table>

L.5.3.2 typedef void(∗SCOREP_Substrates_CallingContextExitCb) (struct SCOREP_Location ∗location, uint64_t timestamp,
SCOREP_CallingContextHandle callingContext, SCOREP_CallingContextHandle previousCallingContext, uint32_t
unwindDistance, uint64_t ∗metricValues)
called when exiting a region via a instrumentation adapter and Score-P is recording calling contexts (i.e., unwinding is enabled). alternative to SCOREP_Substrates_ExitRegionCb

See also

SCOREP_Substrates_CallingContextEnterCb
L.5.3.3 typedef void(∗SCOREP_Substrates_DisableRecordingCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t ∗metricValues)
called when disabling the recording on a process and its sub-locations. This is triggered by user instrumentation and can not be called when in parallel. This event will be generated for SCOREP_Substrates_Mode ENABLED, right before the disabling starts. It is currently not called for SCOREP_Substrates_Mode DISABLED. This might change in the future.
See also
SCOREP_Substrates_EnableRecordingCb

L.5.3.4 typedef void(∗SCOREP_Substrates_EnableRecordingCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t ∗metricValues)
called when enabling the recording on a process and its sub-locations. This is triggered by user instrumentation and can not be called when in parallel. The default mode is enabled. If the default mode is set to disabled by user instrumentation, an enabled event is called before the substrate is finalized. This event will be generated for SCOREP_Substrates_Mode ENABLED, right after the enabling finished. It is currently not called for SCOREP_Substrates_Mode DISABLED. This might change in the future.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event.</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>regionHandle</td>
<td>&quot;MEASUREMENT OFF&quot; region</td>
</tr>
<tr>
<td>metricValues</td>
<td>synchronous metrics at timestamp</td>
</tr>
</tbody>
</table>

L.5.3.5 typedef void(∗SCOREP_Substrates_EnterRegionCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t ∗metricValues)
called when entering a region via some instrumentation adapter. If unwinding is enabled, the event CALLING_CONTEXT_ENTER will be called instead.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>regionHandle</td>
<td>region that is entered</td>
</tr>
<tr>
<td>metricValues</td>
<td>synchronous metrics at timestamp. The synchronous metric belong to the last sampling set definition whose metric occurrence is SCOREP_METRIC_OCCURRENCE_SYNCHRONOUS_STRict and whose class is SCOREP_SAMPLING_SET_CPU</td>
</tr>
</tbody>
</table>

L.5.3.6 typedef void(∗SCOREP_Substrates_EnterRewindRegionCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RegionHandle regionHandle)
called when the user adapter enters a rewind region. The recording of the region and any following region information after this should be discarded when the next SCOREP_Substrates_ExitRewindRegionCb for this regionHandle is called with do_rewind == true
APPENDIX L. FILE DOCUMENTATION

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| regionHandle | region that is entered |

L.5.3.7 typedef void(SCOREP_Substrates_ExitRegionCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t *metricValues)
called when exiting a region via some instrumentation adapter. If unwinding is enabled, the event CALLING_CON←TEXT_EXIT will be called instead.

See also

SCOREP_Substrates_EnterRegionCb

L.5.3.8 typedef void(SCOREP_Substrates_ExitRewindRegionCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, bool doRewind)
called when the user adapter exits a rewind region. The recording of the region and any previous regions since SCOREP_Substrates_ExitRewindRegionCb for this regionHandle should be discarded if do_rewind == true

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| regionHandle | region that is entered |
| doRewind | whether to discard previously recorded data or not |

L.5.3.9 typedef void(SCOREP_Substrates_IoAcquireLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_LockType lockType)
Process I/O lock events (e.g., apply or remove a POSIX advisory lock on an open file)

Parameters

| location | The location where this event happened. |
| timestamp | The time when this event happened. |
| handle | An active I/O handle. |
| lockType | Type of the lock (e.g., exclusive or shared. |

L.5.3.10 typedef void(SCOREP_Substrates_IoChangeStatusFlagsCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoStatusFlag statusFlags)
Records a change to the status flags associated with an active I/O handle.
L.5 SCOREP_SubstrateEvents.h File Reference

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>The location where this event happened.</td>
</tr>
<tr>
<td>timestamp</td>
<td>The time when this event happened.</td>
</tr>
<tr>
<td>handle</td>
<td>An active I/O handle.</td>
</tr>
<tr>
<td>statusFlags</td>
<td>Set flags (e.g., close-on-exec, append, etc.).</td>
</tr>
</tbody>
</table>

L.5.3.11 typedef void(∗SCOREP_Substrates_IoCreateHandleCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoAccessMode mode, SCOREP_IoCreationFlag creationFlags, SCOREP_IoStatusFlag statusFlags)

Records the creation of a new active I/O handle that can be used by subsequent I/O operation events. An IoHandle is active between a pair of consecutive IoCreateHandle and IoDestroyHandle events. All locations of a location group have access to an active IoHandle.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>The location which creates this event.</td>
</tr>
<tr>
<td>timestamp</td>
<td>The timestamp, when the event event occurred.</td>
</tr>
<tr>
<td>handle</td>
<td>A reference to the affected I/O handle which will be activated by this record.</td>
</tr>
<tr>
<td>mode</td>
<td>Determines which I/O operations can be applied to this I/O handle (e.g., read-only, write-only, read-write)</td>
</tr>
<tr>
<td>creationFlags</td>
<td>Requested I/O handle creation flags (e.g., create, exclusive, etc.).</td>
</tr>
<tr>
<td>statusFlags</td>
<td>I/O handle status flags which will be associated with the handle attribute (e.g., append, create, close-on-exec, async, etc.).</td>
</tr>
</tbody>
</table>

L.5.3.12 typedef void(∗SCOREP_Substrates_IoDeleteFileCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_IoParadigmType ioParadigm, SCOREP_IoFileHandle ioFile)

Records the deletion of an I/O file.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>The location where this event happened.</td>
</tr>
<tr>
<td>timestamp</td>
<td>The time when this event happened.</td>
</tr>
<tr>
<td>ioParadigm</td>
<td>The I/O paradigm which induced the deletion.</td>
</tr>
<tr>
<td>ioFile</td>
<td>File identifier.</td>
</tr>
</tbody>
</table>

L.5.3.13 typedef void(∗SCOREP_Substrates_IoDestroyHandleCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_IoHandleHandle handle)

Records the end of an active I/O handle's lifetime.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>The location where this event happened.</td>
</tr>
<tr>
<td>timestamp</td>
<td>The time when this event happened.</td>
</tr>
<tr>
<td>handle</td>
<td>A reference to the affected I/O handle which will be activated by this record.</td>
</tr>
</tbody>
</table>

L.5.3.14 typedef void(∗SCOREP_Substrates_IoDuplicateHandleCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_IoHandleHandle oldHandle, SCOREP_IoHandleHandle newHandle, SCOREP_IoStatusFlag statusFlags)

Records the duplication of an already existing active I/O handle.
Parameters

| location | The location where this event happened. |
| timestamp | The time when this event happened. |
| oldHandle | An active I/O handle. |
| newHandle | A previously inactive I/O handle which will be activated by this record. |
| statusFlags | The status flag for the new I/O handle newHandle. No status flags will be inherited from the I/O handle oldHandle. |

L.5.3.15 typedef void ( *SCOREP_Substrates_IoOperationBeginCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoOperationMode mode, SCOREP_IoOperationFlag operationFlags, uint64_t bytesRequest, uint64_t matchingId, uint64_t offset)

Records the begin of a file operation (read, write, etc.).

