

# OPARI 2

## USER MANUAL

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# Contents

	Page
<b>Contents</b>	<b>iii</b>
<b>1 Opari2</b>	<b>1</b>
1.1 INSTALLATION . . . . .	1
1.2 USAGE . . . . .	2
1.3 CTC string decoding . . . . .	4
1.4 LINKING (startup initialization only) . . . . .	5
1.5 POMP user instrumentation . . . . .	7
1.6 EXAMPLE . . . . .	7
1.7 News . . . . .	8
1.7.1 LINK STEP . . . . .	8
1.7.2 POMP2 . . . . .	8
1.7.3 POMP2_Parallel_fork . . . . .	8
1.7.4 pomp_tpd . . . . .	9
1.7.5 Tasking construct . . . . .	9
1.7.6 Preprocessing of source files . . . . .	10
1.8 SUMMARY . . . . .	10
<b>Appendix A OPARI2 INSTALL</b>	<b>15</b>
<b>Appendix B Data Structure Documentation</b>	<b>25</b>
B.1 POMP2_Region_info Struct Reference . . . . .	25
B.1.1 Detailed Description . . . . .	26
B.1.2 Field Documentation . . . . .	26
<b>Appendix C File Documentation</b>	<b>29</b>
C.1 pomp2_lib.h File Reference . . . . .	29
C.1.1 Detailed Description . . . . .	30
C.1.2 Typedef Documentation . . . . .	30
C.1.3 Function Documentation . . . . .	30
C.2 pomp2_region_info.h File Reference . . . . .	32
C.2.1 Detailed Description . . . . .	33
C.2.2 Enumeration Type Documentation . . . . .	33
C.2.3 Function Documentation . . . . .	33



# Chapter 1

## Opari2

*Opari2* is a tool to automatically instrument C, C++ and Fortran source code files in which OpenMP is used. Function calls to a [POMP2 API](#) are inserted around OpenMP directives. By implementing this API, detailed measurements regarding the runtime behavior of an OpenMP application can be made. A conforming POMP2 implementation needs to implement all POMP2 functions, see [pomp2\\_lib.h](#) for a list of those.

OpenMP 3.0 introduced tasking to OpenMP. To support this feature the POMP2 adapter needs to do some bookkeeping in regard to specific task IDs. The `pomp2_lib.c` provided with this package includes the necessary code so it is strongly advised to use it as a basis for writing an adapter to your own tool.

A detailed description of the first Opari version has been published by Mohr et al. in "Design and prototype of a performance tool interface for OpenMP" (Journal of supercomputing, 23, 2002).

### 1.1 INSTALLATION

*Opari2* was developed with Autotools. After downloading and unpacking, change into your build directory and perform the following steps:

1. `./configure`  
    `[--prefix=<installation directory>]`  
    `[--with-compiler-suite=<gcc|ibm|intel|pathscale|pgi|studio>]`
2. `make`
3. `make install`

See the file `INSTALL` for further information.

## 1.2 USAGE

To create an instrumented version of an OpenMP application, each file of interest is transformed by the OPARI2 tool. The application is then linked against the POMP2 runtime measurement library and optionally to a special initialization file (see section [LINKING \(startup initialization only\)](#) and [SUMMARY](#) for further details).

A call to Opari2 has the following syntax:

Usage: opari2 [OPTION] ... infile [outfile]

with following options and parameters:

- [--f77|--f90|--c|--c++] [OPTIONAL] Specifies the programming language of the input source file. This option is only necessary if the automatic language detection based on the input file suffix fails.
  
- [--free-form] [OPTIONAL] Specifies that free formatting is used for Fortran source files. This is the default for Fortran 90/95.
  
- [--fix-form] [OPTIONAL] Specifies that fixed formatting is used for Fortran source files. This is the default for Fortran 77.
  
- [--nosrc] [OPTIONAL] If specified, OPARI2 does not generate #line constructs, which allow to preserve the original source file and line number information, in the transformation process. This option might be necessary if the OpenMP compiler does not understand #line constructs. The default is to generate #line constructs.
  
- [--nodecl] [OPTIONAL] Disables the generation of POMP2\_DLISTXXXX macros. These are used in the parallel directives of the instrumentation to make the region handles shared. By using this option the shared clause is used directly on the parallel directive with the respective region handles.
  
- [--tpd] [OPTIONAL] Adds the clause 'copyin(<pomp\_tpd>)' to any parallel construct. This allows to pass data from the creating thread to its children. The variable is declared externally in all files, so it needs to be defined by the pomp library. This option is not supported on following systems: K, FX10.
  
- [--disable=<constructs>] [OPTIONAL] Disable the instrumentation of

## 1.2 USAGE

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manually-annotated POMP regions or the more fine-grained OpenMP constructs such as !\$OMP ATOMIC. <constructs> is a comma separated list of the constructs for which the instrumentation should be disabled. Accepted tokens are atomic, critical, master, flush, single, ordered or locks (as well as sync to disable all of them). Furthermore task, omp, and region are accepted.

