Hardware Locality (hwloc)

1.0.3

Generated by Doxygen 1.7.1

Thu Dec 16 2010 06:44:16

Contents

Chapter 1

Hardware Locality

Portable abstraction of hierarchical architectures for high-performance computing

1.1 Introduction

hwloc provides command line tools and a C API to obtain the hierarchical map of key computing elements, such as: NUMA memory nodes, shared caches, processor sockets, processor cores, and processing units (logical processors or "threads"). hwloc also gathers various attributes such as cache and memory information, and is portable across a variety of different operating systems and platforms.

hwloc primarily aims at helping high-performance computing (HPC) applications, but is also applicable to any project seeking to exploit code and/or data locality on modern computing platforms.

Note that the hwloc project represents the merger of the libtopology project from INRIA and the Portable Linux Processor Affinity (PLPA) sub-project from Open MPI. *Both of these prior projects are now deprecated.* The first hwloc release is essentially a "re-branding" of the libtopology code base, but with both a few genuinely new features and a few PLPA-like features added in. More new features and more PLPA-like features will be added to hwloc over time. See Switching from PLPA to hwloc for more details about converting your application from PLPA to hwloc.

hwloc supports the following operating systems:

- Linux (including old kernels not having sysfs topology information, with knowledge of cpusets, offline cpus, ScaleMP vSMP, and Kerrighed support)
- Solaris
- AIX
- Darwin / OS X
- FreeBSD and its variants, such as kFreeBSD/GNU
- OSF/1 (a.k.a., Tru64)
- HP-UX
- Microsoft Windows

hwloc only reports the number of processors on unsupported operating systems; no topology information is available.

For development and debugging purposes, hwloc also offers the ability to work on "fake" topologies:

- Symmetrical tree of resources generated from a list of level arities
- Remote machine simulation through the gathering of Linux sysfs topology files

hwloc can display the topology in a human-readable format, either in graphical mode (X11), or by exporting in one of several different formats, including: plain text, PDF, PNG, and FIG (see CLI Examples below). Note that some of the export formats require additional support libraries.

hwloc offers a programming interface for manipulating topologies and objects. It also brings a powerful CPU bitmap API that is used to describe topology objects location on physical/logical processors. See the Programming Interface below. It may also be used to binding applications onto certain cores or memory nodes. Several utility programs are also provided to ease command-line manipulation of topology objects, binding of processes, and so on.

1.2 Installation

hwloc (`http://www.open-mpi.org/projects/hwloc/`) is available under the BSD license. It is hosted as a sub-project of the overall Open MPI project (`http://www.open-mpi.org/`). Note that hwloc does not require any functionality from Open MPI -- it is a wholly separate (and much smaller!) project and code base. It just happens to be hosted as part of the overall Open MPI project.

Nightly development snapshots are available on the web site. Additionally, the code can be directly checked out of Subversion:

```
shell$ svn checkout http://svn.open-mpi.org/svn/hwloc/trunk hwloc-trunk
shell$ cd hwloc-trunk
shell$ ./autogen.sh
```

Note that GNU Autoconf >=2.63, Automake >=1.10 and Libtool >=2.2.6 are required when building from a Subversion checkout.

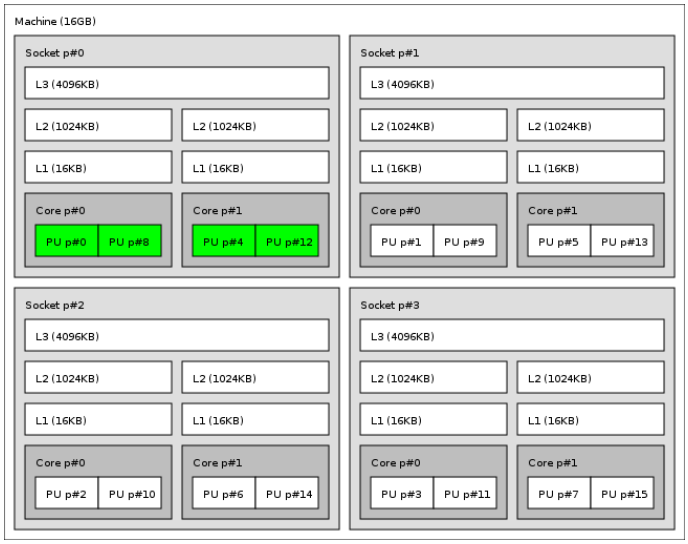
Installation by itself is the fairly common GNU-based process:

```
shell$ ./configure --prefix=...
shell$ make
shell$ make install
```

The hwloc command-line tool "lstopo" produces human-readable topology maps, as mentioned above. It can also export maps to the "fig" file format. Support for PDF, Postscript, and PNG exporting is provided if the "Cairo" development package can be found when hwloc is configured and build. Similarly, lstopo's XML support requires the libxml2 development package.

1.3 CLI Examples

On a 4-socket 2-core machine with hyperthreading, the `lstopo` tool may show the following graphical output:



Here's the equivalent output in textual form:

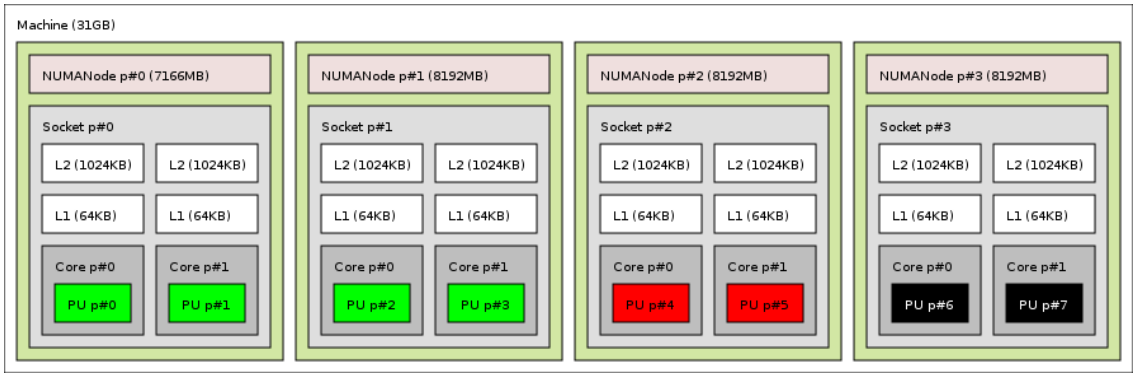
```
Machine (16GB)
  Socket #0 + L3 #0 (4096KB)
    L2 #0 (1024KB) + L1 #0 (16KB) + Core #0
      PU #0 (phys=0)
      PU #1 (phys=8)
    L2 #1 (1024KB) + L1 #1 (16KB) + Core #1
      PU #2 (phys=4)
      PU #3 (phys=12)
  Socket #1 + L3 #1 (4096KB)
    L2 #2 (1024KB) + L1 #2 (16KB) + Core #2
      PU #4 (phys=1)
      PU #5 (phys=9)
    L2 #3 (1024KB) + L1 #3 (16KB) + Core #3
      PU #6 (phys=5)
      PU #7 (phys=13)
  Socket #2 + L3 #2 (4096KB)
    L2 #4 (1024KB) + L1 #4 (16KB) + Core #4
      PU #8 (phys=2)
      PU #9 (phys=10)
    L2 #5 (1024KB) + L1 #5 (16KB) + Core #5
      PU #10 (phys=6)
      PU #11 (phys=14)
  Socket #3 + L3 #3 (4096KB)
    L2 #6 (1024KB) + L1 #6 (16KB) + Core #6
      PU #12 (phys=3)
      PU #13 (phys=11)
    L2 #7 (1024KB) + L1 #7 (16KB) + Core #7
      PU #14 (phys=7)
      PU #15 (phys=15)
```

Finally, here's the equivalent output in XML. Long lines were artificially broken for document clarity (in the real output, each XML tag is on a single line), and only socket #0 is shown for brevity:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE topology SYSTEM "hwloc.dtd">
<topology>
  <object type="Machine" os_level="-1" os_index="0" cpuset="0x0000ffff"
      complete_cpuset="0x0000ffff" online_cpuset="0x0000ffff"
      allowed_cpuset="0x0000ffff"
      dmi_board_vendor="Dell Computer Corporation" dmi_board_name="0RD318"
      local_memory="16648183808">
    <page_type size="4096" count="4064498"/>
```