Parameters

| location | The location where this event happened. |
| timestamp | The time when this event happened. |
| handle | An active I/O handle. |
| mode | Mode of an I/O handle operation (e.g., read or write). |
| operationFlags | Special semantic of this operation. |
| bytesRequest | Requested bytes to write/read. |
| matchingId | Identifier used to correlate associated event records of an I/O operation. This identifier is unique for the referenced I/O handle. |

L.5.3.16 typedef void ( *SCOREP_Substrates_IoOperationCancelledCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, uint64_t matchingId)

Records the successful cancellation of a non-blocking operation (read, write etc.) on an active I/O handle.

Parameters

| location | The location where this event happened. |
| timestamp | The time when this event happened. |
| handle | An active I/O handle. |
| matchingId | Identifier used to correlate associated event records of an I/O operation. This identifier is unique for the referenced I/O handle. |

L.5.3.17 typedef void ( *SCOREP_Substrates_IoOperationCompleteCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, SCOREP_IoOperationMode mode, uint64_t bytesRead, uint64_t matchingId)

Records the end of a file operation (read, write etc.) on an active I/O handle.

Parameters

| location | The location where this event happened. |
L.5.3.18 typedef void (SCOREP_SubstrateEventsIoOperationIssuedCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, uint64_t matchingId)

Records the successful initiation of a non-blocking operation (read, write etc.) on an active I/O handle.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>The location where this event happened.</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>The time when this event happened.</td>
</tr>
<tr>
<td>handle</td>
<td>An active I/O handle.</td>
</tr>
<tr>
<td>matchingId</td>
<td>Identifier used to correlate associated event records of an I/O operation. This identifier is unique for the referenced I/O handle.</td>
</tr>
</tbody>
</table>

L.5.3.19 typedef void (SCOREP_SubstrateEventsIoOperationTestCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, uint64_t matchingId)

Records an unsuccessful test whether an I/O operation has already finished.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>The location where this event happened.</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>The time when this event happened.</td>
</tr>
<tr>
<td>handle</td>
<td>An active I/O handle.</td>
</tr>
<tr>
<td>matchingId</td>
<td>Identifier used to correlate associated event records of an I/O operation. This identifier is unique for the referenced I/O handle.</td>
</tr>
</tbody>
</table>

L.5.3.20 typedef void (SCOREP_SubstrateEventsIoSeekCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_IoHandleHandle handle, int64_t offsetRequest, SCOREP_IoSeekOption whence, uint64_t offsetResult)

Records a change of the position, e.g., within a file.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>The location where this event happened.</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>The time when this event happened.</td>
</tr>
<tr>
<td>handle</td>
<td>An active I/O handle.</td>
</tr>
<tr>
<td>offsetRequest</td>
<td>Requested offset.</td>
</tr>
<tr>
<td>whence</td>
<td>Position inside the file from where offsetRequest should be applied (e.g., absolute from the start or end, relative to the current position).</td>
</tr>
</tbody>
</table>
offsetResult | Resulting offset, e.g., within the file relative to the beginning of the file.

L.5.3.21  typedef void( + SCOREP_Substrates_MpiCollectiveBeginCb) (struct SCOREP_Location ∗location, uint64_t timestamp)

Called when an MPI collective is recognized by the MPI adapter before it is started. See also the MPI specifications at https://www.mpi-forum.org/docs/ More information on the type is passed with the SCOREP_← Substrates_MpiCollectiveEndCb callback

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |

L.5.3.22  typedef void( + SCOREP_Substrates_MpiCollectiveEndCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_InterimCommunicatorHandle communicatorHandle, SCOREP_MpiRank rootRank, SCOREP_CollectiveType collectiveType, uint64_t bytesSent, uint64_t bytesReceived)

called when an MPI collective is recognized by the MPI adapter after it is finished. see also the MPI specifications at https://www.mpi-forum.org/docs/

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| communicator | communicator handle to which the location rank and the destinationRank belong |
| rootRank | rank that sent the message that is to be received |
| tag | provided MPI tag for this message |
| bytesSent | number of bytes received with this message |
| bytesReceived | number of bytes received with this message |

L.5.3.23  typedef void( + SCOREP_Substrates_MpiIrecvCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_MpiRank sourceRank, SCOREP_InterimCommunicatorHandle communicatorHandle, uint32_t tag, uint64_t bytesReceived, SCOREP_MpiRequestId requestId)

Completes an MpiIrecvRequest see also the MPI specifications at https://www.mpi-forum.org/docs/

Parameters

| location | location which sends an MPI message |
| timestamp | timestamp for this event |
| sourceRank | rank that sent the message |
| communicator | communicator of this location and the source rank |
| tag | MPI tag |
| bytesReceived | number of bytes received with this message |
L.5.3.24 typedef void (*SCOREP_Substrates_MpiIrecvRequestCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId)

Called from MPI adapter when an MPI_Irecv is initialized see also the MPI specifications at https://www.mpi-forum.org/docs/ Previously there should be a SCOREP_Substrates_MpiIrecvCb with the same requestId

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| requestId | request ID of the MPI_Irecv (see MPI standard) |

L.5.3.25 typedef void (*SCOREP_Substrates_MpiIsendCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRank destinationRank, SCOREP_InterimCommunicatorHandle communicatorHandle, uint32_t tag, uint64_t bytesSent, SCOREP_MpiRequestId requestId)

Initialize a non blocking send via MPI see also the MPI specifications at https://www.mpi-forum.org/docs/

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| destinationRank | rank that will receive the message |
| communicatorHandle | communicator of this location and the target rank |
| tag | MPI tag |
| bytesSent | number of sent bytes |
| requestId | request ID of the non blocking communication to be canceled (see MPI standard) |

L.5.3.26 typedef void (*SCOREP_Substrates_MpiIsendCompleteCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId)

Called from MPI adapter when an MPI_Isend is completed see also the MPI specifications at https://www.mpi-forum.org/docs/ Previously there should be a SCOREP_Substrates_MpiIsendCb with the same requestId

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| requestId | request ID of the MPI_Isend (see MPI standard) |

L.5.3.27 typedef void (*SCOREP_Substrates_MpiRecvCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRank sourceRank, SCOREP_InterimCommunicatorHandle communicatorHandle, uint32_t tag, uint64_t bytesReceived)

called when an MPI_Recv is recognized by the MPI adapter see also the MPI specifications at https://www.mpi-forum.org/docs/ There should be a SCOREP_Substrates_MpiSendCb call on the location of the sourceRank.
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## Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>sourceRank</td>
<td>rank that sent the message that is to be received</td>
</tr>
<tr>
<td>communicator</td>
<td>communicator handle to which the location rank and the destinationRank belong</td>
</tr>
<tr>
<td>tag</td>
<td>provided MPI tag for this message</td>
</tr>
<tr>
<td>bytesReceived</td>
<td>number of bytes received with this message</td>
</tr>
</tbody>
</table>

### L.5.3.28 typedef void(SCOREP_Substrates_MpiRequestCancelledCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId)

Called from MPI adapter when a non-blocking communication is cancelled see also the MPI specifications at [https://www.mpi-forum.org/docs/](https://www.mpi-forum.org/docs/) Previously there should be an initialization of the non-blocking communication with the same requestId

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>requestId</td>
<td>request ID of the non blocking communication to be canceled (see MPI standard)</td>
</tr>
</tbody>
</table>

### L.5.3.29 typedef void(SCOREP_Substrates_MpiRequestTestedCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRequestId requestId)

Called from MPI adapter when the status of a non-blocking communication is tested see also the MPI specifications at [https://www.mpi-forum.org/docs/](https://www.mpi-forum.org/docs/) Previously there should be an initialization of the non-blocking communication with the same requestId

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>requestId</td>
<td>request ID of the non blocking communication to be tested (see MPI standard)</td>
</tr>
</tbody>
</table>