[--task=  
abort|warn|remove] Special treatment for the task directive  
abort: Stop instrumentation with an error message when encountering a task directive.  
warn: Resume but print a warning.  
remove: Remove all task directives.

[--untied=  
abort|keep|no-warn] Special treatment for the untied task attribute.  
The default behavior is to remove the untied attribute, thus making all tasks tied, and print out a warning.  
abort: Stop instrumentation with an error message when encountering a task directive with the untied attribute.  
keep: Do not remove the untied attribute.  
no-warn: Do not print out a warning.

[--tpd-mangling=  
gnu|intel|sun|pgi|  
ibm|cray] [OPTIONAL] If programming languages are mixed (C and Fortran), the <pomp\_tpd> needs to use the Fortran mangled name also in C files. This option specifies to use the mangling scheme of the gnu, intel, sun, pgi or ibm compiler. The default is to use the mangling scheme of the compiler used to build opari2.

[--preprocessed] [OPTIONAL] Indicates that the source file is already preprocessed. It requires that pomp2\_lib.h is already included. Furthermore, it requires the marker `__POMP2_INCLUDE__` immediately after the included pomp2\_lib.h file.

[--version] [OPTIONAL] Prints version information.

[--help] [OPTIONAL] Prints this help text.

infile Input file name.

[outfile] [OPTIONAL] Output file name. If not specified, opari2 uses the name `infile.mod.suffix` if the input file is called `infile.suffix`.

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

If you run Opari2 on the input file `example.c` it will create two files:

- `example.mod.c` is the instrumented version of `example.c`, i.e. it contains the original code plus calls to the [POMP2 API](#) referencing handles to the OpenMP regions identified by Opari2.
- `example.c.opari.inc` contains the OpenMP region handle definitions accompanied with all the relevant data needed by the handles. This compile time context (CTC) information is encoded into a string for maximum portability. For each region, the tuple (region\_handle, ctc\_string) is passed to an initializing function ([POMP2\\_Assign\\_handle\(\)](#)). All calls to these initializing functions are gathered in a function named `POMP2_Init_reg_XXX_YY`, where `XXX_YY` is unique for each compilation unit.

At some point during the runtime of the instrumented application, the region handles need to be initialized using the information stored in the CTC string. This can be done in one of two ways:

- during *startup* of the measurement/POMP2 system, or
- during *runtime* when a region handle is accessed for the first time.

We *highly* recommend using the first option as it incurs much less runtime overhead than the second one (no locking, no lookup needed). In this case all `POMP2_Init_reg_XXX_YY` functions introduced by opari2 need to be called. See [LINKING \(startup initialization only\)](#) for further details. For runtime initialization the ctc string as argument to the relevant [POMP2 function calls](#) is provided as an argument.

### 1.3 CTC string decoding

As mentioned above, we pass ctc strings to different POMP2 functions. These functions need to parse the string in order to process the encoded information. With [POMP2\\_Region\\_info](#) and [ctcString2RegionInfo\(\)](#) the opari2 package provides means of doing this, see [pomp2\\_region\\_info.h](#).

The CTC string is a string in the format "length\*key=value\*key=value\*[key=value]\*\*, for example:

```
*82*regionType=parallel*sscl=xmpl.c:61:61*escl=xmpl.c:66:66*hasIf=1**
```

Mandatory keys are:

- *regionType* Type of the region (here parallel)

## 1.4 LINKING (startup initialization only)

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- *sscl* First line of the region (usually with full path to file)
- *escl* Last line of the region

Optional keys are

- *hasNumThreads* Set if a numThreads clause is used in the OpenMP directive
- *hasIf* Set if an if clause is used
- *hasOrdered* Set if an ordered clause is used
- *hasReduction* Set if a reduction clause is used
- *hasSchedule* Set if a schedule clause is used
- *hasCollapse* Set if a collapse clause is used

The optional values are set to 0 by default, i.e. the presence of the key denotes the presence of the respective clause.

You can use the function [ctcString2RegionInfo\(\)](#) to decode CTC strings. It can be found in `pomp2_region_info.c` and [pomp2\\_region\\_info.h](#), installed under `<opari-prefix>/share/opari2/devel`.

## 1.4 LINKING (startup initialization only)

For startup initialization all `POMP2_Init_reg_XXX_YY` functions that can be found in the object files and libraries of the application are called. This is done by creating an additional compilation unit that contains calls to following POMP2 functions:

- `POMP2_Init_region()`,
- [POMP2\\_Get\\_num\\_regions\(\)](#), and
- [POMP2\\_Get\\_opari2\\_version\(\)](#).

The resulting object file is linked to the application. During startup of the measurement system the only thing to be done is to call `POMP2_Init_region()` which then calls all `POMP2_Init_reg_XXX_YY` functions.

In order to create the additional compilation unit (for example `pomp2_init_file.c`) the following command sequence can be used:

```
% `opari2-config --nm` <objs_and_libs> | \
  `opari2-config --region-initialization` > pomp2_init_file.c
```

Here, `<objs_and_libs>` denotes the entire set of object files and libraries that were instrumented by opari2.