```
    <page_type size="2097152" count="0"/>
    <object type="Socket" os_level="-1" os_index="0" cpuset="0x00001111"
        complete_cpuset="0x00001111" online_cpuset="0x00001111"
        allowed_cpuset="0x00001111">
      <object type="Cache" os_level="-1" cpuset="0x00001111"
          complete_cpuset="0x00001111" online_cpuset="0x00001111"
          allowed_cpuset="0x00001111" cache_size="4194304" depth="3"
          cache_linesize="64">
        <object type="Cache" os_level="-1" cpuset="0x00000101"
            complete_cpuset="0x00000101" online_cpuset="0x00000101"
            allowed_cpuset="0x00000101" cache_size="1048576" depth="2"
            cache_linesize="64">
          <object type="Cache" os_level="-1" cpuset="0x00000101"
              complete_cpuset="0x00000101" online_cpuset="0x00000101"
              allowed_cpuset="0x00000101" cache_size="16384" depth="1"
              cache_linesize="64">
            <object type="Core" os_level="-1" os_index="0" cpuset="0x00000101"
                complete_cpuset="0x00000101" online_cpuset="0x00000101"
                allowed_cpuset="0x00000101">
              <object type="PU" os_level="-1" os_index="0" cpuset="0x00000001"
                  complete_cpuset="0x00000001" online_cpuset="0x00000001"
                  allowed_cpuset="0x00000001"/>
              <object type="PU" os_level="-1" os_index="8" cpuset="0x00000100"
                  complete_cpuset="0x00000100" online_cpuset="0x00000100"
                  allowed_cpuset="0x00000100"/>
            </object>
          </object>
        </object>
        <object type="Cache" os_level="-1" cpuset="0x00001010"
            complete_cpuset="0x00001010" online_cpuset="0x00001010"
            allowed_cpuset="0x00001010" cache_size="1048576" depth="2"
            cache_linesize="64">
          <object type="Cache" os_level="-1" cpuset="0x00001010"
              complete_cpuset="0x00001010" online_cpuset="0x00001010"
              allowed_cpuset="0x00001010" cache_size="16384" depth="1"
              cache_linesize="64">
            <object type="Core" os_level="-1" os_index="1" cpuset="0x00001010"
                complete_cpuset="0x00001010" online_cpuset="0x00001010"
                allowed_cpuset="0x00001010">
              <object type="PU" os_level="-1" os_index="4" cpuset="0x00000010"
                  complete_cpuset="0x00000010" online_cpuset="0x00000010"
                  allowed_cpuset="0x00000010"/>
              <object type="PU" os_level="-1" os_index="12" cpuset="0x00001000"
                  complete_cpuset="0x00001000" online_cpuset="0x00001000"
                  allowed_cpuset="0x00001000"/>
            </object>
          </object>
        </object>
      </object>
    </object>
    <!-- ...other sockets listed here ... -->
  </object>
</topology>
```

On a 4-socket 2-core Opteron NUMA machine, the `lstopo` tool may show the following graphical output:



Here's the equivalent output in textual form:

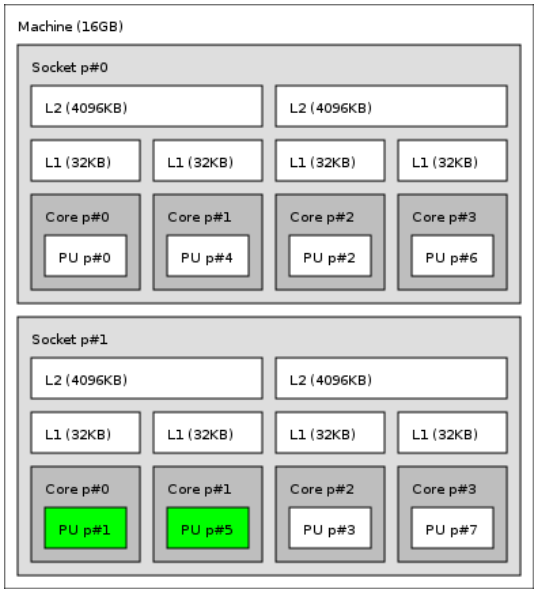
```
Machine (64GB)
  NUMANode #0 (phys=0 8190MB) + Socket #0
    L2 #0 (1024KB) + L1 #0 (64KB) + Core #0 + PU #0 (phys=0)
    L2 #1 (1024KB) + L1 #1 (64KB) + Core #1 + PU #1 (phys=1)
  NUMANode #1 (phys=1 8192MB) + Socket #1
    L2 #2 (1024KB) + L1 #2 (64KB) + Core #2 + PU #2 (phys=2)
    L2 #3 (1024KB) + L1 #3 (64KB) + Core #3 + PU #3 (phys=3)
  NUMANode #2 (phys=2 8192MB) + Socket #2
    L2 #4 (1024KB) + L1 #4 (64KB) + Core #4 + PU #4 (phys=4)
    L2 #5 (1024KB) + L1 #5 (64KB) + Core #5 + PU #5 (phys=5)
  NUMANode #3 (phys=3 8192MB) + Socket #3
    L2 #6 (1024KB) + L1 #6 (64KB) + Core #6 + PU #6 (phys=6)
    L2 #7 (1024KB) + L1 #7 (64KB) + Core #7 + PU #7 (phys=7)
  NUMANode #4 (phys=4 8192MB) + Socket #4
    L2 #8 (1024KB) + L1 #8 (64KB) + Core #8 + PU #8 (phys=8)
    L2 #9 (1024KB) + L1 #9 (64KB) + Core #9 + PU #9 (phys=9)
  NUMANode #5 (phys=5 8192MB) + Socket #5
    L2 #10 (1024KB) + L1 #10 (64KB) + Core #10 + PU #10 (phys=10)
    L2 #11 (1024KB) + L1 #11 (64KB) + Core #11 + PU #11 (phys=11)
  NUMANode #6 (phys=6 8192MB) + Socket #6
    L2 #12 (1024KB) + L1 #12 (64KB) + Core #12 + PU #12 (phys=12)
    L2 #13 (1024KB) + L1 #13 (64KB) + Core #13 + PU #13 (phys=13)
  NUMANode #7 (phys=7 8192MB) + Socket #7
    L2 #14 (1024KB) + L1 #14 (64KB) + Core #14 + PU #14 (phys=14)
    L2 #15 (1024KB) + L1 #15 (64KB) + Core #15 + PU #15 (phys=15)
```

And here's the equivalent output in XML. Similar to above, line breaks were added and only PU#0 is shown for brevity:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE topology SYSTEM "hwloc.dtd">
<topology>
  <object type="Machine" os_level="-1" os_index="0" cpuset="0x000000ff"
      complete_cpuset="0x000000ff" online_cpuset="0x000000ff"
      allowed_cpuset="0x000000ff" nodeset="0x000000ff"
      complete_nodeset="0x000000ff" allowed_nodeset="0x000000ff"
      dmi_board_vendor="TYAN Computer Corp" dmi_board_name="S4881 ">
    <page_type size="4096" count="0"/>
    <page_type size="2097152" count="0"/>
    <object type="NUMANode" os_level="-1" os_index="0" cpuset="0x00000003"
        complete_cpuset="0x00000003" online_cpuset="0x00000003"
        allowed_cpuset="0x00000003" nodeset="0x00000001"
        complete_nodeset="0x00000001" allowed_nodeset="0x00000001"
        local_memory="7514177536">
      <page_type size="4096" count="1834516"/>
      <page_type size="2097152" count="0"/>
      <object type="Socket" os_level="-1" os_index="0" cpuset="0x00000003"
```

```
          complete_cpuset="0x00000003" online_cpuset="0x00000003"
          allowed_cpuset="0x00000003" nodeset="0x00000001"
          complete_nodeset="0x00000001" allowed_nodeset="0x00000001">
        <object type="Cache" os_level="-1" cpuset="0x00000001"
            complete_cpuset="0x00000001" online_cpuset="0x00000001"
            allowed_cpuset="0x00000001" nodeset="0x00000001"
            complete_nodeset="0x00000001" allowed_nodeset="0x00000001"
            cache_size="1048576" depth="2" cache_linesize="64">
          <object type="Cache" os_level="-1" cpuset="0x00000001"
              complete_cpuset="0x00000001" online_cpuset="0x00000001"
              allowed_cpuset="0x00000001" nodeset="0x00000001"
              complete_nodeset="0x00000001" allowed_nodeset="0x00000001"
              cache_size="65536" depth="1" cache_linesize="64">
            <object type="Core" os_level="-1" os_index="0"
                cpuset="0x00000001" complete_cpuset="0x00000001"
                online_cpuset="0x00000001" allowed_cpuset="0x00000001"
                nodeset="0x00000001" complete_nodeset="0x00000001"
                allowed_nodeset="0x00000001">
              <object type="PU" os_level="-1" os_index="0" cpuset="0x00000001"
                  complete_cpuset="0x00000001" online_cpuset="0x00000001"
                  allowed_cpuset="0x00000001" nodeset="0x00000001"
                  complete_nodeset="0x00000001" allowed_nodeset="0x00000001"/>
            </object>
          </object>
        </object>
  <!-- ...more objects listed here ... -->
</topology>
```

On a 2-socket quad-core Xeon (pre-Nehalem, with 2 dual-core dies into each socket):



Here's the same output in textual form:

```
Machine (16GB)
  Socket #0
    L2 #0 (4096KB)
      L1 #0 (32KB) + Core #0 + PU #0 (phys=0)
      L1 #1 (32KB) + Core #1 + PU #1 (phys=4)
    L2 #1 (4096KB)
      L1 #2 (32KB) + Core #2 + PU #2 (phys=2)
      L1 #3 (32KB) + Core #3 + PU #3 (phys=6)
  Socket #1
    L2 #2 (4096KB)
      L1 #4 (32KB) + Core #4 + PU #4 (phys=1)
```

```
      L1 #5 (32KB) + Core #5 + PU #5 (phys=5)
    L2 #3 (4096KB)
      L1 #6 (32KB) + Core #6 + PU #6 (phys=3)
      L1 #7 (32KB) + Core #7 + PU #7 (phys=7)
```

And the same output in XML (line breaks added, only PU#0 shown):