### L.5.3.30 typedef void(SCOREP_Substrates_MpiSendCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_MpiRank destinationRank, SCOREP_InterimCommunicatorHandle communicatorHandle, uint32_t tag, uint64_t bytesSent)

called when an MPI_Send is recognized by the MPI adapter see also the MPI specifications at [https://www.mpi-forum.org/docs/](https://www.mpi-forum.org/docs/) There should be a SCOREP_Substrates_MpiRecvCb call on the location of the destinationRank

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
</tbody>
</table>
L.5 SCOREP_SubstrateEvents.h File Reference

<table>
<thead>
<tr>
<th>destinationRank</th>
<th>rank that should receive the message</th>
</tr>
</thead>
<tbody>
<tr>
<td>communicatorHandle</td>
<td>communicator handle to which the location rank and the destinationRank belong</td>
</tr>
<tr>
<td>tag</td>
<td>provided MPI tag for this message</td>
</tr>
<tr>
<td>bytesSent</td>
<td>number of bytes sent with this message</td>
</tr>
</tbody>
</table>

L.5.3.31 typedef void(SCOREP_Substrates_OnTracingBufferFlushBeginCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t *metricValues)
called when flushing the tracing buffer of a location

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| regionHandle | "TRACE BUFFER FLUSH" region |
| metricValues | synchronous metrics at timestamp |

L.5.3.32 typedef void(SCOREP_Substrates_OnTracingBufferFlushEndCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t *metricValues)
called after flushing the tracing buffer of a location,

See also

SCOREP_Substrates_OnTracingBufferFlushBeginCb

L.5.3.33 typedef void(SCOREP_Substrates_ProgramBeginCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_StringHandle programName, uint32_t numberOfProgramArgs, SCOREP_StringHandle *programArguments, SCOREP_RegionHandle programRegionHandle, uint64_t processId, uint64_t threadId)
called on each process when the application starts

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| programName | name of the application |
| numberOfProgramArgs | number of arguments of the application |
| programArguments | the list of arguments |
| programRegionHandle | the program region that is entered |
| processId | process identifier of the operating system If processId is not set, it has the value SCOREP_INVALID_PID. |
typedef void (*SCOREP_Substrates_ProgramEndCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ExitStatus exitStatus, SCOREP_RegionHandle programRegionHandle)

called on each process when the application ends

Parameters

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>exitStatus</td>
<td>exit status of the application</td>
</tr>
<tr>
<td>programRegionHandle</td>
<td>the program region that is entered</td>
</tr>
</tbody>
</table>

typedef void (*SCOREP_Substrates_RmaAcquireLockCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId, SCOREP_LockType lockType)

Marks the time that a lock is granted. This is the typical situation. It has to be followed by a matching SCOREP_Substrates_RmaRequestLockCb record later on.

Parameters

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>windowHandle</td>
<td>Memory window.</td>
</tr>
<tr>
<td>remote</td>
<td>Rank of target in context of window.</td>
</tr>
<tr>
<td>lockId</td>
<td>Lock id in context of window.</td>
</tr>
<tr>
<td>lockType</td>
<td>Type of lock (shared vs. exclusive).</td>
</tr>
</tbody>
</table>

typedef void (*SCOREP_Substrates_RmaAtomicCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, SCOREP_RmaAtomicType type, uint64_t bytesSent, uint64_t bytesReceived, uint64_t matchingId)

The atomic RMA operations are similar to the get and put operations. As an additional field they provide the type of operation. Depending on the type, data may be received, sent, or both, therefore, the sizes are specified separately. Matching the local and optionally remote completion works the same way as for get and put operations.

Parameters

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>windowHandle</td>
<td>Window.</td>
</tr>
<tr>
<td>remote</td>
<td>Rank of target in context of window.</td>
</tr>
<tr>
<td>type</td>
<td>Type of atomic operation (see SCOREP_RmaAtomicType).</td>
</tr>
<tr>
<td>bytesSent</td>
<td>Number of bytes transferred to remote target.</td>
</tr>
</tbody>
</table>
begin a collective operation on an MPI remote memory access window see also the MPI specifications at https://www.mpi-forum.org/docs/ More information is passed with the next call SCOREP_SubstrateEvents_RmaCollectiveEndCb

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| syncLevel | synchronization level |

end a collective operation on an MPI remote memory access window see also the MPI specifications at https://www.mpi-forum.org/docs/

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| collectiveOp | type of the collective operation |
| syncLevel | synchronization level |
| windowHandle | the previously defined and created window handle |
| root | Root process/rank if there is one |
| bytesSent | number of bytes sent |
| bytesReceived | number of bytes received |

This record marks the synchronization of a sub-group of the locations associated with the given memory window. It needs to be recorded for all participating locations.

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| syncLevel | Synchronization level. |
| windowHandle | Memory window. |
L.5.3.40 typedef void(SCOREP_Substrates_RmaOpCompleteBlockingCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint64_t matchingId)

The completion records mark the end of RMA operations. Local completion for every RMA operation (get, put, or atomic operation) always has to be marked with either SCOREP_Substrates_RmaOpCompleteBlockingCb or SCOREP_Substrates_RmaOpCompleteNonBlockingCb using the same matching number as the RMA operation record. An RMA operation is blocking when the operation completes locally before leaving the call, for non-blocking operations local completion has to be ensured by a subsequent call.

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| windowHandle | Memory window. |
| matchingId | Matching number. |

L.5.3.41 typedef void(SCOREP_Substrates_RmaOpCompleteRemoteCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint64_t matchingId)

An optional remote completion point can be specified with SCOREP_Substrates_RmaOpCompleteRemoteCb. It is recorded on the same location as the RMA operation itself. Again, multiple RMA operations may map to the same SCOREP_Substrates_RmaOpCompleteRemoteCb. The target locations are not explicitly specified but implicitly as all those that were referenced in matching RMA operations.

Parameters

| location | location which creates this event |
| timestamp | timestamp for this event |
| windowHandle | Memory window. |
| matchingId | Matching number. |

L.5.3.42 typedef void(SCOREP_Substrates_RmaPutCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t bytes, uint64_t matchingId)

The get and put operations access remote memory addresses. The corresponding get and put records mark when they are issued. The actual start and the completion may happen later.
Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>windowHandle</td>
<td>Memory window.</td>
</tr>
<tr>
<td>remote</td>
<td>Rank of target in context of window.</td>
</tr>
<tr>
<td>bytes</td>
<td>Number of bytes transferred.</td>
</tr>
<tr>
<td>matchingId</td>
<td>Matching number.</td>
</tr>
</tbody>
</table>

Note

The matching number allows to reference the point of completion of the operation. It will reappear in a completion record on the same location.

L.5.3.44 typedef void(∗SCOREP_Substrates_RmaReleaseLockCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId)

Marks the time the lock is freed. It contains all fields that are necessary to match it to either an earlier SCOREP_Substrates_RmaAcquireLockCb or SCOREP_Substrates_RmaRequestLockCb event and is required to follow either of the two.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>windowHandle</td>
<td>Memory window.</td>
</tr>
<tr>
<td>remote</td>
<td>Rank of target in context of window.</td>
</tr>
<tr>
<td>lockId</td>
<td>Lock id in context of window.</td>
</tr>
</tbody>
</table>

L.5.3.45 typedef void(∗SCOREP_Substrates_RmaRequestLockCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId, SCOREP_LockType lockType)

This record marks the time that a request for a lock is issued where the RMA model ensures that the lock is granted eventually without further notification. As of now this is specific for MPI. In this case, the SCOREP_RmaAcquireLock event is not present.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>win</td>
<td>Memory window.</td>
</tr>
<tr>
<td>remote</td>
<td>Rank of target in context of window.</td>
</tr>
<tr>
<td>lockId</td>
<td>Lock id in context of window.</td>
</tr>
<tr>
<td>lockType</td>
<td>Type of lock (shared vs. exclusive).</td>
</tr>
</tbody>
</table>