Due to portability reasons `nm`, and the `awk` script to create the additional file are not called directly but via the provided `opari2-config` tool.

A call to the `opari2-config` tool has the following syntax:

Usage: `opari2-config [OPTION] ... <command>`

with the following commands:

<code>--nm</code>	Prints the <code>nm</code> command.
<code>--region-initialization</code>	Prints the script used to create the <code>pomp2_init_regions.c</code> file.
<code>--create-pomp2-regions</code> <code>&lt;object files&gt;</code>	Prints the whole command necessary for creating the initialization file.
<code>--awk-cmd</code>	[Deprecated, use <code>--region-initialization</code> instead.] Prints the <code>awk</code> command.
<code>--awk-script</code>	[Deprecated, use <code>--region-initialization</code> instead.] Prints the <code>awk</code> script.
<code>--egrep</code>	[Deprecated, use <code>--region-initialization</code> instead.] Prints the <code>egrep</code> command.
<code>--cflags[=(gnu intel sun </code> <code>pgi ibm cray fujitsu)]</code>	Prints compiler options to include installed headers and adds compiler specific flags to prevent warnings for unused variables which can occur during the instrumentation.
<code>--fortran</code>	Indicates that the target language is fortran. Sometimes for fortran different compile flags are provided, in most of the cases there is no difference.
<code>--version</code>	Prints the opari2 version number.
<code>--interface-version</code>	Prints the pomp2 API version that instrumented files conform too.
<code>--opari2-revision</code>	Prints the revision number of the OPARI2 package.
<code>--common-revision</code>	Prints the revision number of the common package.
<code>--help</code>	Prints this help text.

## 1.5 POMP user instrumentation

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and the following options:

<code>--build-check]</code>	Tells opari2-config to use build paths instead of install paths. Used for build testing.
<code>--config=&lt;config file&gt;]</code>	Reads in a configuration from the given file.

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

## 1.5 POMP user instrumentation

For manual user instrumentation the following pragmas are provided.

C/C++:

```
#pragma pomp inst init
#pragma pomp inst begin(region_name)
#pragma pomp inst altend(region_name)
#pragma pomp inst end(region_name)
#pragma pomp noinstrument
#pragma pomp instrument
```

Fortran:

```
!$POMP INST INIT
!$POMP INST BEGIN(region_name)
!$POMP INST ALTEND(region_name)
!$POMP INST END(region_name)
!$POMP NOINSTRUMENT
!$POMP INSTRUMENT
```

Users can specify code regions, like functions for example, with `INST BEGIN` and `INST END`. If a region contains several exit points like `return/break/exit/...` all but the last need to be marked with `INST ALTEND` pragmas. The `INST INIT` pragma should be used for initialization in the beginning of main, if no other initialization method is used. The `NOINSTRUMENT` and `INSTRUMENT` pragmas can be used to turn off or on the instrumentation of OpenMP pragmas. All pragmas between `NOINSTRUMENT` and `INSTRUMENT` except for parallel regions are not instrumented. Parallel regions are always instrumented to allow a correct thread management in the performance tool. See the [EXAMPLE](#) section for an example on how to use user instrumentation.

## 1.6 EXAMPLE

The directory <prefix>/share/doc/opari2/example contains the following files:

```
example.c  
example.f  
Makefile
```

The Makefile contains all required information for building the instrumented and uninstrumented binaries. It demonstrates the compilation and linking steps as described above.

Additional examples which illustrate the use of user instrumentation can be found in `<prefix>/share/doc/opari2/example_user_instrumentation`. The folder contains the following files:

```
example_user_instrumentation.c  
example_user_instrumentation.f  
Makefile
```

## **1.7 News**

### **1.7.1 LINK STEP**

Opari2 uses a new mechanism to link files. The main advantage is, that no `opari.rc` file is needed anymore. Libraries can now be preinstrumented and parallel builds are supported. To achieve this, the handles for parallel regions are instrumented using a `ctc_string`.

### **1.7.2 POMP2**

The POMP2 interface is not compatible with the original POMP interface. All functions of the new API begin with `POMP2_`. The declaration prototypes can be found in [pomp2\\_lib.h](#).

### **1.7.3 POMP2\_Parallel\_fork**

The `POMP2_Parallel_fork()` call has an additional argument to pass the requested number of threads to the POMP2 library. This allows the library to prepare data structures and allocate memory for the threads before they are created. The value passed to the library is determined as follows:

- If a `num_threads` clause is present, the expression inside this clause is evaluated into a local variable `pomp_num_threads`. This variable is afterwards passed in the call to `POMP2_Parallel_fork()` and in the `num_threads` clause itself.

## 1.7 News

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- If no `num_threads` clause is present, `omp_get_max_threads()` is used to determine the requested value for the next parallel region. This value is stored in `pomp_num_threads` and passed to the `POMP2_Parallel_fork()` call.