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE topology SYSTEM "hwloc.dtd">
<topology>
  <object type="Machine" os_level="-1" os_index="0" cpuset="0x000000ff"
      complete_cpuset="0x000000ff" online_cpuset="0x000000ff"
      allowed_cpuset="0x000000ff" dmi_board_vendor="Dell Inc."
      dmi_board_name="0NR282" local_memory="16865292288">
    <page_type size="4096" count="4117503"/>
    <page_type size="2097152" count="0"/>
    <object type="Socket" os_level="-1" os_index="0" cpuset="0x00000055"
        complete_cpuset="0x00000055" online_cpuset="0x00000055"
        allowed_cpuset="0x00000055">
      <object type="Cache" os_level="-1" cpuset="0x00000011"
          complete_cpuset="0x00000011" online_cpuset="0x00000011"
          allowed_cpuset="0x00000011" cache_size="4194304" depth="2"
          cache_linesize="64">
        <object type="Cache" os_level="-1" cpuset="0x00000001"
            complete_cpuset="0x00000001" online_cpuset="0x00000001"
            allowed_cpuset="0x00000001" cache_size="32768" depth="1"
            cache_linesize="64">
          <object type="Core" os_level="-1" os_index="0" cpuset="0x00000001"
              complete_cpuset="0x00000001" online_cpuset="0x00000001"
              allowed_cpuset="0x00000001">
            <object type="PU" os_level="-1" os_index="0" cpuset="0x00000001"
                complete_cpuset="0x00000001" online_cpuset="0x00000001"
                allowed_cpuset="0x00000001"/>
          </object>
        </object>
        <object type="Cache" os_level="-1" cpuset="0x00000010"
            complete_cpuset="0x00000010" online_cpuset="0x00000010"
            allowed_cpuset="0x00000010" cache_size="32768" depth="1"
            cache_linesize="64">
          <object type="Core" os_level="-1" os_index="1" cpuset="0x00000010"
              complete_cpuset="0x00000010" online_cpuset="0x00000010"
              allowed_cpuset="0x00000010">
            <object type="PU" os_level="-1" os_index="4" cpuset="0x00000010"
                complete_cpuset="0x00000010" online_cpuset="0x00000010"
                allowed_cpuset="0x00000010"/>
          </object>
        </object>
      </object>
  <!-- ...more objects listed here ... -->
</topology>
```

1.4 Programming Interface

The basic interface is available in hwloc.h. It essentially offers low-level routines for advanced programmers that want to manually manipulate objects and follow links between them. Documentation for everything in hwloc.h are provided later in this document. Developers should also look at hwloc/helper.h (and also in this document, which provides good higher-level topology traversal examples.

To precisely define the vocabulary used by hwloc, a Terms and Definitions section is available and should probably be read first.

Each hwloc object contains a cpuset describing the list of processing units that it contains. These cpusets may be used for Binding. hwloc offers an extensive cpuset manipulation interface in hwloc/cpuset.h.

Moreover, hwloc also comes with additional helpers for interoperability with several commonly used environments. See the Interoperability with other software section for details.

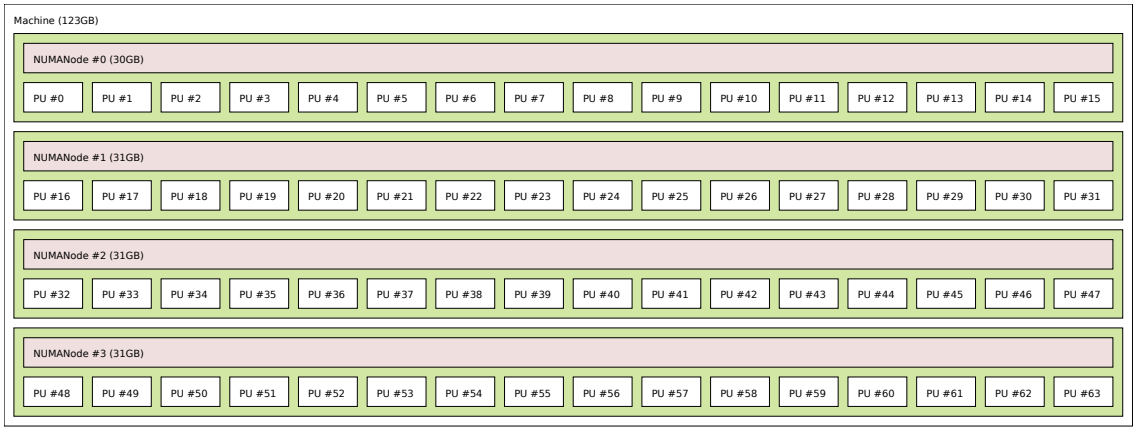
The complete API documentation is available in a full set of HTML pages, man pages, and self-contained PDF files (formatted for both both US letter and A4 formats) in the source tarball in doc/doxygen-doc/.

NOTE: If you are building the documentation from a Subversion checkout, you will need to have Doxygen and pdflatex installed -- the documentation will be built during the normal "make" process. The documentation is installed during "make install" to $prefix/share/doc/hwloc/ and your systems default man page tree (under $prefix, of course).

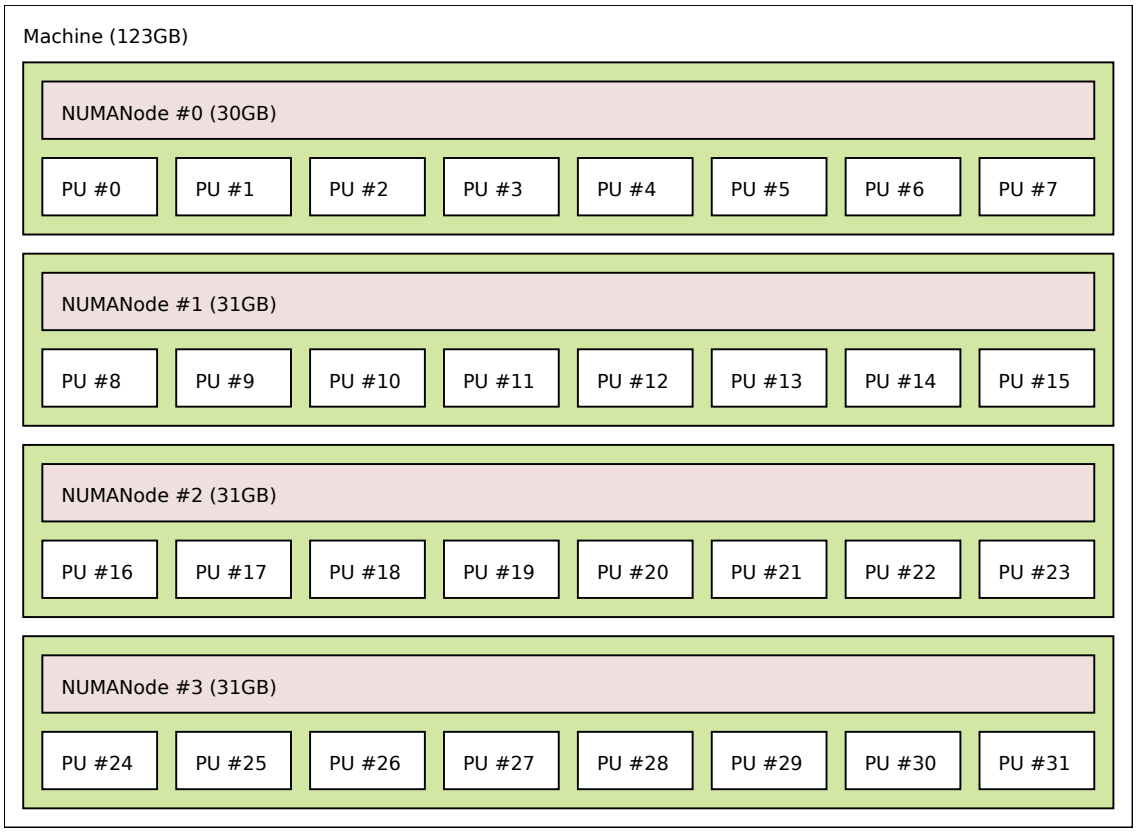
1.4.1 Portability (especially when using the API or XML)

As shown in CLI Examples, hwloc can obtain information on a wide variety of hardware topologies. However, some platforms and/or operating system versions will only report a subset of this information. For example, on an PPC64-based system with 32 cores (each with 2 hardware threads) running a default 2.6.18-based kernel from RHEL 5.4, hwloc is only able to glean information about NUMA nodes and processor units (PUs). No information about caches, sockets, or cores is available.

Here's the graphical output from lstopo on this platform when Simultaneous Multi-Threading (SMT) is enabled:



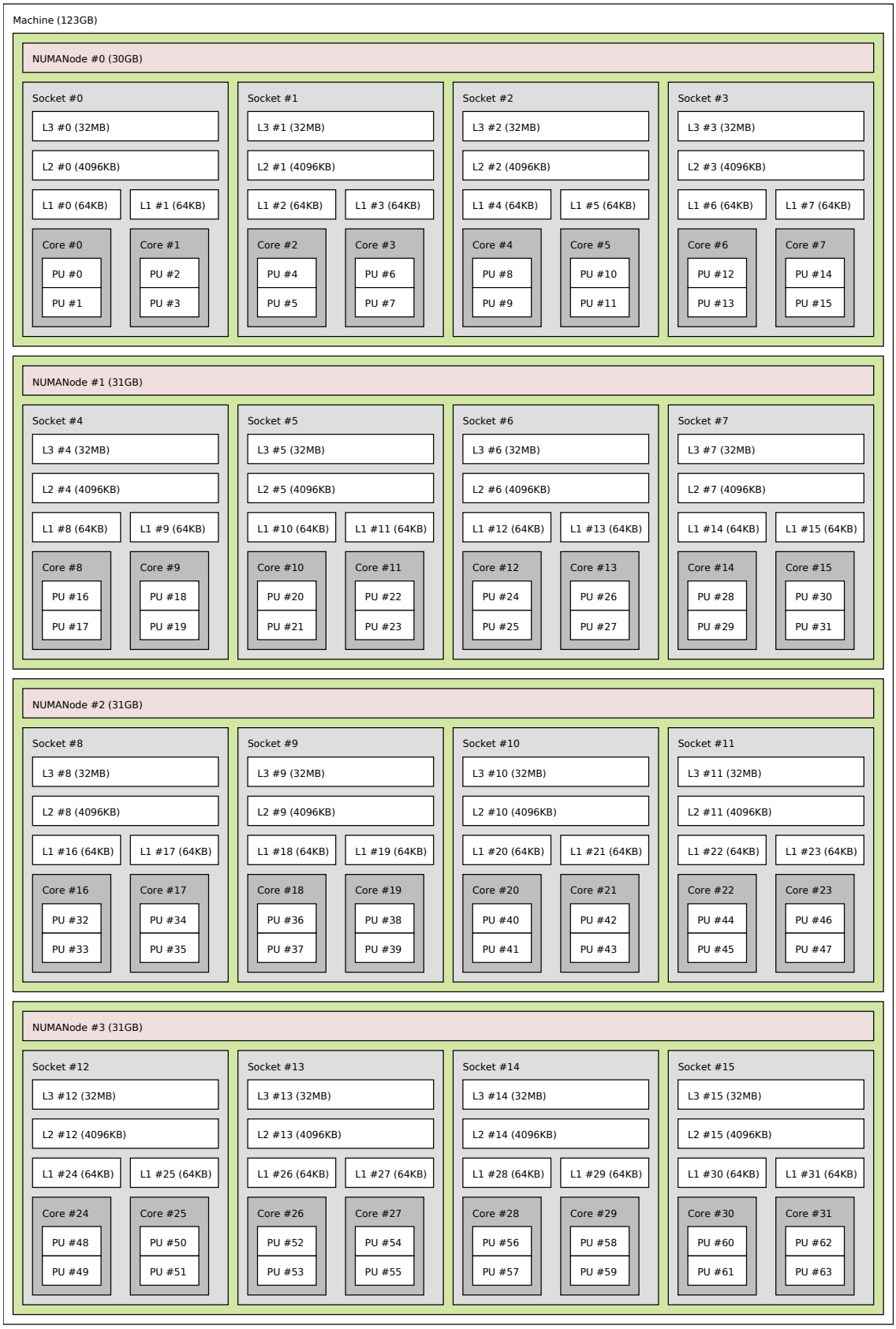
And here's the graphical output from lstopo on this platform when SMT is disabled:



Notice that hwloc only sees half the PUs when SMT is disabled. PU#15, for example, seems to change location from NUMA node #0 to #1. In reality, no PUs "moved" -- they were simply re-numbered when hwloc only saw half as many. Hence, PU#15 in the SMT-disabled picture probably corresponds to PU#30 in the SMT-enabled picture.

This same "PUs have disappeared" effect can be seen on other platforms -- even platforms / OSs that provide much more information than the above PPC64 system. This is an unfortunate side-effect of how operating systems report information to hwloc.

Note that upgrading the Linux kernel on the same PPC64 system mentioned above to 2.6.34, hwloc is able to discover all the topology information. The following picture shows the entire topology layout when SMT is enabled:


Machine (123GB)
NUMANode #0 (30GB)
Socket #0
L3 #0 (32MB)
L2 #0 (4096KB)
L1 #0 (64KB)
L1 #1 (64KB)
Core #0
PU #0
PU #1
Core #1
PU #2
PU #3
Socket #1
L3 #1 (32MB)
L2 #1 (4096KB)
L1 #2 (64KB)
L1 #3 (64KB)
Core #2
PU #4
PU #5
Core #3
PU #6
PU #7
Socket #2
L3 #2 (32MB)
L2 #2 (4096KB)
L1 #4 (64KB)
L1 #5 (64KB)
Core #4
PU #8
PU #9
Core #5
PU #10
PU #11
Socket #3
L3 #3 (32MB)
L2 #3 (4096KB)
L1 #6 (64KB)
L1 #7 (64KB)
Core #6
PU #12
PU #13
Core #7
PU #14
PU #15
NUMANode #1 (31GB)
Socket #4
L3 #4 (32MB)
L2 #4 (4096KB)
L1 #8 (64KB)
L1 #9 (64KB)
Core #8
PU #16
PU #17
Core #9
PU #18
PU #19
Socket #5
L3 #5 (32MB)
L2 #5 (4096KB)
L1 #10 (64KB)
L1 #11 (64KB)
Core #10
PU #20
PU #21
Core #11
PU #22
PU #23
Socket #6
L3 #6 (32MB)
L2 #6 (4096KB)
L1 #12 (64KB)
L1 #13 (64KB)
Core #12
PU #24
PU #25
Core #13
PU #26
PU #27
Socket #7
L3 #7 (32MB)
L2 #7 (4096KB)
L1 #14 (64KB)
L1 #15 (64KB)
Core #14
PU #28
PU #29
Core #15
PU #30
PU #31
NUMANode #2 (31GB)
Socket #8
L3 #8 (32MB)
L2 #8 (4096KB)
L1 #16 (64KB)
L1 #17 (64KB)
Core #16
PU #32
PU #33
Core #17
PU #34
PU #35
Socket #9
L3 #9 (32MB)
L2 #9 (4096KB)
L1 #18 (64KB)
L1 #19 (64KB)
Core #18
PU #36
PU #37
Core #19
PU #38
PU #39
Socket #10
L3 #10 (32MB)
L2 #10 (4096KB)
L1 #20 (64KB)
L1 #21 (64KB)
Core #20
PU #40
PU #41
Core #21
PU #42
PU #43
Socket #11
L3 #11 (32MB)
L2 #11 (4096KB)
L1 #22 (64KB)
L1 #23 (64KB)
Core #22
PU #44
PU #45
Core #23
PU #46
PU #47
NUMANode #3 (31GB)
Socket #12
L3 #12 (32MB)
L2 #12 (4096KB)
L1 #24 (64KB)
L1 #25 (64KB)
Core #24
PU #48
PU #49
Core #25
PU #50
PU #51
Socket #13
L3 #13 (32MB)
L2 #13 (4096KB)
L1 #26 (64KB)
L1 #27 (64KB)
Core #26
PU #52
PU #53
Core #27
PU #54
PU #55
Socket #14
L3 #14 (32MB)
L2 #14 (4096KB)
L1 #28 (64KB)
L1 #29 (64KB)
Core #28
PU #56
PU #57
Core #29
PU #58
PU #59
Socket #15
L3 #15 (32MB)
L2 #15 (4096KB)
L1 #30 (64KB)
L1 #31 (64KB)
Core #30
PU #60
PU #61
Core #31
PU #62
PU #63

Developers using the hwloc API or XML output for portable applications should therefore be extremely careful to not make any assumptions about the structure of data that is returned. For example, per the above reported PPC topology, it is not safe to assume that PUs will always be descendants of cores.

Additionally, future hardware may insert new topology elements that are not available in this version of hwloc. Long-lived applications that are meant to span multiple different hardware platforms should also be careful about making structure assumptions. For example, there may someday be an element "lower" than a PU, or perhaps a new element may exist between a core and a PU.

1.4.2 API Example

The following small C example (named “hwloc-hello.c”) prints the topology of the machine and bring the process to the first logical processor of the second core of the machine.