L.5.3.46 typedef void(∗SCOREP_Substrates_RmaSyncCb) (struct SCOREP_Location ∗location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, SCOREP_RmaSyncType syncType)

This record marks a simple pairwise synchronization.
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L.5.3.47 typedef void (*SCOREP_Substrates_RmaTryLockCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle, uint32_t remote, uint64_t lockId, SCOREP_LockType lockType)

An attempt to acquire a lock which turns out negative can be marked with SCOREP_Substrates_RmaTryLockCb. In this case, no release record may follow. With this a series of unsuccessful locking attempts can be identified. If an lock attempt is successful, it is marked with SCOREP_Substrates_RmaAcquireLockCb right away instead of a pair of SCOREP_Substrates_RmaTryLockCb and @SCOREP_Substrates_RmaAcquireLockCb. see also the MPI specifications at https://www.mpi-forum.org/docs/

L.5.3.48 typedef void (*SCOREP_Substrates_RmaWaitChangeCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle)

The SCOREP_EVENT_RMA_WAIT_CHANGE event marks a synchronization point that blocks until a remote operation modifies a given memory field. This event marks the beginning of the waiting period. The memory field in question is part of the specified window.

L.5.3.49 typedef void (*SCOREP_Substrates_RmaWinCreateCb)(struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle)

create a remote memory access window see also the MPI specifications at https://www.mpi-forum.org/docs/
typedef void (\*SCOREP_Substrates_RmaWinDestroyCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_RmaWindowHandle windowHandle)

destroy a remote memory access window see also the MPI specifications at https://www.mpi-forum.org/docs/

L.5.3.51 typedef void (\*SCOREP_Substrates_SampleCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_CallingContextHandle callingContext, SCOREP_CallingContextHandle previousCallingContext, uint32_t unwindDistance, SCOREP_InterruptGeneratorHandle interruptGeneratorHandle, uint64_t \*metricValues)

called when a sampling adapter interrupts the workload and records a sample. Called from a signal handler, so used functions should be async-signal safe. If a function is not signal safe, but is interrupted by a signal (i.e., a sample event) and used within the signal context, its behavior is unpredictable.

L.5.3.52 typedef void (\*SCOREP_Substrates_ThreadAcquireLockCb) (struct SCOREP_Location \*location, uint64_t timestamp, SCOREP_ParadigmType paradigm, uint32_t lockId, uint32_t acquisitionOrder)

Process a thread acquire/release lock event in the measurement system.
### APPENDIX L. FILE DOCUMENTATION

<table>
<thead>
<tr>
<th><code>timestamp</code></th>
<th>timestamp for this event</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>paradigm</code></td>
<td>the underlying parallelization paradigm of the lock</td>
</tr>
<tr>
<td><code>lockId</code></td>
<td>A unique ID to identify the lock, maintained by the caller.</td>
</tr>
<tr>
<td><code>acquisitionOrder</code></td>
<td>A monotonically increasing ID to determine the order of lock acquisitions. Same for corresponding acquire-release events.</td>
</tr>
</tbody>
</table>

L.5.3.53  
```c
typedef void( + SCOREP_Substrates_ThreadCreateWaitCreateCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t createSequenceCount)
```

process a thread event for a create/wait thread model instrumentation adapter e.g., pthreads

**Parameters**

| `location` | location which creates this event |
| `timestamp` | timestamp for this event |
| `paradigm` | One of the predefined threading models. |
| `threadTeam` | previously defined thread team |
| `createSequenceCount` | a process unique increasing number that is increased at every SCOREP_Substrates_ThreadCreateWaitCreateCb and SCOREP_Substrates_ThreadForkJoinForkCb |

L.5.3.54  
```c
typedef void( + SCOREP_Substrates_ThreadForkJoinForkCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, uint32_t nRequestedThreads, uint32_t forkSequenceCount)
```

called from threading instrumentation adapters before a thread team is forked, e.g., before an OpenMP parallel region

**Parameters**

| `location` | location which creates this event |
| `timestamp` | timestamp for this event |
| `paradigm` | threading paradigm |
| `nRequestedThreads` | number of threads to be forked. Note that this does not necessarily represent actual threads but threads can also be reused, e.g., in OpenMP runtimes. |
| `forkSequenceCount` | an increasing number, unique for each process that allows to identify a parallel region |

L.5.3.55  
```c
typedef void( + SCOREP_Substrates_ThreadForkJoinJoinCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm)
```

called from threading instrumentation after a thread team is joined, e.g., after an OpenMP parallel region

**Parameters**

| `location` | location which creates this event |
L.5 SCOREP_SubstrateEvents.h File Reference

<table>
<thead>
<tr>
<th>timestamp</th>
<th>timestamp for this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>paradigm</td>
<td>threading paradigm</td>
</tr>
</tbody>
</table>

L.5.3.56 typedef void(SCOREP_SubstrateEvents::ThreadForkJoinTaskBeginCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_RegionHandle regionHandle, uint64_t *metricValues, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t threadId, uint32_t generationNumber, SCOREP_TaskHandle taskHandle)

Process a task begin/end event

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>metricValues</td>
<td>synchronous metrics</td>
</tr>
<tr>
<td>paradigm</td>
<td>One of the predefined threading models.</td>
</tr>
<tr>
<td>regionHandle</td>
<td>Region handle of the task region.</td>
</tr>
<tr>
<td>threadTeam</td>
<td>previously defined thread team</td>
</tr>
<tr>
<td>threadId</td>
<td>Id of the this thread within the team of threads that constitute the parallel region.</td>
</tr>
<tr>
<td>generation←Number</td>
<td>The sequence number for this task. Each task created gets a thread private generation number attached. Combined with the threadId, this constitutes a unique task ID inside the parallel region.</td>
</tr>
<tr>
<td>taskHandle</td>
<td>A handle to the executed task</td>
</tr>
</tbody>
</table>

L.5.3.57 typedef void(SCOREP_SubstrateEvents::ThreadForkJoinTaskCreateCb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t threadId, uint32_t generationNumber)

Process a task create event in the measurement system.

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>paradigm</td>
<td>One of the predefined threading models.</td>
</tr>
<tr>
<td>threadTeam</td>
<td>previously defined thread team</td>
</tr>
<tr>
<td>threadId</td>
<td>Id of the this thread within the team of threads that constitute the parallel region.</td>
</tr>
<tr>
<td>generation←Number</td>
<td>The sequence number for this task. Each task created gets a thread private generation number number attached. Combined with the threadId, this constitutes a unique task ID inside the parallel region.</td>
</tr>
</tbody>
</table>

L.5.3.58 typedef void(SCOREP_SubstrateEvents::ThreadForkJoinTaskSwitchCb) (struct SCOREP_Location *location, uint64_t timestamp, uint64_t *metricValues, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint32_t threadId, uint32_t generationNumber, SCOREP_TaskHandle taskHandle)

Process a task switch event
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Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>metricValues</td>
<td>synchronous metrics</td>
</tr>
<tr>
<td>paradigm</td>
<td>One of the predefined threading models.</td>
</tr>
<tr>
<td>threadTeam</td>
<td>previously defined thread team</td>
</tr>
<tr>
<td>threadId</td>
<td>Id of the thread within the team of threads that constitute the parallel region.</td>
</tr>
<tr>
<td>generation</td>
<td>The sequence number for this task. Each task gets a thread private generation number of the creating thread attached. Combined with threadId, this constitutes a unique task ID inside the parallel region.</td>
</tr>
<tr>
<td>taskHandle</td>
<td>A handle to the resumed task.</td>
</tr>
</tbody>
</table>

L.5.3.59 typedef void(SCOREP_Substrates_ThreadForkJoinTeamBeginCb)(struct SCOREP_Location* location, uint64_t timestamp, SCOREP_ParadigmType paradigm, SCOREP_InterimCommunicatorHandle threadTeam, uint64_t threadId)
called from threading instrumentation after a thread team is created/before it is joined.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>paradigm</td>
<td>threading paradigm</td>
</tr>
<tr>
<td>threadTeam</td>
<td>previously defined thread team</td>
</tr>
<tr>
<td>threadId</td>
<td>thread identifier of the operating system. If threadId is not set, it has the value SCOREP_INVALID_TID.</td>
</tr>
</tbody>
</table>

L.5.3.60 typedef void(SCOREP_Substrates_TrackAllocCb)(struct SCOREP_Location* location, uint64_t timestamp, uint64_t addrAllocated, size_t bytesAllocated, void* substrateData[], size_t bytesAllocatedMetric, size_t bytesAllocatedProcess)
Event for allocating memory using malloc/calloc.