In Fortran, instead of `omp_get_max_threads()`, a wrapper function `pomp_get_max_threads_XXX_X` is used. This function is needed to avoid multiple definitions of `omp_get_max_threads()` since we do not know whether it is defined in the user code or not. Removing all definitions in the user code would require much more Fortran parsing than is done with `opari2`, since function definitions cannot easily be distinguished from variable definitions.

### 1.7.4 `pomp_tpd`

If it is necessary for the POMP2 library to pass information from the master thread to its children, the option `--tpd` can be used. `Opari2` uses the `copyin` clause to pass a threadprivate variable `pomp_tpd` to the newly spawned threads at the beginning of a parallel region. This is a 64 bit integer variable, since Fortran does not allow pointers. However a pointer can be stored in this variable, passed to child threads with the `copyin` clause (in C/C++ or Fortran) and later on be cast back to a pointer in the `pomp` library.

To support mixed programming (C/Fortran) the variable name depends on the name mangling of the Fortran compiler. This means, for GNU, Sun, Intel and PGI C compilers the variable is called `pomp_tpd_` and for IBM it is called `pomp_tpd` in C. In Fortran it is of course always called `pomp_tpd`. The `--tpd-mangling` option can be used to change this. The variable is declared extern in all program units, so the `pomp` library contains the actual variable declaration of `pomp_tpd` as a 64 bit integer.

### 1.7.5 Tasking construct

In *OpenMP 3.0* the new tasking construct was introduced. All parts of a program are now implicitly executed as tasks and the user gets the possibility of creating tasks that can be scheduled for asynchronous execution. Furthermore these tasks can be interrupted at certain scheduling points and resumed later on (see the OpenMP API 3.0 for more detailed information).

`Opari2` instruments functions `POMP2_Task_create_begin` and `POMP2_Task_create_end` to allow the recording of the task creation time. For the task execution time, the functions `POMP2_Task_begin` and `POMP2_Task_end` are instrumented in the code. To correctly record a profile or a trace of a program execution these different instances of tasks need to be differentiated. Since OpenMP does not provide Task ids, the performance measurement system needs to create and maintain own task ids. This cannot be done by code instrumentation as done by *Opari2* alone but

requires some administration of task ids during runtime. To allow the measurement system to administrate these ids, additional task id parameters (pomp\_old\_task/pomp\_new\_task) were added to all functions belonging to OpenMP constructs which are task scheduling points. With this package there is a "dummy" library, which can be used as an adapter to your measurement system. This library contains all the relevant functionality to keep track of the different instances of tasks and it is highly recommended to use it as a template to implement your own adapter for your measurement system.

For more detailed information on this mechanism see:

"How to Reconcile Event-Based Performance Analysis with Tasking in OpenMP"

by Daniel Lorenz, Bernd Mohr, Christian Rössel, Dirk Schmidl, and Felix Wolf

In: Proc. of 6th Int. Workshop of OpenMP (IWOMP), LNCS, vol. 6132, pp. 109121

DOI: 10.1007/978-3-642-13217-9\_9

### **1.7.6 Preprocessing of source files**

Opari2 allows to instrument preprocessed source files. This feature is useful when header files contain OpenMP code or when preprocessor defines are used around OpenMP constructs. To use this feature, some special steps have to be taken before the instrumentation, to ensure, that the instrumented code is at the right position.

These steps are:

1. Add the following lines as first lines of your source file.

```
#include <stdint.h>
#include <opari2/pomp2_lib.h>
___POMP2_INCLUDE___
```

2. Preprocess the source file with the same preprocessor defines as usual. Usually compilers provide an option to do this step (e.g. -E for the gcc compiler). We recommend to use the same compiler for this step and for the compilation later on, since compilers set additional defines.
3. Instrument the generated file with opari2 and the flag `--preprocessed`.
4. Proceed with the instrumented file as usual.

## **1.8 SUMMARY**

The typical usage of OPARI2 consists of the following steps:

## 1.8 SUMMARY

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1. Call OPARI2 for each input source file

```
% opari2 file1.f90
...
% opari2 fileN.f90
```

2. Compile all modified output files \*.mod.\* using the OpenMP compiler
3. Generate the initialization file

```
% `opari2-config --nm` <objs_and_libs> | \
  `opari2-config --region-initialization` > pomp2_init_file.c
```

4. Link the resulting object files against the pomp2 runtime measurement library.



# **Appendices**



## Appendix A

# OPARI2 INSTALL

For generic installation instructions see below.