```
/* Example hwloc API program.
 *
 * Copyright © 2009 INRIA, Université Bordeaux 1
 * Copyright © 2009-2010 Cisco Systems, Inc.  All rights reserved.
 *
 * hwloc-hello.c
 */

#include <hwloc.h>

static void print_children(hwloc_topology_t topology, hwloc_obj_t obj,
                           int depth)
{
    char string[128];
    unsigned i;

    hwloc_obj_snprintf(string, sizeof(string), topology, obj, "#", 0);
    printf("%*s%s\n", 2*depth, "", string);
    for (i = 0; i < obj->arity; i++) {
        print_children(topology, obj->children[i], depth + 1);
    }
}

int main(void)
{
    int depth;
    unsigned i;
    unsigned long size;
    int levels;
    char string[128];
    int topodepth;
    hwloc_topology_t topology;
    hwloc_cpuset_t cpuset;
    hwloc_obj_t obj;

    /* Allocate and initialize topology object. */
    hwloc_topology_init(&topology);

    /* ... Optionally, put detection configuration here to ignore
       some objects types, define a synthetic topology, etc....

       The default is to detect all the objects of the machine that
       the caller is allowed to access.  See Configure Topology
       Detection. */

    /* Perform the topology detection. */
    hwloc_topology_load(topology);

    /* Optionally, get some additional topology information
       in case we need the topology depth later. */
```

```
topodepth = hwloc_topology_get_depth(topology);

/*****************************************************************
 * First example:
 * Walk the topology with an array style, from level 0 (always
 * the system level) to the lowest level (always the proc level).
 *****************************************************************/
for (depth = 0; depth < topodepth; depth++) {
    printf("*** Objects at level %d\n", depth);
    for (i = 0; i < hwloc_get_nbobjs_by_depth(topology, depth);
         i++) {
        hwloc_obj_snprintf(string, sizeof(string), topology,
                    hwloc_get_obj_by_depth(topology, depth, i),
                    "#", 0);
        printf("Index %u: %s\n", i, string);
    }
}

/*****************************************************************
 * Second example:
 * Walk the topology with a tree style.
 *****************************************************************/
printf("*** Printing overall tree\n");
print_children(topology, hwloc_get_root_obj(topology), 0);

/*****************************************************************
 * Third example:
 * Print the number of sockets.
 *****************************************************************/
depth = hwloc_get_type_depth(topology, HWLOC_OBJ_SOCKET);
if (depth == HWLOC_TYPE_DEPTH_UNKNOWN) {
    printf("*** The number of sockets is unknown\n");
} else {
    printf("*** %u socket(s)\n",
           hwloc_get_nbobjs_by_depth(topology, depth));
}

/*****************************************************************
 * Fourth example:
 * Compute the amount of cache that the first logical processor
 * has above it.
 *****************************************************************/
levels = 0;
size = 0;
for (obj = hwloc_get_obj_by_type(topology, HWLOC_OBJ_PU, 0);
     obj;
     obj = obj->parent)
  if (obj->type == HWLOC_OBJ_CACHE) {
    levels++;
    size += obj->attr->cache.size;
  }
printf("*** Logical processor 0 has %d caches totaling %luKB\n",
       levels, size / 1024);

/*****************************************************************
 * Fifth example:
 * Bind to only one thread of the last core of the machine.
 *
 * First find out where cores are, or else smaller sets of CPUs if
 * the OS doesn't have the notion of a "core".
 *****************************************************************/
depth = hwloc_get_type_or_below_depth(topology, HWLOC_OBJ_CORE);

/* Get last core. */
obj = hwloc_get_obj_by_depth(topology, depth,
                hwloc_get_nbobjs_by_depth(topology, depth) - 1);
if (obj) {
```

```
        /* Get a copy of its cpuset that we may modify. */
        cpuset = hwloc_cpuset_dup(obj->cpuset);

        /* Get only one logical processor (in case the core is
           SMT/hyperthreaded). */
        hwloc_cpuset_singlify(cpuset);

        /* And try to bind ourself there. */
        if (hwloc_set_cpubind(topology, cpuset, 0)) {
            char *str;
            hwloc_cpuset_asprintf(&str, obj->cpuset);
            printf("Couldn't bind to cpuset %s\n", str);
            free(str);
        }

        /* Free our cpuset copy */
        hwloc_cpuset_free(cpuset);
    }

    /* Destroy topology object. */
    hwloc_topology_destroy(topology);

    return 0;
}
```

hwloc provides a `pkg-config` executable to obtain relevant compiler and linker flags. For example, it can be used thusly to compile applications that utilize the hwloc library (assuming GNU Make):

```
CFLAGS += $(pkg-config --cflags hwloc)
LDLIBS += $(pkg-config --libs hwloc)
cc hwloc-hello.c $(CFLAGS) -o hwloc-hello $(LDLIBS)
```

On a machine with 4GB of RAM and 2 processor sockets -- each socket of which has two processing cores -- the output from running `hwloc-hello` could be something like the following:

```
shell$ ./hwloc-hello
*** Objects at level 0
Index 0: Machine(3938MB)
*** Objects at level 1
Index 0: Socket#0
Index 1: Socket#1
*** Objects at level 2
Index 0: Core#0
Index 1: Core#1
Index 2: Core#3
Index 3: Core#2
*** Objects at level 3
Index 0: PU#0
Index 1: PU#1
Index 2: PU#2
Index 3: PU#3
*** Printing overall tree
Machine(3938MB)
  Socket#0
    Core#0
      PU#0
    Core#1
      PU#1
  Socket#1
    Core#3
      PU#2
    Core#2
      PU#3
*** 2 socket(s)
shell$
```

1.5 Questions and Bugs

Questions should be sent to the devel mailing list (http://www.open-mpi.org/community/lists/hwloc.php). Bug reports should be reported in the tracker (https://svn.open-mpi.org/trac/hwloc/).

If hwloc discovers an incorrect topology for your machine, the very first thing you should check is to ensure that you have the most recent updates installed for your operating system. Indeed, most of hwloc topology discovery relies on hardware information retrieved through the operation system (e.g., via the /sys virtual filesystem of the Linux kernel). If upgrading your OS or Linux kernel does not solve your problem, you may also want to ensure that you are running the most recent version of the BIOS for your machine.

If those things fail, contact us on the mailing list for additional help. Please attach the output of lstopo after having given the --enable-debug option to ./configure and rebuilt completely, to get debugging output.

1.6 History / Credits

hwloc is the evolution and merger of the libtopology (http://runtime.bordeaux.inria.fr/libtopology/) project and the Portable Linux Processor Affinity (PLPA) (http://www.open-mpi.org/projects/plpa/) project. Because of functional and ideological overlap, these two code bases and ideas were merged and released under the name "hwloc" as an Open MPI sub-project.

libtopology was initially developed by the INRIA Runtime Team-Project (http://runtime.bordeaux.inria.fr/) (headed by Raymond Namyst (http://dept-info.labri.fr/~namyst/). PLPA was initially developed by the Open MPI development team as a sub-project. Both are now deprecated in favor of hwloc, which is distributed as an Open MPI sub-project.

Chapter 2

Terms and Definitions

Object Interesting kind of part of the system, such as a Core, a Cache, a Memory node, etc. The different types detected by hwloc are detailed in the hwloc_obj_type_t enumeration.

They are topologically sorted by CPU set into a tree.

CPU set The set of logical processors (or processing units) logically included in an object (if it makes sense). They are always expressed using physical logical processor numbers (as announced by the OS). They are just masks, they do *not* have any relation with an operating system actual binding notion like Linux' cpusets.

Parent object The object logically containing the current object, for example because its CPU set includes the CPU set of the current object.

Ancestor object The parent object, or its own parent object, and so on.

Children object(s) The object (or objects) contained in the current object because their CPU set is included in the CPU set of the current object.

Arity The number of children of an object.

Sibling objects Objects of the same type which have the same parent.

Sibling rank Index to uniquely identify objects of the same type which have the same parent, and is always in the range [0, parent_arity).

Cousin objects Objects of the same type as the current object.

Level Set of objects of the same type.

OS or physical index The index that the operating system (OS) uses to identify the object. This may be completely arbitrary, or it may depend on the BIOS configuration.

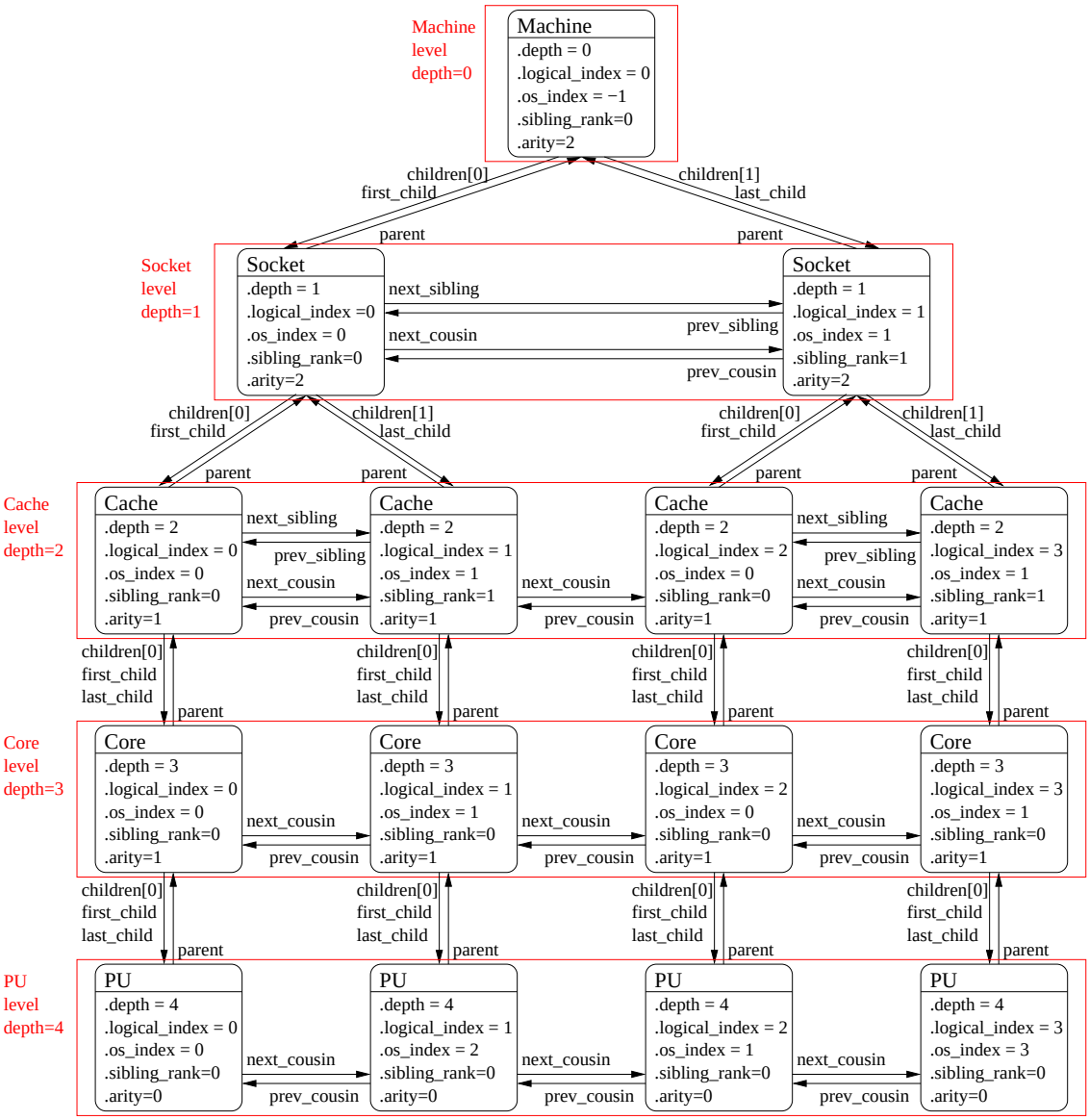
Depth Nesting level in the object tree, starting from the 0th object.

Logical index Index to uniquely identify objects of the same type. It expresses proximity in a generic way. This index is always linear and in the range [0, num_objs_same_type_same_level). Think of it as "cousin rank." The ordering is based on topology first, and then on OS CPU numbers, so it is stable across everything except firmware CPU renumbering.

Logical processor

Processing unit The smallest processing element that can be represented by a hwloc object. It may be a single-core processor, a core of a multicore processor, or a single thread in SMT processor.

The following diagram can help to understand the vocabulary of the relationships by showing the example of a machine with two dual core sockets (with no hardware threads); thus, a topology with 4 levels. Each box with rounded corner corresponds to one hwloc_obj_t, containing the values of the different integer fields (depth, logical_index, etc.), and arrows show to which other hwloc_obj_t pointers point to (first_child, parent, etc.)



It should be noted that for PU objects, the logical index -- as computed linearly by hwloc -- is not the same as the OS index.

Chapter 3

Command-line tools

hwloc comes with an extensive C programming interface and several command line utilities. Each of them is fully documented in its own manual page; the following is a summary of the available command line tools.

3.1 lstopo

lstopo (also known as hwloc-info and hwloc-ls) displays the hierarchical topology map of the current system. The output may be graphical or textual, and can also be exported to numerous file formats such as PDF, PNG, XML, and others.

Note that lstopo can read XML files and/or alternate chroot filesystems and display topological maps representing those systems (e.g., use lstopo to output an XML file on one system, and then use lstopo to read in that XML file and display it on a different system).

3.2 hwloc-bind

hwloc-bind binds processes to specific hardware objects through a flexible syntax. A simple example is binding an executable to specific cores (or sockets or cpusets or ...). The hwloc-bind(1) man page provides much more detail on what is possible.

hwloc-bind can also be used to retrieve the current process' binding.

3.3 hwloc-calc

hwloc-calc is generally used to create cpuset strings to pass to hwloc-bind. Although hwloc-bind accepts many forms of object specification (i.e., cpuset strings are one of many forms that hwloc-bind understands), they can be useful, compact representations in shell scripts, for example.

hwloc-calc generates cpuset strings from given hardware objects with the ability to aggregate them, intersect them, and more. hwloc-calc generally uses the same syntax than hwloc-bind, but multiple instances may be composed to generate complex combinations.

Note that hwloc-calc can also generate lists of logical processors or NUMA nodes that are convenient to pass to some external tools such as taskset or numactl.

3.4 hwloc-distrib

hwloc-distrib generates a set of cpuset strings that are uniformly distributed across the machine for the given number of processes. These strings may be used with hwloc-bind to run processes to maximize their memory bandwidth by properly distributing them across the machine.

Chapter 4

Environment variables

The behavior of the hwloc library and tools may be tuned thanks to the following environment variables.

HWLOC_XMLFILE=/path/to/file.xml enforces the discovery from the given XML file as if hwloc_topology_set_xml() had been called. This file may have been generated earlier with lstopo file.xml. For convenience, this backend provides empty binding hooks which just return success. To have hwloc still actually call OS-specific hooks, HWLOC_THISSYSTEM should be set 1 in the environment too, to assert that the loaded file is really the underlying system.

HWLOC_FSROOT=/path/to/linux/filesystem-root/ switches to reading the topology from the specified Linux filesystem root instead of the main file-system root, as if hwloc_topology_set_fsroot() had been called. Not using the main file-system root causes hwloc_topology_is_thissystem() to return 0. For convenience, this backend provides empty binding hooks which just return success. To have hwloc still actually call OS-specific hooks, HWLOC_THISSYSTEM should be set 1 in the environment too, to assert that the loaded file is really the underlying system.

HWLOC_THISSYSTEM=1 enforces the return value of hwloc_topology_is_thissystem(). It means that it makes hwloc assume that the selected backend provides the topology for the system on which we are running, even if it is not the OS-specific backend but the XML backend for instance. This means making the binding functions actually call the OS-specific system calls and really do binding, while the XML backend would otherwise provide empty hooks just returning success. This can be used for efficiency reasons to first detect the topology once, save it to an XML file, and quickly reload it later through the XML backend, but still having binding functions actually do bind.

Chapter 5

Interoperability with other software

Although hwloc offers its own portable interface, it still may have to interoperate with specific or non-portable libraries that manipulate similar kinds of objects. hwloc therefore offers several specific "helpers" to assist converting between those specific interfaces and hwloc.

Some external libraries may be specific to a particular OS; others may not always be available. The hwloc core therefore generally does not explicitly depend on these types of libraries. However, when a custom application uses or otherwise depends on such a library, it may optionally include the corresponding hwloc helper to extend the hwloc interface with dedicated helpers.

Linux specific features hwloc/linux.h offers Linux-specific helpers that utilize some non-portable features of the Linux system, such as binding threads through their thread ID ("tid") or parsing kernel CPU mask files.

Linux libnuma hwloc/linux-libnuma.h provides conversion helpers between hwloc CPU sets and libnuma-specific types, such as nodemasks and bitmasks. It helps you use libnuma memory-binding functions with hwloc CPU sets.

Glibc hwloc/glibc-sched.h offers conversion routines between Glibc and hwloc CPU sets in order to use hwloc with functions such as sched_setaffinity().

OpenFabrics Verbs hwloc/openfabrics-verbs.h helps interoperability with the OpenFabrics Verbs interface. For example, it can return a list of processors near an OpenFabrics device.

Chapter 6

Thread safety

Like most libraries that mainly fill data structures, hwloc is not thread safe but rather reentrant: all state is held in a hwloc_topology_t instance without mutex protection. That means, for example, that two threads can safely operate on and modify two different hwloc_topology_t instances, but they should not simultaneously invoke functions that modify the *same* instance. Similarly, one thread should not modify a hwloc_topology_t instance while another thread is reading or traversing it. However, two threads can safely read or traverse the same hwloc_topology_t instance concurrently.

When running in multiprocessor environments, be aware that proper thread synchronization and/or memory coherency protection is needed to pass hwloc data (such as hwloc_topology_t pointers) from one processor to another (e.g., a mutex, semaphore, or a memory barrier). Note that this is not a hwloc-specific requirement, but it is worth mentioning.

For reference, hwloc_topology_t modification operations include (but may not be limited to):

Creation and destruction `hwloc_topology_init()`, `hwloc_topology_load()`, `hwloc_topology_destroy()` (see Create and Destroy Topologies) imply major modifications of the structure, including freeing some objects. No other thread cannot access the topology or any of its objects at the same time.

Also references to objects inside the topology are not valid anymore after these functions return.

Runtime topology modifications `hwloc_topology_insert_misc_object_by_*` (see Tinker with topologies.) may modify the topology significantly by adding objects inside the tree, changing the topology depth, etc.

Although references to former objects *may* still be valid after insertion, it is strongly advised to not rely on any such guarantee and always re-consult the topology to reacquire new instances of objects.

Locating topologies `hwloc_topology_ignore*`, `hwloc_topology_set*` (see Configure Topology Detection) do not modify the topology directly, but they do modify internal structures describing the behavior of the next invocation of `hwloc_topology_load()`. Hence, all of these functions should not be used concurrently.

Note that these functions do not modify the current topology until it is actually reloaded; it is possible to use them while other threads are only read the current topology.

Chapter 7

Embedding hwloc in other software

It can be desirable to include hwloc in a larger software package (be sure to check out the LICENSE file) so that users don't have to separately download and install it before installing your software. This can be advantageous to ensure that your software uses a known-tested/good version of hwloc, or for use on systems that do not have hwloc pre-installed.

When used in "embedded" mode, hwloc will:

- not install any header files
- not build any documentation files
- not build or install any executables or tests
- not build `libhwloc.*` -- instead, it will build `libhwloc_embedded.*`

There are two ways to put hwloc into "embedded" mode. The first is directly from the configure command line:

```
shell$ ./configure --enable-embedded-mode ...
```

The second requires that your software project uses the GNU Autoconf / Automake / Libtool tool chain to build your software. If you do this, you can directly integrate hwloc's m4 configure macro into your configure script. You can then invoke hwloc's configuration tests and build setup by calling an m4 macro (see below).

7.1 Using hwloc's M4 Embedding Capabilities

Every project is different, and there are many different ways of integrating hwloc into yours. What follows is *one* example of how to do it.

If your project uses recent versions Autoconf, Automake, and Libtool to build, you can use hwloc's embedded m4 capabilities. We have tested the embedded m4 with projects that use Autoconf 2.65, Automake 1.11.1, and Libtool 2.2.6b. Slightly earlier versions of may also work but are untested. Autoconf versions prior to 2.65 are almost certain to not work.

You can either copy all the config/hwloc∗m4 files from the hwloc source tree to the directory where your project's m4 files reside, or you can tell aclocal to find more m4 files in the embedded hwloc's "config" subdirectory (e.g., add "-Ipath/to/embedded/hwloc/config" to your Makefile.am's ACLOCAL_AMFLAGS).

The following macros can then be used from your configure script (only HWLOC_SETUP_CORE *must* be invoked if using the m4 macros):

- HWLOC_SETUP_CORE(config-dir-prefix, action-upon-success, action-upon-failure, print_-banner_or_not): Invoke the hwloc configuration tests and setup the hwloc tree to build. The first argument is the prefix to use for AC_OUTPUT files -- it's where the hwloc tree is located relative to `$top_srcdir`. Hence, if your embedded hwloc is located in the source tree at contrib/hwloc, you should pass `[contrib/hwloc]` as the first argument. If HWLOC_SETUP_CORE and the rest of `configure` completes successfully, then "make" traversals of the hwloc tree with standard Automake targets (all, clean, install, etc.) should behave as expected. For example, it is safe to list the hwloc directory in the SUBDIRS of a higher-level Makefile.am. The last argument, if not empty, will cause the macro to display an announcement banner that it is starting the hwloc core configuration tests.

HWLOC_SETUP_CORE will set the following environment variables and AC_SUBST them: HWLOC_EMBEDDED_CFLAGS, HWLOC_EMBEDDED_CPPFLAGS, and HWLOC_EMBEDDED_-LIBS. These flags are filled with the values discovered in the hwloc-specific m4 tests, and can be used in your build process as relevant. The _CFLAGS, _CPPFLAGS, and _LIBS variables are necessary to build libhwloc (or libhwloc_embedded) itself.

HWLOC_SETUP_CORE also sets HWLOC_EMBEDDED_LDADD environment variable (and AC_-SUBSTs it) to contain the location of the libhwloc_embedded.la convenience Libtool archive. It can be used in your build process to link an application or other library against the embedded hwloc library.

NOTE: If the HWLOC_SET_SYMBOL_PREFIX macro is used, it must be invoked *before* HWLOC_SETUP_CORE.

- HWLOC_BUILD_STANDALONE: HWLOC_SETUP_CORE defaults to building hwloc in an "embedded" mode (described above). If HWLOC_BUILD_STANDALONE is invoked ∗before∗ HWLOC_SETUP_CORE, the embedded definitions will not apply (e.g., libhwloc.la will be built, not libhwloc_embedded.la).

- HWLOC_SET_SYMBOL_PREFIX(foo_): Tells the hwloc to prefix all of hwloc's types and public symbols with "foo_"; meaning that function hwloc_init() becomes foo_hwloc_init(). Enum values are prefixed with an upper-case translation if the prefix supplied; HWLOC_OBJ_SYSTEM becomes FOO_HWLOC_OBJ_SYSTEM. This is recommended behavior if you are including hwloc in middleware -- it is possible that your software will be combined with other software that links to another copy of hwloc. If both uses of hwloc utilize different symbol prefixes, there will be no type/symbol clashes, and everything will compile, link, and run successfully. If you both embed hwloc without changing the symbol prefix and also link against an external hwloc, you may get multiple symbol definitions when linking your final library or application.

- HWLOC_SETUP_DOCS, HWLOC_SETUP_UTILS, HWLOC_SETUP_TESTS: These three macros only apply when hwloc is built in "standalone" mode (i.e., they should NOT be invoked unless HWLOC_BUILD_STANDALONE has already been invoked).

- HWLOC_DO_AM_CONDITIONALS: If you embed hwloc in a larger project and build it conditionally with Automake (e.g., if HWLOC_SETUP_CORE is invoked conditionally), you must unconditionally invoke HWLOC_DO_AM_CONDITIONALS to avoid warnings from Automake (for the cases where hwloc is not selected to be built). This macro is necessary because hwloc uses some AM_CONDITIONALs to build itself, and AM_CONDITIONALs cannot be defined conditionally. Note that it is safe (but unnecessary) to call HWLOC_DO_AM_CONDITIONALS even if HWLOC_SETUP_CORE is invoked unconditionally. If you are not using Automake to build hwloc, this macro is unncessary (and will actually cause errors because it invoked AM_∗ macros that will be undefined).

<strongNOTE: When using the HWLOC_SETUP_CORE m4 macro, it may be necessary to explicitly invoke AC_CANONICAL_TARGET (which requires config.sub and config.guess) and/or AC_USE_-SYSTEM_EXTENSIONS macros early in the configure script (e.g., after AC_INIT but before AM_INIT_-AUTOMAKE). See the Autoconf documentation for further information.

Also note that hwloc's top-level configure.ac script uses exactly the macros described above to build hwloc in a standalone mode (by default). You may want to examine it for one example of how these macros are used.

7.2 Example Embedding hwloc

Here's an example of integrating with a larger project named sandbox that already uses Autoconf, Automake, and Libtool to build itself:

```
# First, cd into the sandbox project source tree
shell$ cd sandbox
shell$ cp -r /somewhere/else/hwloc-<version> my-embedded-hwloc
shell$ edit Makefile.am
  1. Add "-Imy-embedded-hwloc/config" to ACLOCAL_AMFLAGS
  2. Add "my-embedded-hwloc" to SUBDIRS
  3. Add "$(HWLOC_EMBEDDED_LDADD)" and "$(HWLOC_EMBEDDED_LIBS)" to
     sandbox's executable's LDADD line.  The former is the name of the
     Libtool convenience library that hwloc will generate.  The latter
     is any dependent support libraries that may be needed by
     $(HWLOC_EMBEDDED_LDADD).
  4. Add "$(HWLOC_EMBEDDED_CFLAGS)" to AM_CFLAGS
  5. Add "$(HWLOC_EMBEDDED_CPPFLAGS)" to AM_CPPFLAGS
shell$ edit configure.ac
  1. Add "HWLOC_SET_SYMBOL_PREFIX(sandbox_hwloc_)" line
  2. Add "HWLOC_SETUP_CORE([my-embedded-hwloc], [happy=yes], [happy=no])" line
  3. Add error checking for happy=no case
shell$ edit sandbox.c
  1. Add #include <hwloc.h>
  2. Add calls to sandbox_hwloc_init() and other hwloc API functions
```

Now you can bootstrap, configure, build, and run the sandbox as normal -- all calls to "sandbox_hwloc_$*$" will use the embedded hwloc rather than any system-provided copy of hwloc.

Chapter 8

Switching from PLPA to hwloc

Although PLPA and hwloc share some of the same ideas, their programming interfaces are quite different. After much debate, it was decided *not* to emulate the PLPA API with hwloc's API because hwloc's API is already far more rich than PLPA's.

More specifically, exploiting modern computing architecture *requires* the flexible functionality provided by the hwloc API -- the PLPA API is too rigid in its definitions and practices to handle the evolving server hardware landscape (e.g., PLPA only understands cores and sockets; hwloc understands a much larger set of hardware objects).

As such, even though it is fully possible to emulate the PLPA API with hwloc (e.g., only deal with sockets and cores), and while the documentation below describes how to do this, we encourage any existing PLPA application authors to actually re-think their application in terms of more than just sockets and cores. In short, we encourage you to use the full hwloc API to exploit *all* the hardware.

8.1 Topology Context vs. Caching

First, all hwloc functions take a `topology` parameter. This parameter serves as an internal storage for the result of the topology discovery. It replaces PLPA's caching abilities and even lets you manipulate multiple topologies as the same time, if needed.

Thus, all programs should first run hwloc_topology_init() and hwloc_topology_destroy() as they did plpa_-init() and plpa_finalize() in the past.

8.2 Hierarchy vs. Core@Socket

PLPA was designed to understand only cores and sockets. hwloc offers many more different types of objects (e.g., cores, sockets, hardware threads, NUMA nodes, and others) and stores them within a tree of resources.

To emulate the PLPA model, it is possible to find sockets using functions such as hwloc_get_obj_by_-type(). Iterating over sockets is also possible using hwloc_get_next_obj_by_type(). Then, finding a core within a socket may be done using hwloc_get_obj_inside_cpuset_by_type() or hwloc_get_next_obj_-inside_cpuset_by_type().

It is also possible to directly find an object "below" another object using hwloc_get_obj_below_by_type() (or hwloc_get_obj_below_array_by_type()).

8.3 Logical vs. Physical/OS Indexes

hwloc manipulates logical indexes, meaning indexes specified with regard to the ordering of objects in the hwloc-provided hierarchical tree. Physical or OS indexes may be entirely hidden if not strictly required. The reason for this is that physical/OS indexes may change with the OS or with the BIOS version. They may be non-consecutive, multiple objects may have the same physical/OS indexes, making their manipulation tricky and highly non-portable.

Note that hwloc tries very hard to always present a hierarchical tree with the same logical ordering, regardless of physical or OS index ordering.

It is still possible to retrieve physical/OS indexes through the `os_index` field of objects, but such practice should be avoided as much as possible for the reasons described above (except perhaps for prettyprinting / debugging purposes).

HWLOC_OBJ_PU objects are supposed to have different physical/OS indexes since the OS uses them for binding. The `os_index` field of these objects provides the identifier that may be used for such binding, and hwloc_get_proc_obj_by_os_index() finds the object associated with a specific OS index.

But as mentioned above, we discourage the use of these conversion methods for actual binding. Instead, hwloc offers its own binding model using the `cpuset` field of objects. These cpusets may be duplicated, modified, combined, etc. (see hwloc/cpuset.h for details) and then passed to hwloc_set_cpubind() for binding.

8.4 Counting Specification

PLPA offers a countspec parameter to specify whether counting all CPUs, only the online ones or only the offline ones. However, some operating systems do not expose the topology of offline CPUs (i.e., offline CPUs are not reported at all by the OS). Also, some processors may not be visible to the current application due to administrative restrictions. Finally, some processors let you shutdown a single hardware thread in a core, making some of the PLPA features irrelevant.

hwloc stores in the hierarchical tree of objects all CPUs that have known topology information. It then provides the applications with several cpusets that contain the list of CPUs that are actually known, that have topology information, that are online, or that are available to the application. These cpusets may be retrieved with hwloc_topology_get_online_cpuset() and other similar functions to filter the object that are relevant or not.

Chapter 9

Module Index

9.1 Modules

Here is a list of all modules:

Chapter 10

Data Structure Index

10.1 Data Structures

Here are the data structures with brief descriptions:

Chapter 11

Module Documentation

11.1 API version

Defines

- #define HWLOC_API_VERSION 0x00010000

  Indicate at build time which hwloc API version is being used.

11.1.1 Define Documentation

11.1.1.1 #define HWLOC_API_VERSION 0x00010000

Indicate at build time which hwloc API version is being used.

11.2 Topology context

Typedefs

- typedef struct hwloc_topology * hwloc_topology_t

  Topology context.

11.2.1 Typedef Documentation

11.2.1.1 typedef struct hwloc_topology* hwloc_topology_t

Topology context.

To be initialized with hwloc_topology_init() and built with hwloc_topology_load().

11.3 Topology Object Types

Enumerations

- enum hwloc_obj_type_t {
  HWLOC_OBJ_SYSTEM, HWLOC_OBJ_MACHINE, HWLOC_OBJ_NODE, HWLOC_OBJ_-SOCKET,
  HWLOC_OBJ_CACHE, HWLOC_OBJ_CORE, HWLOC_OBJ_PU, HWLOC_OBJ_GROUP,
  HWLOC_OBJ_MISC }
  Type of topology object.
- enum hwloc_compare_types_e { HWLOC_TYPE_UNORDERED }

Functions

- HWLOC_DECLSPEC int hwloc_compare_types (hwloc_obj_type_t type1, hwloc_obj_type_-t type2) __hwloc_attribute_const
  Compare the depth of two object types.

11.3.1 Enumeration Type Documentation

11.3.1.1 enum hwloc_compare_types_e

Enumerator:

HWLOC_TYPE_UNORDERED Value returned by hwloc_compare_types when types can not be compared.

11.3.1.2 enum hwloc_obj_type_t

Type of topology object.

Note

Do not rely on the ordering or completeness of the values as new ones may be defined in the future! If you need to compare types, use hwloc_compare_types() instead.

Enumerator:

HWLOC_OBJ_SYSTEM Whole system (may be a cluster of machines). The whole system that is accessible to hwloc. That may comprise several machines in SSI systems like Kerrighed.

HWLOC_OBJ_MACHINE Machine. The typical root object type. A set of processors and memory with cache coherency.

HWLOC_OBJ_NODE NUMA node. A set of processors around memory which the processors can directly access.

HWLOC_OBJ_SOCKET Socket, physical package, or chip. In the physical meaning, i.e. that you can add or remove physically.

HWLOC_OBJ_CACHE Data cache. Can be L1, L2, L3, ...

HWLOC_OBJ_CORE Core. A computation unit (may be shared by several logical processors).

HWLOC_OBJ_PU Processing Unit, or (Logical) Processor. An execution unit (may share a core with some other logical processors, e.g. in the case of an SMT core). Objects of this kind are always reported and can thus be used as fallback when others are not.

HWLOC_OBJ_GROUP Group objects. Objects which do not fit in the above but are detected by hwloc and are useful to take into account for affinity. For instance, some OSes expose their arbitrary processors aggregation this way. And hwloc may insert such objects to group NUMA nodes according to their distances. These objects are ignored when they do not bring any structure.

HWLOC_OBJ_MISC Miscellaneous objects. Objects without particular meaning, that can e.g. be added by the application for its own use.

11.3.2 Function Documentation

11.3.2.1 HWLOC_DECLSPEC int hwloc_compare_types (hwloc_obj_type_t *type1*, hwloc_obj_type_t *type2*) const

Compare the depth of two object types.

Types shouldn't be compared as they are, since newer ones may be added in the future. This function returns less than, equal to, or greater than zero respectively if `type1` objects usually include `type2` objects, are the same as `type2` objects, or are included in `type2` objects. If the types can not be compared (because neither is usually contained in the other), HWLOC_TYPE_UNORDERED is returned. Object types containing CPUs can always be compared (usually, a system contains machines which contain nodes which contain sockets which contain caches, which contain cores, which contain processors).

Note

HWLOC_OBJ_PU will always be the deepest.
This does not mean that the actual topology will respect that order: e.g. as of today cores may also contain caches, and sockets may also contain nodes. This is thus just to be seen as a fallback comparison method.

11.4 Topology Objects

Data Structures

- struct hwloc_obj_memory_s

  Object memory.

- struct hwloc_obj

  Structure of a topology object.

- union hwloc_obj_attr_u

  Object type-specific Attributes.

Typedefs

- typedef struct hwloc_obj * hwloc_obj_t

  Convenience typedef; a pointer to a struct hwloc_obj.

11.4.1 Typedef Documentation

11.4.1.1 typedef struct hwloc_obj* hwloc_obj_t

Convenience typedef; a pointer to a struct hwloc_obj.

11.5 Create and Destroy Topologies

Functions

- HWLOC_DECLSPEC int hwloc_topology_init (hwloc_topology_t *topologyp)
  Allocate a topology context.
- HWLOC_DECLSPEC int hwloc_topology_load (hwloc_topology_t topology)
  Build the actual topology.
- HWLOC_DECLSPEC void hwloc_topology_destroy (hwloc_topology_t topology)
  Terminate and free a topology context.
- HWLOC_DECLSPEC void hwloc_topology_check (hwloc_topology_t topology)
  Run internal checks on a topology structure.

11.5.1 Function Documentation

11.5.1.1 HWLOC_DECLSPEC void hwloc_topology_check (hwloc_topology_t *topology*)