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>location which creates this event</td>
</tr>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>addrAllocated</td>
<td>allocated address, should be converted to void*</td>
</tr>
<tr>
<td>bytesAllocated</td>
<td>number of bytes allocated</td>
</tr>
<tr>
<td>substrateData</td>
<td>Internal substrates may register data for this address. They should use their substrate id to access their specific item. Substrate plugins should NOT access this variable.</td>
</tr>
<tr>
<td>bytesAllocated</td>
<td>The total size of the metric. E.g., all memory regions tracked with the memory adapters count into a specific metric.</td>
</tr>
</tbody>
</table>

L.5.3.61 typedef void(SCOREP_Substrates_TrackFreeCb)(struct SCOREP_Location* location, uint64_t timestamp, uint64_t addrFreed, size_t bytesFreed, void* substrateData[], size_t bytesAllocatedMetric, size_t bytesAllocatedProcess)
Event for freeing memory using free.
Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>addrFreed</td>
<td>address passed to free</td>
</tr>
<tr>
<td>bytesFreed</td>
<td>number of bytes freed</td>
</tr>
<tr>
<td>substrateData</td>
<td>Internal substrates get previously registered data for addrFreed. They should use their substrate id to access their specific item. Substrate plugins should NOT access this variable.</td>
</tr>
<tr>
<td>bytesAllocated</td>
<td>The total size of the metric. E.g., all memory regions tracked with the memory adapters count into a specific metric</td>
</tr>
<tr>
<td>Process</td>
<td>total number of bytes allocated in the process</td>
</tr>
</tbody>
</table>

L.5.3.62 typedef void(SCOREP_Substrates_TrackReallocCb) (struct SCOREP_Location *location, uint64_t timestamp, uint64_t oldAddr, size_t oldBytesAllocated, void *oldSubstrateData[], uint64_t newAddr, size_t newBytesAllocated, void *newSubstrateData[], size_t bytesAllocatedMetric, size_t bytesAllocatedProcess)

Event for allocating/freeing memory using realloc

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>oldAddr</td>
<td>address passed to realloc</td>
</tr>
<tr>
<td>oldBytesAllocated</td>
<td>size allocated to oldAddr before calling realloc</td>
</tr>
<tr>
<td>oldSubstrateData</td>
<td>Internal substrates get their previously registered data for oldAddr. They should use their substrate id to access their specific item. Substrate plugins should NOT access this variable.</td>
</tr>
<tr>
<td>newAddr</td>
<td>address gained from realloc</td>
</tr>
<tr>
<td>newBytesAllocated</td>
<td>size of object at newAddr after realloc</td>
</tr>
<tr>
<td>newSubstrateData</td>
<td>Internal substrates can register data for newAddr. They should use their substrate id to access their specific item. Substrate plugins should NOT access this variable.</td>
</tr>
<tr>
<td>bytesAllocated</td>
<td>The total size of the metric. E.g., all memory regions tracked with the memory adapters count into a specific metric</td>
</tr>
<tr>
<td>Process</td>
<td>total number of bytes allocated in the process</td>
</tr>
</tbody>
</table>

L.5.3.63 typedef void(SCOREP_Substrates_TriggerCounterInt64Cb) (struct SCOREP_Location *location, uint64_t timestamp, SCOREP_SamplingSetHandle counterHandle, int64_t value)

Trigger a counter, which represents more or less a metric

See also

also SCOREP_User_TriggerMetricInt64  SCOREP_User_TriggerMetricUint64  SCOREP_User_TriggerMetricDouble 243
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Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>counterHandle</td>
<td>previously defined counter handle</td>
</tr>
<tr>
<td>value</td>
<td>value of the counter when triggered. The datatype depends on the called function</td>
</tr>
</tbody>
</table>

L.5.3.64  typedef void(+ SCOREP_Substrates_TriggerParameterInt64Cb)(struct SCOREP_Location +location, uint64_t timestamp, SCOREP_ParameterHandle parameterHandle, int64_t value)

Trigger a user defined parameter with a specific value

See also

also SCOREP_User_ParameterInt64 SCOREP_User_ParameterUint64

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>parameterHandle</td>
<td>previously defined parameter handle</td>
</tr>
<tr>
<td>value</td>
<td>value of the parameter when triggered. The datatype depends on the called function</td>
</tr>
</tbody>
</table>

L.5.3.65  typedef void(+ SCOREP_Substrates_TriggerParameterStringCb)(struct SCOREP_Location +location, uint64_t timestamp, SCOREP_ParameterHandle parameterHandle, SCOREP_StringHandle string_handle)

Trigger a user defined parameter with a specific value

See also

also SCOREP_User_ParameterString

Parameters

<table>
<thead>
<tr>
<th>location</th>
<th>location which creates this event</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>timestamp for this event</td>
</tr>
<tr>
<td>parameterHandle</td>
<td>previously defined parameter handle</td>
</tr>
<tr>
<td>string_handle</td>
<td>previously defined string when the parameter is triggered.</td>
</tr>
</tbody>
</table>

L.5.3.66  typedef void(+ SCOREP_Substrates_WriteMetricsCb)(struct SCOREP_Location +location, uint64_t timestamp, SCOREP_SamplingSetHandle samplingSet, const uint64_t *metricValues)

Used to record metrics. Provided by substrates as arguments to SCOREP_Metric_WriteStrictlySynchronousMetrics(), SCOREP_Metric_WriteSynchronousMetrics(), and SCOREP_Metric_WriteAsynchronousMetrics(). These functions are supposed to be called during following events: [CallingContext]Enter, [CallingContext]Exit, Sample. Will also be used for writing post mortem asynchronous metrics during SCOREP_EVENT_WRITE_PSTMORTEM_METRICS.
L.5 SCOREP_SubstrateEvents.h File Reference

Parameters

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>location</td>
<td>A pointer to the thread location data of the thread that executed the metric event.</td>
</tr>
<tr>
<td>timestamp</td>
<td>The timestamp, when the metric event occurred.</td>
</tr>
<tr>
<td>samplingSet</td>
<td>The sampling set with metrics</td>
</tr>
<tr>
<td>metricValues</td>
<td>Array of the metric values</td>
</tr>
</tbody>
</table>

L.5.4 Enumeration Type Documentation

L.5.4.1 enum SCOREP_Substrates_EventType

Substrate events. Lists every event that is going to be used by the substrate mechanism. More details can be found in the respective functions. To maintain API stability, new events need to be added at the end of the enum.