Configuration of OPARI2

\*\*\*\*\*

Optional Features:

--disable-FEATURE	do not include FEATURE (same as --enable-FEATURE=no)
--enable-FEATURE[=ARG]	include FEATURE [ARG=yes]
--enable-silent-rules	less verbose build output (undo: 'make V=1')
--disable-silent-rules	verbose build output (undo: 'make V=0')
--disable-libtool-lock	avoid locking (might break parallel builds)
--disable-openmp	do not use OpenMP
--disable-option-checking	ignore unrecognized --enable/--with options
--disable-dependency-tracking	speeds up one-time build
--enable-dependency-tracking	do not reject slow dependency extractors
--enable-shared[=PKGS]	build shared libraries [default=no]
--enable-static[=PKGS]	build static libraries [default=yes]
--enable-fast-install[=PKGS]	optimize for fast installation [default=yes]

Optional Packages:

--with-PACKAGE[=ARG]	use PACKAGE [ARG=yes]
--without-PACKAGE	do not use PACKAGE (same as --with-PACKAGE=no)
--with-compiler-suite=(gcc ibm intel pgi studio)	The compiler suite to build this package with. Needs to be in \$PATH [gcc].
--with-gnu-ld	assume the C compiler uses GNU ld [default=no]
--with-sysroot=DIR	Search for dependent libraries within DIR (or the compiler's sysroot if not specified).

Some influential environment variables:

(note that the `_FOR_BUILD` variables take precedence, e.g. if you call `opari's configure` from a top level configure in a cross-compile environment that defines `CC` as well as `CC_FOR_BUILD` etc.)

`CC_FOR_BUILD`

C compiler command for the frontend build

`CXX_FOR_BUILD`

---

## APPENDIX A. OPARI2 INSTALL

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>  
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>  
CXX C++ compiler command  
CXXFLAGS C++ compiler flags  
F77 Fortran 77 compiler command  
FFLAGS Fortran 77 compiler flags  
FC Fortran compiler command  
FCFLAGS Fortran compiler flags  
CPP C preprocessor  
CXXCPP C++ preprocessor

Use these variables to override the choices made by 'configure' or to help  
it to find libraries and programs with nonstandard names/locations.

Please report bugs to <support@score-p.org>.

Installation Instructions  
\*\*\*\*\*

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without warranty of any kind.

## Basic Installation

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Briefly, the shell commands `./configure; make; make install` should configure, build, and install this package. The following more-detailed instructions are generic; see the `'README'` file 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. More recommendations for GNU packages can be found in `*note Makefile Conventions: (standards)Makefile Conventions`.

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 cache files.

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 the address given in the `'README'` 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.

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## APPENDIX A. OPARI2 INSTALL

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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 be 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`

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## APPENDIX A. OPARI2 INSTALL

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`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). The `'README'` should mention any `'--enable-'` and `'--with-'` options that the package recognizes.

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  
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'.

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## APPENDIX A. OPARI2 INSTALL

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### 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

# Data Structure Documentation

### B.1 POMP2\_Region\_info Struct Reference

This struct stores all information on an OpenMP region, like the region type or corresponding source lines. The function [ctcString2RegionInfo\(\)](#) can be used to fill this struct with data from a ctcString.

```
#include <pomp2_region_info.h>
```

#### Data Fields

##### Required attributes

- [POMP2\\_Region\\_type](#) mRegionType
- char \* [mStartFileName](#)
- unsigned [mStartLine1](#)
- unsigned [mStartLine2](#)
- char \* [mEndFileName](#)
- unsigned [mEndLine1](#)
- unsigned [mEndLine2](#)

##### Currently not provided by opari

- bool [mHasCopyIn](#)
- bool [mHasCopyPrivate](#)
- bool [mHasIf](#)
- bool [mHasFirstPrivate](#)
- bool [mHasLastPrivate](#)
- bool [mHasNoWait](#)
- bool [mHasNumThreads](#)
- bool [mHasOrdered](#)

- bool [mHasReduction](#)
- bool [mHasCollapse](#)
- bool [mHasUntied](#)
- [POMP2\\_Schedule\\_type](#) [mScheduleType](#)
- char \* [mUserGroupName](#)

### Attributes for specific region types

- unsigned [mNumSections](#)
- char \* [mCriticalName](#)
- char \* [mUserRegionName](#)

#### B.1.1 Detailed Description

This struct stores all information on an OpenMP region, like the region type or corresponding source lines. The function [ctcString2RegionInfo\(\)](#) can be used to fill this struct with data from a ctcString.

#### B.1.2 Field Documentation

##### B.1.2.1 char\* POMP2\_Region\_info::mCriticalName

name of a named critical region

##### B.1.2.2 char\* POMP2\_Region\_info::mEndFileName

name of the corresponding source file from the closing pragma

##### B.1.2.3 unsigned POMP2\_Region\_info::mEndLine1

line number of the first line from the closing pragma

##### B.1.2.4 unsigned POMP2\_Region\_info::mEndLine2

line number of the last line from the closing pragma

##### B.1.2.5 bool POMP2\_Region\_info::mHasCollapse

true if a collapse clause is present

## **B.1 POMP2\_Region\_info Struct Reference**

---

### **B.1.2.6 bool POMP2\_Region\_info::mHasCopyIn**

true if a copyin clause is present

### **B.1.2.7 bool POMP2\_Region\_info::mHasCopyPrivate**

true if a copyprivate clause is present

### **B.1.2.8 bool POMP2\_Region\_info::mHasFirstPrivate**

true if a firstprivate clause is present

### **B.1.2.9 bool POMP2\_Region\_info::mHasIf**

true if an if clause is present

### **B.1.2.10 bool POMP2\_Region\_info::mHasLastPrivate**

true if a lastprivate clause is present

### **B.1.2.11 bool POMP2\_Region\_info::mHasNoWait**

true if a nowait clause is present

### **B.1.2.12 bool POMP2\_Region\_info::mHasNumThreads**

true if a numThreads clause is present

### **B.1.2.13 bool POMP2\_Region\_info::mHasOrdered**

true if an ordered clause is present

### **B.1.2.14 bool POMP2\_Region\_info::mHasReduction**

true if a reduction clause is present

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## APPENDIX B. DATA STRUCTURE DOCUMENTATION