Run internal checks on a topology structure.

Parameters

topology is the topology to be checked

11.5.1.2 HWLOC_DECLSPEC void hwloc_topology_destroy (hwloc_topology_t *topology*)

Terminate and free a topology context.

Parameters

topology is the topology to be freed

11.5.1.3 HWLOC_DECLSPEC int hwloc_topology_init (hwloc_topology_t * *topologyp*)

Allocate a topology context.

Parameters

`[out]` ***topologyp*** is assigned a pointer to the new allocated context.

Returns

0 on success, -1 on error.

11.5.1.4 HWLOC_DECLSPEC int hwloc_topology_load (hwloc_topology_t *topology*)

Build the actual topology.

Build the actual topology once initialized with hwloc_topology_init() and tuned with Configure Topology Detection routines. No other routine may be called earlier using this topology context.

Parameters

topology is the topology to be loaded with objects.

Returns

0 on success, -1 on error.

See also

Configure Topology Detection

11.6 Configure Topology Detection

Data Structures

- struct hwloc_topology_discovery_support

  Flags describing actual discovery support for this topology.

- struct hwloc_topology_cpubind_support

  Flags describing actual binding support for this topology.

- struct hwloc_topology_support

  Set of flags describing actual support for this topology.

Enumerations

- enum hwloc_topology_flags_e { HWLOC_TOPOLOGY_FLAG_WHOLE_SYSTEM, HWLOC_-TOPOLOGY_FLAG_IS_THISSYSTEM }

  Flags to be set onto a topology context before load.

Functions

- HWLOC_DECLSPEC int hwloc_topology_ignore_type (hwloc_topology_t topology, hwloc_obj_-type_t type)

  Ignore an object type.

- HWLOC_DECLSPEC int hwloc_topology_ignore_type_keep_structure (hwloc_topology_t topology, hwloc_obj_type_t type)

  Ignore an object type if it does not bring any structure.

- HWLOC_DECLSPEC int hwloc_topology_ignore_all_keep_structure (hwloc_topology_t topology)

  Ignore all objects that do not bring any structure.

- HWLOC_DECLSPEC int hwloc_topology_set_flags (hwloc_topology_t topology, unsigned long flags)

  Set OR'ed flags to non-yet-loaded topology.

- HWLOC_DECLSPEC int hwloc_topology_set_fsroot (hwloc_topology_t __hwloc_restrict topology, const char *__hwloc_restrict fsroot_path)

  Change the file-system root path when building the topology from sysfs/procfs.

- HWLOC_DECLSPEC int hwloc_topology_set_pid (hwloc_topology_t __hwloc_restrict topology, hwloc_pid_t pid)

  Change which pid the topology is viewed from.

- HWLOC_DECLSPEC int hwloc_topology_set_synthetic (hwloc_topology_t __hwloc_restrict topology, const char *__hwloc_restrict description)

  Enable synthetic topology.

- HWLOC_DECLSPEC int hwloc_topology_set_xml (hwloc_topology_t __hwloc_restrict topology, const char *__hwloc_restrict xmlpath)

  Enable XML-file based topology.

- HWLOC_DECLSPEC struct hwloc_topology_support * hwloc_topology_get_support (hwloc_topology_t __hwloc_restrict topology)

  Retrieve the topology support.

11.6.1 Detailed Description

These functions can optionally be called between hwloc_topology_init() and hwloc_topology_load() to configure how the detection should be performed, e.g. to ignore some objects types, define a synthetic topology, etc.

If none of them is called, the default is to detect all the objects of the machine that the caller is allowed to access.

This default behavior may also be modified through environment variables if the application did not modify it already. Setting HWLOC_XMLFILE in the environment enforces the discovery from a XML file as if hwloc_topology_set_xml() had been called. HWLOC_FSROOT switches to reading the topology from the specified Linux filesystem root as if hwloc_topology_set_fsroot() had been called. Finally, HWLOC_THISSYSTEM enforces the return value of hwloc_topology_is_thissystem().

11.6.2 Enumeration Type Documentation

11.6.2.1 enum hwloc_topology_flags_e

Flags to be set onto a topology context before load.

Flags should be given to hwloc_topology_set_flags().

Enumerator:

HWLOC_TOPOLOGY_FLAG_WHOLE_SYSTEM Detect the whole system, ignore reservations and offline settings. Gather all resources, even if some were disabled by the administrator. For instance, ignore Linux Cpusets and gather all processors and memory nodes, and ignore the fact that some resources may be offline.

HWLOC_TOPOLOGY_FLAG_IS_THISSYSTEM Assume that the selected backend provides the topology for the system on which we are running. This forces hwloc_topology_is_thissystem to return 1, i.e. makes hwloc assume that the selected backend provides the topology for the system on which we are running, even if it is not the OS-specific backend but the XML backend for instance. This means making the binding functions actually call the OS-specific system calls and really do binding, while the XML backend would otherwise provide empty hooks just returning success.

Setting the environment variable HWLOC_THISSYSTEM may also result in the same behavior.

This can be used for efficiency reasons to first detect the topology once, save it to an XML file, and quickly reload it later through the XML backend, but still having binding functions actually do bind.

11.6.3 Function Documentation

11.6.3.1 HWLOC_DECLSPEC struct hwloc_topology_support* hwloc_topology_get_support (hwloc_topology_t __hwloc_restrict *topology*) [read]

Retrieve the topology support.

11.6.3.2 HWLOC_DECLSPEC int hwloc_topology_ignore_all_keep_structure (hwloc_topology_t *topology*)

Ignore all objects that do not bring any structure.

Ignore all objects that do not bring any structure: Each ignored object should have a single children or be the only child of its parent.

11.6.3.3 HWLOC_DECLSPEC int hwloc_topology_ignore_type (hwloc_topology_t *topology,* hwloc_obj_type_t *type*)

Ignore an object type.

Ignore all objects from the given type. The bottom-level type HWLOC_OBJ_PU may not be ignored. The top-level object of the hierarchy will never be ignored, even if this function succeeds.

11.6.3.4 HWLOC_DECLSPEC int hwloc_topology_ignore_type_keep_structure (hwloc_topology_t *topology,* hwloc_obj_type_t *type*)

Ignore an object type if it does not bring any structure.

Ignore all objects from the given type as long as they do not bring any structure: Each ignored object should have a single children or be the only child of its parent. The bottom-level type HWLOC_OBJ_PU may not be ignored.

11.6.3.5 HWLOC_DECLSPEC int hwloc_topology_set_flags (hwloc_topology_t *topology*, unsigned long *flags*)

Set OR'ed flags to non-yet-loaded topology.

Set a OR'ed set of hwloc_topology_flags_e onto a topology that was not yet loaded.

11.6.3.6 HWLOC_DECLSPEC int hwloc_topology_set_fsroot (hwloc_topology_t __hwloc_restrict *topology*, const char *__hwloc_restrict *fsroot_path*)

Change the file-system root path when building the topology from sysfs/procfs.

On Linux system, use sysfs and procfs files as if they were mounted on the given `fsroot_path` instead of the main file-system root. Setting the environment variable HWLOC_FSROOT may also result in this behavior. Not using the main file-system root causes hwloc_topology_is_thissystem() to return 0.

Note

For conveniency, this backend provides empty binding hooks which just return success. To have hwloc still actually call OS-specific hooks, the HWLOC_TOPOLOGY_FLAG_IS_THISSYSTEM has to be set to assert that the loaded file is really the underlying system.

11.6.3.7 HWLOC_DECLSPEC int hwloc_topology_set_pid (hwloc_topology_t __hwloc_restrict *topology*, hwloc_pid_t *pid*)

Change which pid the topology is viewed from.

On some systems, processes may have different views of the machine, for instance the set of allowed CPUs. By default, hwloc exposes the view from the current process. Calling hwloc_topology_set_pid() permits to make it expose the topology of the machine from the point of view of another process.

Note

hwloc_pid_t is pid_t on unix platforms, and HANDLE on native Windows platforms
The ENOSYS error is returned on platforms that does not support this feature.

11.6.3.8 HWLOC_DECLSPEC int hwloc_topology_set_synthetic (hwloc_topology_t __hwloc_restrict *topology*, const char *__hwloc_restrict *description*)

Enable synthetic topology.

Gather topology information from the given `description` which should be a comma separated string of numbers describing the arity of each level. Each number may be prefixed with a type and a colon to enforce the type of a level. If only some level types are enforced, hwloc will try to choose the other types according to usual topologies, but it may fail and you may have to specify more level types manually.

Note

For conveniency, this backend provides empty binding hooks which just return success.

11.6.3.9 HWLOC_DECLSPEC int hwloc_topology_set_xml (hwloc_topology_t __hwloc_restrict *topology*, const char *__hwloc_restrict *xmlpath*)

Enable XML-file based topology.

Gather topology information from the XML file given at `xmlpath`. Setting the environment variable HWLOC_XMLFILE may also result in this behavior. This file may have been generated earlier with lstopo file.xml.

Note

For conveniency, this backend provides empty binding hooks which just return success. To have hwloc still actually call OS-specific hooks, the HWLOC_TOPOLOGY_FLAG_IS_THISSYSTEM has to be set to assert that the loaded file is really the underlying system.

11.7 Tinker with topologies.

Functions

- HWLOC_DECLSPEC void hwloc_topology_export_xml (hwloc_topology_t topology, const char *xmlpath)

  Export the topology into an XML file.

- HWLOC_DECLSPEC hwloc_obj_t hwloc_topology_insert_misc_object_by_cpuset (hwloc_topology_t topology, hwloc_const_cpuset_t cpuset, const char *name)

  Add a MISC object to the topology.

- HWLOC_DECLSPEC hwloc_obj_t hwloc_topology_insert_misc_object_by_parent (hwloc_topology_t topology, hwloc_obj_t parent, const char *name)

  Add a MISC object to the topology.

11.7.1 Function Documentation

11.7.1.1 HWLOC_DECLSPEC void hwloc_topology_export_xml (hwloc_topology_t *topology*, const char * *xmlpath*)

Export the topology into an XML file.

This file may be loaded later through hwloc_topology_set_xml().

11.7.1.2 HWLOC_DECLSPEC hwloc_obj_t hwloc_topology_insert_misc_object_by_cpuset (hwloc_topology_t *topology*, hwloc_const_cpuset_t *cpuset*, const char * *name*)

Add a MISC object to the topology.

A new MISC object will be created and inserted into the topology at the position given by cpuset.

cpuset and name will be copied.

Returns

the newly-created object

11.7.1.3 HWLOC_DECLSPEC hwloc_obj_t hwloc_topology_insert_misc_object_by_parent (hwloc_topology_t *topology*, hwloc_obj_t *parent*, const char * *name*)

Add a MISC object to the topology.

A new MISC object will be created and inserted into the topology at the position given by parent.

name will be copied.

Returns

the newly-created object

11.8 Get some Topology Information

Enumerations