Enumerator

- **SCOREP_EVENT_ENABLE_RECORDING** enable recording of events, see SCOREP_Substrates_EnableRecordingCb()
- **SCOREP_EVENT_DISABLE_RECORDING** disable recording of events, see SCOREP_Substrates_DisableRecordingCb()
- **SCOREP_EVENT_ON_TRACING_BUFFER_FLUSH_BEGIN** start flushing trace buffer to disk, see SCOREP_Substrates_OnTracingBufferFlushBeginCb()
- **SCOREP_EVENT_ON_TRACING_BUFFER_FLUSH_END** end flushing trace buffer to disk, see SCOREP_Substrates_OnTracingBufferFlushEndCb()
- **SCOREP_EVENT_ENTER_REGION** enter an instrumented region, see SCOREP_Substrates_EnterRegionCb()
- **SCOREP_EVENT_EXIT_REGION** exit an instrumented region, see SCOREP_Substrates_ExitRegionCb()
- **SCOREP_EVENT_SAMPLE** record a calling context from sampling, see SCOREP_Substrates_SampleCb()
- **SCOREP_EVENT_CALLING_CONTEXT_ENTER** enter an instrumented region with calling context information, replaces SCOREP_EVENT_ENTER_REGION when unwinding is enabled, see SCOREP_Substrates_CallingContextEnterCb()
- **SCOREP_EVENT_CALLING_CONTEXT_EXIT** exit an instrumented region with calling context information, replaces SCOREP_EVENT_EXIT_REGION when unwinding is enabled, see SCOREP_Substrates_CallingContextExitCb()
- **SCOREP_EVENT_ENTER_REWIND_REGION** enter rewinding, see SCOREP_Substrates_EnterRewindRegionCb()
- **SCOREP_EVENT_EXIT_REWIND_REGION** exit rewinding, see SCOREP_Substrates_ExitRewindRegionCb()
- **SCOREP_EVENT_MPI_SEND** MPI_Send, see SCOREP_Substrates_MpiSendCb()
- **SCOREP_EVENT_MPI_RECV** MPI_Recv, see SCOREP_Substrates_MpiRecvCb()
- **SCOREP_EVENT_MPI_COLLECTIVE_BEGIN** starts an MPI collective, see SCOREP_Substrates_MpiCollectiveBeginCb()
- **SCOREP_EVENT_MPI_COLLECTIVE_END** ends an MPI collective, see SCOREP_Substrates_MpiCollectiveEndCb()
- **SCOREP_EVENT_MPI_IRECVD_COMPLETE** marks the completion of an MPI_Irecv, see SCOREP_Substrates_MpiIrecvCompleteCb()
- **SCOREP_EVENT_MPI_REQUEST_TESTED** marks the test of an MPI request (e.g., in an MPI_Waitsome(...)), see SCOREP_Substrates_MpiRequestTestedCb()
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**SCOREP_EVENT_MPI_REQUEST_CANCELLED** marks the cancellation of an MPI request (e.g., an `MPI_Cancel(...)` call that returned true in its second parameter), see `SCOREP_Substrates_MPI_RequestCancelledCb()

**SCOREP_EVENT_MPI_ISEND** marks the start of an MPI ISend, see `SCOREP_Substrates_MPIIsendCb()

**SCOREP_EVENT_MPI_IRecv** marks the start of an MPI IRecv, see `SCOREP_Substrates_MPIIrecvCb()

**SCOREP_EVENT_RMA_WIN_CREATE** marks the creation of an RMA window (used by cuda, opencl, and shmem), see `SCOREP_Substrates_RmaWinCreateCb()

**SCOREP_EVENT_RMA_WIN_DESTROY** marks the destruction of an RMA window (used by cuda, opencl, and shmem), see `SCOREP_Substrates_RmaWinDestroyCb()

**SCOREP_EVENT_RMA_COLLECTIVE_BEGIN** marks the start of an RMA collective (used by shmem), see `SCOREP_Substrates_RmaCollectiveBeginCb()

**SCOREP_EVENT_RMA_COLLECTIVE_END** marks the start of an RMA collective (used by shmem), see `SCOREP_Substrates_RmaCollectiveEndCb()

**SCOREP_EVENT_RMA_TRY_LOCK** marks an RMA trylock (used by shmem), see `SCOREP_Substrates_RmaTryLockCb()

**SCOREP_EVENT_RMA_ACQUIRE_LOCK** marks the acquisition of an RMA lock (used by shmem), see `SCOREP_Substrates_RmaAcquireLockCb()

**SCOREP_EVENT_RMA_REQUEST_LOCK** marks a request for an RMA lock (used by shmem), see `SCOREP_Substrates_RmaRequestLockCb()

**SCOREP_EVENT_RMA_RELEASE_LOCK** marks a release of an RMA lock (used by shmem), see `SCOREP_Substrates_RmaReleaseLockCb()

**SCOREP_EVENT_RMA_SYNC** marks a simple pairwise RMA synchronization, see `SCOREP_Substrates_RmaSyncCb()

**SCOREP_EVENT_RMA_GROUP_SYNC** marks an RMA synchronization of a sub-group of locations on a given window, see `SCOREP_Substrates_RmaGroupSyncCb()

**SCOREP_EVENT_RMA_PUT** marks a put operation to an RMA memory (used by cuda, opencl, and shmem), see `SCOREP_Substrates_RmaPutCb()

**SCOREP_EVENT_RMA_GET** marks a get operation from an RMA memory (used by cuda, opencl, and shmem), see `SCOREP_Substrates_RmaGetCb()

**SCOREP_EVENT_RMA_ATOMIC** marks an atomic RMA operation (used by shmem), see `SCOREP_Substrates_RmaAtomicCb()

**SCOREP_EVENT_RMA_WAIT_CHANGE** marks a blocks until a remote operation modifies a given RMA memory field (used by shmem), see `SCOREP_Substrates_RmaWaitChangeCb()

**SCOREP_EVENT_RMA_OP_COMPLETE_BLOCKING** marks completion of a blocking RMA operation (used by cuda, opencl, and shmem), see `SCOREP_Substrates_RmaOpCompleteBlockingCb()

**SCOREP_EVENT_RMA_OP_COMPLETE_NON_BLOCKING** marks completion of a non-blocking RMA operation, see `SCOREP_Substrates_RmaOpCompleteNonBlockingCb()

**SCOREP_EVENT_RMA_OP_TEST** marks a test for completion of a non-blocking RMA operation, see `SCOREP_Substrates_RmaOpTestCb()

**SCOREP_EVENT_RMA_OP_COMPLETE_REMOTE** marks a remote completion point, see `SCOREP_Substrates_RmaOpCompleteRemoteCb()

**SCOREP_EVENT_THREAD_ACQUIRE_LOCK** marks when a thread acquires a lock (pthreads, explicit and implicit OpenMP locks), see `SCOREP_Substrates_ThreadAcquireLockCb()

**SCOREP_EVENT_THREAD_RELEASE_LOCK** marks when a thread releases a lock (pthreads, explicit and implicit OpenMP locks), see `SCOREP_Substrates_ThreadreleaseLockCb()

**SCOREP_EVENT_TRIGER_COUNTER_INT64** called when an int64 counter is triggered, see `SCOREP_Substrates_TriggerCounterInt64Cb()

**SCOREP_EVENT_TRIGER_COUNTER_UINT64** called when an uint64 counter is triggered, see `SCOREP_Substrates_TriggerCounterUint64Cb()

**SCOREP_EVENT_TRIGER_COUNTER_DOUBLE** called when a double counter is triggered, see `SCOREP_Substrates_TriggerCounterDoubleCb()
SCOREP_EVENT_TRIGGER_PARAMETER_INT64 called when an int64 parameter is triggered, called from user instrumentation, see SCOREP_Substrates_TriggerParameterInt64Cb()

SCOREP_EVENT_TRIGGER_PARAMETER_UINT64 called when an uint64 parameter is triggered, called from user instrumentation, see SCOREP_Substrates_TriggerParameterUint64Cb()

SCOREP_EVENT_TRIGGER_PARAMETER_STRING called when an string parameter is triggered, called from user instrumentation, see SCOREP_Substrates_TriggerParameterStringCb()