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### **B.1.2.15    `bool POMP2_Region_info::mHasUntied`**

true if a untied clause was present, even if the task was changed to tied during instrumentation.

### **B.1.2.16    `unsigned POMP2_Region_info::mNumSections`**

number of sections

### **B.1.2.17    `POMP2_Region_type POMP2_Region_info::mRegionType`**

type of the OpenMP region

### **B.1.2.18    `POMP2_Schedule_type POMP2_Region_info::mScheduleType`**

schedule type in the schedule clause

### **B.1.2.19    `char* POMP2_Region_info::mStartFileName`**

name of the corresponding source file from the opening pragma

### **B.1.2.20    `unsigned POMP2_Region_info::mStartLine1`**

line number of the first line from the opening pragma

### **B.1.2.21    `unsigned POMP2_Region_info::mStartLine2`**

line number of the last line from the opening pragma

### **B.1.2.22    `char* POMP2_Region_info::mUserGroupName`**

user group name

### **B.1.2.23    `char* POMP2_Region_info::mUserRegionName`**

name of a user defined region

The documentation for this struct was generated from the following file:

- [pomp2\\_region\\_info.h](#)

## Appendix C

# File Documentation

### C.1 pomp2.lib.h File Reference

This file contains the declarations of all POMP2 functions.

```
#include <stddef.h>
```

```
#include <stdint.h>
```

#### Typedefs

- typedef void \* [POMP2\\_Region\\_handle](#)

#### Functions

- void [POMP2\\_Assign\\_handle](#) ([POMP2\\_Region\\_handle](#) \*pomp2\_handle, const char ctc\_string[])
- void [POMP2\\_Begin](#) ([POMP2\\_Region\\_handle](#) \*pomp2\_handle, const char ctc\_string[])
- void [POMP2\\_End](#) ([POMP2\\_Region\\_handle](#) \*pomp2\_handle)
- void [POMP2\\_Finalize](#) (void)
- [POMP2\\_Task\\_handle](#) [POMP2\\_Get\\_new\\_task\\_handle](#) (void)
- void [POMP2\\_Init](#) (void)
- void [POMP2\\_Off](#) (void)
- void [POMP2\\_On](#) (void)

#### Functions generated by the instrumenter

- size\_t [POMP2\\_Get\\_num\\_regions](#) (void)

---

## APPENDIX C. FILE DOCUMENTATION

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- void [POMP2\\_Init\\_regions](#) (void)
- const char \* [POMP2\\_Get\\_opari2\\_version](#) (void)

### C.1.1 Detailed Description

This file contains the declarations of all POMP2 functions.

### C.1.2 Typedef Documentation

#### C.1.2.1 typedef void\* POMP2\_Region\_handle

Handles to identify OpenMP regions.

### C.1.3 Function Documentation

#### C.1.3.1 void POMP2.Assign\_handle ( POMP2\_Region\_handle \* *pomp2\_handle*, const char *ctc\_string*[] )

Registers a POMP2 region and returns a region handle.

##### Parameters

<i>pomp2_handle</i>	Returns the handle for the newly registered region.
<i>ctc_string</i>	A string containing the region data.

#### C.1.3.2 void POMP2.Begin ( POMP2\_Region\_handle \* *pomp2\_handle*, const char *ctc\_string*[] )

Called at the begin of a user defined POMP2 region.

##### Parameters

<i>pomp2_handle</i>	The handle of the started region.
<i>ctc_string</i>	A string containing the region data.

#### C.1.3.3 void POMP2.End ( POMP2\_Region\_handle \* *pomp2\_handle* )

Called at the begin of a user defined POMP2 region.

## C.1 pomp2\_lib.h File Reference

---

### Parameters

<i>pomp2_- handle</i>	The handle of the started region.
---------------------------	-----------------------------------

#### C.1.3.4 void POMP2.Finalize ( void )

Finalizes the POMP2 adapter. It is inserted at the #pragma pomp inst end.

#### C.1.3.5 POMP2.Task\_handle POMP2.Get\_new\_task\_handle ( void )

Function that returns a new task handle.

### Returns

new task handle

#### C.1.3.6 size\_t POMP2.Get\_num\_regions ( void )

Returns the number of instrumented regions.

The instrumenter scans all opari-created include files with nm and greps the POMP2\_-INIT\_uuid\_numRegions() function calls. Here we return the sum of all numRegions.