SCOREP_EVENT_THREAD_FORK_JOIN_FORK called before a fork-join based thread-parallel programming model (e.g., OpenMP) forks its threads logically, see SCOREP_Substrates_ThreadForkJoinForkCb()

SCOREP_EVENT_THREAD_FORK_JOIN_JOIN called after a fork-join based thread-parallel programming model (e.g., OpenMP) joins its threads logically, see SCOREP_Substrates_ThreadForkJoinJoinCb()

SCOREP_EVENT_THREAD_FORK_JOIN_TEAM_BEGIN begin of a parallel execution on a thread created by either SCOREP_ThreadForkJoin_Fork, is called by all created threads, see SCOREP_Substrates_ThreadForkJoinTeamBeginCb()

SCOREP_EVENT_THREAD_FORK_JOIN_TEAM_END end of a parallel execution on a thread created by either SCOREP_ThreadForkJoin_Fork, is called by all created threads, see SCOREP_Substrates_ThreadForkJoinTeamBeginCb()

SCOREP_EVENT_THREAD_FORK_JOIN_TASK_CREATE creation of a task in a fork-join based thread-parallel programming model (e.g., OpenMP), see SCOREP_Substrates_ThreadForkJoinTaskCreateCb()

SCOREP_EVENT_THREAD_FORK_JOIN_TASK_SWITCH switching of tasks in a fork-join based thread-parallel programming model (e.g., OpenMP), see SCOREP_Substrates_ThreadForkJoinTaskSwitchCb()

SCOREP_EVENT_THREAD_FORK_JOIN_TASK_BEGIN begin of a task in a fork-join based thread-parallel programming model (e.g., OpenMP), see SCOREP_Substrates_ThreadForkJoinTaskBeginCb()

SCOREP_EVENT_THREAD_FORK_JOIN_TASK_END end of a task in a fork-join based thread-parallel programming model (e.g., OpenMP), see SCOREP_Substrates_ThreadForkJoinTaskEndCb()

SCOREP_EVENT_TRACK_ALLOC track malloc/calloc memory allocation, see SCOREP_Substrates_TrackAllocCb()

SCOREP_EVENT_TRACK_REALLOC track realloc memory (de-)allocation, see SCOREP_Substrates_TrackReallocCb()

SCOREP_EVENT_TRACK_FREE track realloc memory deallocation, see SCOREP_Substrates_TrackFreeCb()

SCOREP_EVENT_WRITE_POST_MORTEM_METRICS write post mortem metrics before unify, see SCOREP_Substrates_WriteMetricsCb()

SCOREP_EVENT_PROGRAM_BEGIN begin of program and measurement, see SCOREP_Substrates_ProgramBeginCb()

SCOREP_EVENT_PROGRAM_END end of program and measurement, see SCOREP_Substrates_ProgramEndCb()

SCOREP_EVENT_IO_CREATE_HANDLE marks the creation of a new I/O handle, the handle gets active and can be used in subsequent I/O operations, see SCOREP_Substrates_IoCreateHandleCb
**SCOREP_EVENT_IO_DESTROY_HANDLE** marks the deletion of an I/O handle, the I/O handle can’t be used in subsequent I/O operations any longer, see SCOREP_Substrates_IoDestroyHandleCb

**SCOREP_EVENT_IO_DUPLICATE_HANDLE** marks the duplication of an already existing I/O handle, the new one gets active and can be used in subsequent I/O operations, see SCOREP_Substrates_IoDuplicateHandleCb

**SCOREP_EVENT_IO_SEEK** marks a seek operation, sets the file position indicator, see SCOREP_Substrates_IoSeekCb

**SCOREP_EVENT_IO_CHANGE_STATUS_FLAGS** called when status information of an I/O handle are changed, see SCOREP_Substrates_IoChangeStatusFlagsCb

**SCOREP_EVENT_IO_DELETE_FILE** marks the deletion of a file, see SCOREP_Substrates_IoDeleteFileCb

**SCOREP_EVENT_IO_OPERATION_BEGIN** marks the begin of an I/O operation, see SCOREP_Substrates_IoOperationBeginCb

**SCOREP_EVENT_IO_OPERATION_ISSUED** called when an asynchronous I/O operation is submitted to the I/O subsystem, see SCOREP_Substrates_IoOperationIssuedCb

**SCOREP_EVENT_IO_OPERATION_TEST** called when an asynchronous I/O operation is tested for completion but is not finished yet, see SCOREP_Substrates_IoOperationTestCb

**SCOREP_EVENT_IO_OPERATION_COMPLETE** called when an asynchronous I/O operation is successfully tested for completion, see SCOREP_Substrates_IoOperationCompleteCb

**SCOREP_EVENT_IO_OPERATION_CANCELLED** called when an asynchronous I/O operation is aborted, see SCOREP_Substrates_IoOperationCancelledCb

**SCOREP_EVENT_IO_ACQUIRE_LOCK** marks the acquisition of an I/O lock, see SCOREP_Substrates_IoAcquireLockCb

**SCOREP_EVENT_IO_RELEASE_LOCK** marks the release of an I/O lock, see SCOREP_Substrates_IoReleaseLockCb

**SCOREP_EVENT_IO_TRY_LOCK** called when, see SCOREP_Substrates_IoTryLockCb

**SCOREP_SUBSTRATES_NUM_EVENTS** Non-ABI, marks the end of the currently supported events and can change with different versions of Score-P (increases with increasing Score-P version)

---

**L.5.4.2 enum SCOREP_Substrates_Mode**

Substrates need to provide two sets of callbacks for the modes SCOREP_SUBSTATES_RECORDING_ENABLED and SCOREP_SUBSTRATES_RECORDING_DISABLED. This enum is used as an array index.

**Enumerator**

- **SCOREP_SUBSTRATES_RECORDING_ENABLED** The recording of events is enabled (default)
- **SCOREP_SUBSTRATES_RECORDING_DISABLED** The recording of events is disabled
- **SCOREP_SUBSTRATES_NUM MODES** Non-ABI

---

**L.6 SCOREP_SubstratePlugins.h File Reference**

Description of the substrate plugin header. For information on how to use substrate plugins, please refer to section 'Substrate Plugins'.

```c
#include <stdlib.h>
#include <stdio.h>
#include <stddef.h>
#include <scorep/SCOREP_PublicTypes.h>
#include <scorep/SCOREP_PublicHandles.h>
#include <scorep/SCOREP_SubstrateEvents.h>
```
Data Structures

- struct SCOREP_SubstratePluginCallbacks
- struct SCOREP_SubstratePluginInfo

Macros

- #define SCOREP_SUBSTRATE_PLUGIN_ENTRY(_name)
- #define SCOREP_SUBSTRATE_PLUGIN_UNDEFINED_MANAGEMENT_FUNCTIONS 99
- #define SCOREP_SUBSTRATE_PLUGIN_VERSION 3

L.6.1 Detailed Description

Description of the substrate plugin header. For information on how to use substrate plugins, please refer to section ‘Substrate Plugins’.

L.6.2 Macro Definition Documentation

L.6.2.1 #define SCOREP_SUBSTRATE_PLUGIN_ENTRY(_name)

Value:

```c
EXTERN SCOREP_SubstratePluginInfo \\
    SCOREP_SubstratePlugin_ ## _name ## _get_info( void )
```

Macro used for implementation of the 'get_info' function

L.6.2.2 #define SCOREP_SUBSTRATE_PLUGIN_UNDEFINED_MANAGEMENT_FUNCTIONS 99

This should be reduced by 1 for each new function added to SCOREP_SubstratePluginInfo

L.6.2.3 #define SCOREP_SUBSTRATE_PLUGIN_VERSION 3

L.6.3 Advice for developers

The developer of a substrate plugin should provide a README file which explains how to compile, install and use the plugin. In particular, the supported substrates should be described in the README file.

Each substrate plugin has to include SCOREP_SubstratePlugins.h and implement a 'get_info' function. Therefore, use the SCOREP_SUBSTRATE_PLUGIN_ENTRY macro and provide the name of the plugin library as the argument. The plugin library must be called libscorep_substrate_<libraryname>.so For example, the example substrate plugin libscorep_substrate_example.so should use SCOREP_SUBSTRATE_PLUGIN_ENTRY( example ). Substrate plugins that implement event functions should also include SCOREP_SubstrateEvents.h Plugin writers should also refer to SCOREP_PublicHandles.h and SCOREP_PublicTypes.h to handle SCOREP handles given in event functions.
L.6.4 Functions

See each function for details. All functions except init are optional!

init
Check requirements and initialize the plugin.

assign_id
The plugin gets an id that can be used later to store location specific data.

init_mpp
If an MPP paradigm is used, it will be initialized when this call occurs. If no MPP paradigm is used, this function will be called as well.

finalize
Finalization of Score-P.

create_location
Create a new location (e.g., when a thread is created)

delete_location
Delete an existing location

activate_cpu_location
Activate a CPU location to write events. Called, for example, after create_location on CPU locations.

deactivate_cpu_location
Deactivate a CPU location. Called, for example, before delete_location.

pre_unify
Called before the unify step, after the measurement.

write_data
Called after the measurement when writing data.

core_task_create
Create a task (e.g., an OpenMP task)

core_task_complete
Complete a task (e.g., an OpenMP task)

new_definition_handle
Called when a handle is defined, which could define, for example a region or a metric. Plugins can use callbacks to get meta data for this handle.

get_event_functions
Called twice with different modes. Get a list of events that shall be passed to the plugin.

set_callbacks
Called before get_event_functions. Set a list of callbacks so that the plugin can get meta data for handles.

undeclared
MUST be set to zero. Added for extendability.
L.6.5 Mandatory variable

plugin_version

Must be set to SCOREP_SUBSTRATE_PLUGIN_VERSION Current version of Score-P substrate plugin interface

L.7 SCOREP_User.h File Reference

This file contains the interface for the manual user instrumentation.

#include <scorep/SCOREP_User_Variables.h>
#include <scorep/SCOREP_User_Functions.h>

Macros

Macros for region instrumentation

- #define SCOREP_USER_FUNC_DEFINE()
- #define SCOREP_USER_OA_PHASE_BEGIN(handle, name, type)
- #define SCOREP_USER_OA_PHASE_END(handle) SCOREP_User_OaPhaseEnd( handle );
- #define SCOREP_USER_REGION_DEFINE(handle) static SCOREP_User_RegionHandle handle = SCOREP_USER_INVALID_REGION;
- #define SCOREP_USER_REGION_ENTER(handle) SCOREP_User_RegionEnter( handle );
- #define SCOREP_USER_REGION_BEGIN(handle, name, type)
- #define SCOREP_USER_REGION_INIT(handle, name, type)
- #define SCOREP_USER_REGION_END(handle) SCOREP_User_RegionEnd( handle );
- #define SCOREP_USER_FUNC_BEGIN()
- #define SCOREP_USER_FUNC_END() SCOREP_User_RegionEnd( scorep_user_func_handle );
- #define SCOREP_USER_GLOBAL_REGION_DEFINE(handle) SCOREP_User_RegionHandle handle = SCOREP_USER_INVALID_REGION;
- #define SCOREP_USER_GLOBAL_REGION_EXTERNAL(handle) extern SCOREP_User_RegionHandle handle;

Macros for parameter instrumentation

- #define SCOREP_USER_PARAMETER_INT64(name, value)
- #define SCOREP_USER_PARAMETER_UINT64(name, value)
- #define SCOREP_USER_PARAMETER_STRING(name, value)

Macros to provide user metrics

- #define SCOREP_USER_METRIC_LOCAL(metricHandle)
- #define SCOREP_USER_METRIC_GLOBAL(metricHandle)
- #define SCOREP_USER_METRIC_EXTERNAL(metricHandle) extern SCOREP_SamplingSetHandle metricHandle;
- #define SCOREP_USER_METRIC_INIT(metricHandle, name, unit, type, context) SCOREP_User_InitMetric( &metricHandle, name, unit, type, context );
- #define SCOREP_USER_METRIC_INT64(metricHandle, value)
- #define SCOREP_USER_METRIC_UINT64(metricHandle, value)
- #define SCOREP_USER_METRIC_DOUBLE(metricHandle, value)

Macros for creation of user topologies

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### C++ specific macros for region instrumentation

- `#define SCOREP_USER_REGION(name, type)

### Macros for measurement control

- `#define SCOREP_RECORDING_ON() SCOREP_User_EnableRecording();`
- `#define SCOREP_RECORDING_OFF() SCOREP_User_DisableRecording();`
- `#define SCOREP_RECORDING_IS_ON() SCOREP_User_RecordingEnabled()

### L.7.1 Detailed Description

This file contains the interface for the manual user instrumentation.

### L.8 SCOREP_User_Types.h File Reference

This file contains type definitions for manual user instrumentation.

```c
#include <scorep/SCOREP_PublicTypes.h>
```

### Macros

- `#define SCOREP_USER_INVALID_PARAMETER -1`
- `#define SCOREP_USER_INVALID_REGION NULL`
- `#define SCOREP_USER_INVALID_TOPOLOGY -1`

### Region types

- `#define SCOREP_USER_REGION_TYPE_COMMON 0`
- `#define SCOREP_USER_REGION_TYPE_FUNCTION 1`
- `#define SCOREP_USER_REGION_TYPE_LOOP 2`
- `#define SCOREP_USER_REGION_TYPE_DYNAMIC 4`
- `#define SCOREP_USER_REGION_TYPE_PHASE 8`

### Metric types

- `#define SCOREP_USER_METRIC_TYPE_INT64 0`
- `#define SCOREP_USER_METRIC_TYPE_UINT64 1`
- `#define SCOREP_USER_METRIC_TYPE_DOUBLE 2`

### Metric contexts

- `#define SCOREP_USER_METRIC_CONTEXT_GLOBAL 0`
- `#define SCOREP_USER_METRIC_CONTEXT_CALLPATH 1`
L.8 SCReP_User_Types.h File Reference

typedef struct SCReP_User_Topology * SCReP_User_CartesianTopologyHandle
typedef uint32_t SCReP_User_MetricType
typedef uint64_t SCReP_User_ParameterHandle
typedef struct SCReP_User_Region * SCReP_User_RegionHandle
typedef uint32_t SCReP_User_RegionType

L.8.1 Detailed Description

This file contains type definitions for manual user instrumentation.

L.8.2 Macro Definition Documentation

L.8.2.1 #define SCReP_USER_INVALID_PARAMETER -1
Marks an parameter handle as invalid or uninitialized

L.8.2.2 #define SCReP_USER_INVALID_REGION NULL
Value for uninitialized or invalid region handles

L.8.2.3 #define SCReP_USER_INVALID_TOPOLOGY -1
Marks a topology handle as invalid or uninitialized

L.8.3 Typedef Documentation

L.8.3.1 typedef struct SCReP_User_Topology * SCReP_User_CartesianTopologyHandle
Type for topology handles in the user adapter

L.8.3.2 typedef uint32_t SCReP_User_MetricType
Type for the user metric type

L.8.3.3 typedef uint64_t SCReP_User_ParameterHandle
Type for parameter handles

L.8.3.4 typedef struct SCReP_User_Region * SCReP_User_RegionHandle
Type for region handles in the user adapter.

L.8.3.5 typedef uint32_t SCReP_User_RegionType
Type for the region type
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