### Returns

number of instrumented regions

#### C.1.3.7 const char\* POMP2.Get\_opari2\_version ( void )

Returns the opari version.

### Returns

version string

#### C.1.3.8 void POMP2.Init ( void )

Initializes the POMP2 adapter. It is inserted at the #pragma pomp inst begin.

### C.1.3.9 void POMP2.Init\_regions ( void )

Init all opari-created regions.

The instrumentor scans all opari-created include files with nm and greps the POMP2\_INIT\_uuid\_numRegions() function calls. The instrumentor then defines these functions by calling all grepped functions.

### C.1.3.10 void POMP2.Off ( void )

Disables the POMP2 adapter.

### C.1.3.11 void POMP2.On ( void )

Enables the POMP2 adapter.

## C.2 pomp2\_region\_info.h File Reference

This file contains function declarations and structs which handle informations on OpenMP regions. [POMP2\\_Region\\_info](#) is used to store these informations. It can be filled with a ctcString by [ctcString2RegionInfo\(\)](#).

```
#include <stdbool.h>
```

### Data Structures

- struct [POMP2\\_Region\\_info](#)

*This struct stores all information on an OpenMP region, like the region type or corresponding source lines. The function [ctcString2RegionInfo\(\)](#) can be used to fill this struct with data from a ctcString.*

### Enumerations

- enum [POMP2\\_Region\\_type](#)
- enum [POMP2\\_Schedule\\_type](#)

### Functions

- void [ctcString2RegionInfo](#) (const char ctcString[ ], [POMP2\\_Region\\_info](#) \*regionInfo)
- void [freePOMP2RegionInfoMembers](#) ([POMP2\\_Region\\_info](#) \*regionInfo)
- const char \* [pomp2RegionType2String](#) ([POMP2\\_Region\\_type](#) regionType)

## C.2 pomp2\_region\_info.h File Reference

---

- const char \* [pomp2ScheduleType2String](#) (POMP2\_Schedule\_type sched-  
uleType)

### C.2.1 Detailed Description

This file contains function declarations and structs which handle informations on OpenMP regions. [POMP2\\_Region\\_info](#) is used to store these informations. It can be filled with a ctcString by [ctcString2RegionInfo\(\)](#).

#### Date

Started Fri Mar 20 16:30:45 2009

### C.2.2 Enumeration Type Documentation

#### C.2.2.1 enum POMP2\_Region\_type

POMP2\_Region\_type

#### C.2.2.2 enum POMP2\_Schedule\_type

type to store the scheduling type of a for worksharing construct

### C.2.3 Function Documentation

#### C.2.3.1 void ctcString2RegionInfo ( const char *ctcString*[], POMP2\_Region\_info \* *regionInfo* )

[ctcString2RegionInfo\(\)](#) fills the [POMP2\\_Region\\_info](#) object with data read from the ctcString. If the ctcString does not comply with the specification, the program aborts with exit code 1.

Rationale: [ctcString2RegionInfo\(\)](#) is used during initialization of the measurement system. If an error occurs, it is better to abort than to struggle with undefined behaviour or *guessing* the meaning of the broken string.

#### Note

Can be called from multiple threads concurrently, assuming malloc is thread-safe.

[ctcString2RegionInfo\(\)](#) will assign memory to the members of *regionInfo*. You are supposed to release this memory by calling [freePOMP2RegionInfoMembers\(\)](#).

---

## APPENDIX C. FILE DOCUMENTATION

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### Parameters

<i>ctcString</i>	A string in the format "length*key=value*[key=value]*". The length field is parsed but not used by this implementation. Possible values for key are listed in <code>ctcTokenMap</code> . The string must at least contain values for the keys <code>regionType</code> , <code>sscl</code> and <code>escl</code> . Possible values for the key <code>regionType</code> are listed in <code>regionTypesMap</code> . The format for <code>sscl</code> resp. <code>escl</code> values is "filename:lineNo1:lineNo2".
<i>regionInfo</i>	must be a valid object

### Postcondition

At least the required attributes (see [POMP2\\_Region\\_info](#)) are set.

All other members of *regionInfo* are set to 0 resp. false resp. `POMP2_No_schedule`.

If `regionType=sections` than `POMP2_Region_info::mNumSections` has a value  $> 0$ .

If `regionType=region` than `POMP2_Region_info::mUserRegionName` has a value  $\neq 0$ .

If `regionType=critical` than `POMP2_Region_info::mCriticalName` may have a value  $\neq 0$ .

#### C.2.3.2 void freePOMP2RegionInfoMembers ( POMP2\_Region\_info \* *regionInfo* )

Free the memory of the *regionInfo* members.

### Parameters

<i>regionInfo</i>	The regioninfo to be freed.
-------------------	-----------------------------

#### C.2.3.3 const char\* pomp2RegionType2String ( POMP2\_Region\_type *regionType* )

converts *regionType* into a string

### Parameters

<i>regionType</i>	The <i>regionType</i> to be converted.
-------------------	--

### Returns

string representation of the region type

## C.2 pomp2\_region\_info.h File Reference

---

### C.2.3.4 `const char* pomp2ScheduleType2String ( POMP2_Schedule_type scheduleType )`

converts `scheduleType` into a string

#### Parameters

<i>schedule- Type</i>	The <code>scheduleType</code> to be converted.
---------------------------	--

#### Returns

string representation of the `scheduleType`

# Index

ctcString2RegionInfo  
    pomp2\_region\_info.h, [33](#)

freePOMP2RegionInfoMembers  
    pomp2\_region\_info.h, [34](#)

mCriticalName  
    POMP2\_Region\_info, [26](#)

mEndFileName  
    POMP2\_Region\_info, [26](#)

mEndLine1  
    POMP2\_Region\_info, [26](#)

mEndLine2  
    POMP2\_Region\_info, [26](#)

mHasCollapse  
    POMP2\_Region\_info, [26](#)

mHasCopyIn  
    POMP2\_Region\_info, [26](#)

mHasCopyPrivate  
    POMP2\_Region\_info, [27](#)

mHasFirstPrivate  
    POMP2\_Region\_info, [27](#)

mHasIf  
    POMP2\_Region\_info, [27](#)

mHasLastPrivate  
    POMP2\_Region\_info, [27](#)

mHasNoWait  
    POMP2\_Region\_info, [27](#)

mHasNumThreads  
    POMP2\_Region\_info, [27](#)

mHasOrdered  
    POMP2\_Region\_info, [27](#)

mHasReduction  
    POMP2\_Region\_info, [27](#)

mHasUntied  
    POMP2\_Region\_info, [27](#)

mNumSections  
    POMP2\_Region\_info, [28](#)

mRegionType  
    POMP2\_Region\_info, [28](#)

mScheduleType  
    POMP2\_Region\_info, [28](#)

mStartFileName  
    POMP2\_Region\_info, [28](#)

mStartLine1  
    POMP2\_Region\_info, [28](#)

mStartLine2  
    POMP2\_Region\_info, [28](#)

mUserGroupName  
    POMP2\_Region\_info, [28](#)

mUserRegionName  
    POMP2\_Region\_info, [28](#)

POMP2\_Assign\_handle  
    pomp2\_lib.h, [30](#)

POMP2\_Begin  
    pomp2\_lib.h, [30](#)

POMP2\_End  
    pomp2\_lib.h, [30](#)

POMP2\_Finalize  
    pomp2\_lib.h, [31](#)

POMP2\_Get\_new\_task\_handle  
    pomp2\_lib.h, [31](#)

POMP2\_Get\_num\_regions  
    pomp2\_lib.h, [31](#)

POMP2\_Get\_opari2\_version  
    pomp2\_lib.h, [31](#)

POMP2\_Init  
    pomp2\_lib.h, [31](#)

POMP2\_Init\_regions  
    pomp2\_lib.h, [31](#)

pomp2\_lib.h, [29](#)

## INDEX

---

POMP2\_Assign\_handle, 30  
POMP2\_Begin, 30  
POMP2\_End, 30  
POMP2\_Finalize, 31  
POMP2\_Get\_new\_task\_handle, 31  
POMP2\_Get\_num\_regions, 31  
POMP2\_Get\_opari2\_version, 31  
POMP2\_Init, 31  
POMP2\_Init\_regions, 31  
POMP2\_Off, 32  
POMP2\_On, 32  
POMP2\_Region\_handle, 30  
POMP2\_Off  
    pomp2\_lib.h, 32  
POMP2\_On  
    pomp2\_lib.h, 32  
POMP2\_Region\_handle  
    pomp2\_lib.h, 30  
POMP2\_Region\_info, 25  
    mCriticalName, 26  
    mEndFileName, 26  
    mEndLine1, 26  
    mEndLine2, 26  
    mHasCollapse, 26  
    mHasCopyIn, 26  
    mHasCopyPrivate, 27  
    mHasFirstPrivate, 27  
    mHasIf, 27  
    mHasLastPrivate, 27  
    mHasNoWait, 27  
    mHasNumThreads, 27  
    mHasOrdered, 27  
    mHasReduction, 27  
    mHasUntied, 27  
    mNumSections, 28  
    mRegionType, 28  
    mScheduleType, 28  
    mStartFileName, 28  
    mStartLine1, 28  
    mStartLine2, 28  
    mUserGroupName, 28  
    mUserRegionName, 28  
pomp2\_region\_info.h, 32  
    ctcString2RegionInfo, 33  
    freePOMP2RegionInfoMembers, 34  
POMP2\_Region\_type, 33  
POMP2\_Schedule\_type, 33  
    pomp2RegionType2String, 34  
    pomp2ScheduleType2String, 34  
POMP2\_Region\_type  
    pomp2\_region\_info.h, 33  
POMP2\_Schedule\_type  
    pomp2\_region\_info.h, 33  
pomp2RegionType2String  
    pomp2\_region\_info.h, 34  
pomp2ScheduleType2String  
    pomp2\_region\_info.h, 34

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