- enum hwloc_get_type_depth_e { HWLOC_TYPE_DEPTH_UNKNOWN, HWLOC_TYPE_DEPTH_MULTIPLE }

Functions

- HWLOC_DECLSPEC unsigned hwloc_topology_get_depth (hwloc_topology_t __hwloc_restrict topology) __hwloc_attribute_pure

  Get the depth of the hierachical tree of objects.

- HWLOC_DECLSPEC int hwloc_get_type_depth (hwloc_topology_t topology, hwloc_obj_type_t type)

  Returns the depth of objects of type `type`.

- HWLOC_DECLSPEC hwloc_obj_type_t hwloc_get_depth_type (hwloc_topology_t topology, unsigned depth) __hwloc_attribute_pure

  Returns the type of objects at depth `depth`.

- HWLOC_DECLSPEC unsigned hwloc_get_nbobjs_by_depth (hwloc_topology_t topology, unsigned depth) __hwloc_attribute_pure

  Returns the width of level at depth `depth`.

- static __hwloc_inline int __hwloc_attribute_pure hwloc_get_nbobjs_by_type (hwloc_topology_t topology, hwloc_obj_type_t type)

  Returns the width of level type `type`.

- HWLOC_DECLSPEC int hwloc_topology_is_thissystem (hwloc_topology_t __hwloc_restrict topology) __hwloc_attribute_pure

  Does the topology context come from this system?

11.8.1 Enumeration Type Documentation

11.8.1.1 enum hwloc_get_type_depth_e

Enumerator:

HWLOC_TYPE_DEPTH_UNKNOWN No object of given type exists in the topology.

HWLOC_TYPE_DEPTH_MULTIPLE Objects of given type exist at different depth in the topology.

11.8.2 Function Documentation

11.8.2.1 HWLOC_DECLSPEC hwloc_obj_type_t hwloc_get_depth_type (hwloc_topology_t *topology,* unsigned *depth*)

Returns the type of objects at depth `depth`.

Returns

-1 if depth `depth` does not exist.

11.8.2.2 HWLOC_DECLSPEC unsigned hwloc_get_nbobjs_by_depth (hwloc_topology_t *topology,* unsigned *depth*)

Returns the width of level at depth `depth`.

11.8.2.3 static __hwloc_inline int __hwloc_attribute_pure hwloc_get_nbobjs_by_type (hwloc_topology_t *topology,* hwloc_obj_type_t *type*) [static]

Returns the width of level type `type`.

If no object for that type exists, 0 is returned. If there are several levels with objects of that type, -1 is returned.

11.8.2.4 HWLOC_DECLSPEC int hwloc_get_type_depth (hwloc_topology_t *topology,* hwloc_obj_type_t *type*)

Returns the depth of objects of type `type`.

If no object of this type is present on the underlying architecture, or if the OS doesn't provide this kind of information, the function returns HWLOC_TYPE_DEPTH_UNKNOWN.

If type is absent but a similar type is acceptable, see also hwloc_get_type_or_below_depth() and hwloc_get_type_or_above_depth().

11.8.2.5 HWLOC_DECLSPEC unsigned hwloc_topology_get_depth (hwloc_topology_t __hwloc_restrict *topology*)

Get the depth of the hierachical tree of objects.

This is the depth of HWLOC_OBJ_PU objects plus one.

11.8.2.6 HWLOC_DECLSPEC int hwloc_topology_is_thissystem (hwloc_topology_t __hwloc_restrict *topology*)

Does the topology context come from this system?

Returns

1 if this topology context was built using the system running this program.
0 instead (for instance if using another file-system root, a XML topology file, or a synthetic topology).

11.9 Retrieve Objects

Functions

- HWLOC_DECLSPEC hwloc_obj_t hwloc_get_obj_by_depth (hwloc_topology_t topology, unsigned depth, unsigned idx) __hwloc_attribute_pure

  Returns the topology object at index `index` from depth `depth`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_by_type (hwloc_topology_t topology, hwloc_obj_type_t type, unsigned idx)

  Returns the topology object at index `index` with type `type`.

11.9.1 Function Documentation

11.9.1.1 HWLOC_DECLSPEC hwloc_obj_t hwloc_get_obj_by_depth (hwloc_topology_t *topology*, unsigned *depth*, unsigned *idx*)

Returns the topology object at index `index` from depth `depth`.

11.9.1.2 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_by_type (hwloc_topology_t *topology*, hwloc_obj_type_t *type*, unsigned *idx*) [static]

Returns the topology object at index `index` with type `type`.

If no object for that type exists, `NULL` is returned. If there are several levels with objects of that type, `NULL` is returned and ther caller may fallback to hwloc_get_obj_by_depth().

11.10 Object/String Conversion

Functions

- HWLOC_DECLSPEC const char * hwloc_obj_type_string (hwloc_obj_type_t type) __hwloc_attribute_const

  Return a stringified topology object type.

- HWLOC_DECLSPEC hwloc_obj_type_t hwloc_obj_type_of_string (const char *string) __hwloc_attribute_pure

  Return an object type from the string.

- HWLOC_DECLSPEC int hwloc_obj_type_snprintf (char *__hwloc_restrict string, size_t size, hwloc_obj_t obj, int verbose)

  Stringify the type of a given topology object into a human-readable form.

- HWLOC_DECLSPEC int hwloc_obj_attr_snprintf (char *__hwloc_restrict string, size_t size, hwloc_obj_t obj, const char *__hwloc_restrict separator, int verbose)

  Stringify the attributes of a given topology object into a human-readable form.

- HWLOC_DECLSPEC int hwloc_obj_snprintf (char *__hwloc_restrict string, size_t size, hwloc_topology_t topology, hwloc_obj_t obj, const char *__hwloc_restrict indexprefix, int verbose)

  Stringify a given topology object into a human-readable form.

- HWLOC_DECLSPEC int hwloc_obj_cpuset_snprintf (char *__hwloc_restrict str, size_t size, size_t nobj, const hwloc_obj_t *__hwloc_restrict objs)

  Stringify the cpuset containing a set of objects.

11.10.1 Function Documentation

11.10.1.1 HWLOC_DECLSPEC int hwloc_obj_attr_snprintf (char *__hwloc_restrict *string*, size_t *size*, hwloc_obj_t *obj*, const char *__hwloc_restrict *separator*, int *verbose*)

Stringify the attributes of a given topology object into a human-readable form.

Attribute values are separated by `separator`.

Only the major attributes are printed in non-verbose mode.

Returns

how many characters were actually written (not including the ending \0), or -1 on error.

11.10.1.2 HWLOC_DECLSPEC int hwloc_obj_cpuset_snprintf (char *__hwloc_restrict *str*, size_t *size*, size_t *nobj*, const hwloc_obj_t *__hwloc_restrict *objs*)

Stringify the cpuset containing a set of objects.

Returns

how many characters were actually written (not including the ending \0).

11.10.1.3 HWLOC_DECLSPEC int hwloc_obj_snprintf (char *__hwloc_restrict *string*, size_t *size*, hwloc_topology_t *topology*, hwloc_obj_t *obj*, const char *__hwloc_restrict *indexprefix*, int *verbose*)

Stringify a given topology object into a human-readable form.

Note

This function is deprecated in favor of hwloc_obj_type_snprintf() and hwloc_obj_attr_snprintf() since it is not very flexible and only prints physical/OS indexes.

Fill string `string` up to `size` characters with the description of topology object `obj` in topology `topology`.

If `verbose` is set, a longer description is used. Otherwise a short description is used.

`indexprefix` is used to prefix the `os_index` attribute number of the object in the description. If `NULL`, the # character is used.

Returns

how many characters were actually written (not including the ending \0), or -1 on error.

11.10.1.4 HWLOC_DECLSPEC hwloc_obj_type_t hwloc_obj_type_of_string (const char * *string*)

Return an object type from the string.

Returns

-1 if unrecognized.

11.10.1.5 HWLOC_DECLSPEC int hwloc_obj_type_snprintf (char *__hwloc_restrict *string*, size_t *size*, hwloc_obj_t *obj*, int *verbose*)

Stringify the type of a given topology object into a human-readable form.

It differs from hwloc_obj_type_string() because it prints type attributes such as cache depth.

Returns

how many characters were actually written (not including the ending \0), or -1 on error.

11.10.1.6 HWLOC_DECLSPEC const char* hwloc_obj_type_string (hwloc_obj_type_t *type*) const

Return a stringified topology object type.

11.11 Binding

Enumerations

- enum hwloc_cpubind_policy_t { HWLOC_CPUBIND_PROCESS, HWLOC_CPUBIND_THREAD, HWLOC_CPUBIND_STRICT }

  Process/Thread binding policy.

Functions

- HWLOC_DECLSPEC int hwloc_set_cpubind (hwloc_topology_t topology, hwloc_const_cpuset_t set, int policy)

Bind current process or thread on cpus given in cpuset `set`.

- HWLOC_DECLSPEC int hwloc_get_cpubind (hwloc_topology_t topology, hwloc_cpuset_t set, int policy)

  Get current process or thread binding.

- HWLOC_DECLSPEC int hwloc_set_proc_cpubind (hwloc_topology_t topology, hwloc_pid_t pid, hwloc_const_cpuset_t set, int policy)

  Bind a process `pid` *on cpus given in cpuset* `set`.

- HWLOC_DECLSPEC int hwloc_get_proc_cpubind (hwloc_topology_t topology, hwloc_pid_t pid, hwloc_cpuset_t set, int policy)

  Get the current binding of process `pid`.

- HWLOC_DECLSPEC int hwloc_set_thread_cpubind (hwloc_topology_t topology, hwloc_thread_t tid, hwloc_const_cpuset_t set, int policy)

  Bind a thread `tid` *on cpus given in cpuset* `set`.

- HWLOC_DECLSPEC int hwloc_get_thread_cpubind (hwloc_topology_t topology, hwloc_thread_t tid, hwloc_cpuset_t set, int policy)

  Get the current binding of thread `tid`.

11.11.1 Detailed Description

It is often useful to call hwloc_cpuset_singlify() first so that a single CPU remains in the set. This way, the process will not even migrate between different CPUs. Some OSes also only support that kind of binding.

Note

Some OSes do not provide all ways to bind processes, threads, etc and the corresponding binding functions may fail. ENOSYS is returned when it is not possible to bind the requested kind of object processes/threads). EXDEV is returned when the requested cpuset can not be enforced (e.g. some systems only allow one CPU, and some other systems only allow one NUMA node)

The most portable version that should be preferred over the others, whenever possible, is

```
hwloc_set_cpubind(topology, set, 0),
```

as it just binds the current program, assuming it is monothread, or

```
hwloc_set_cpubind(topology, set, HWLOC_CPUBIND_THREAD),
```

which binds the current thread of the current program (which may be multithreaded).

Note

To unbind, just call the binding function with either a full cpuset or a cpuset equal to the system cpuset.

11.11.2 Enumeration Type Documentation

11.11.2.1 enum hwloc_cpubind_policy_t

Process/Thread binding policy.

These flags can be used to refine the binding policy.

The default (0) is to bind the current process, assumed to be mono-thread, in a non-strict way. This is the most portable way to bind as all OSes usually provide it.

Enumerator:

HWLOC_CPUBIND_PROCESS Bind all threads of the current multithreaded process. This may not be supported by some OSes.

HWLOC_CPUBIND_THREAD Bind current thread of current process.

HWLOC_CPUBIND_STRICT Request for strict binding from the OS. By default, when the designated CPUs are all busy while other CPUs are idle, OSes may execute the thread/process on those other CPUs instead of the designated CPUs, to let them progress anyway. Strict binding means that the thread/process will _never_ execute on other cpus than the designated CPUs, even when those are busy with other tasks and other CPUs are idle.

Note

Depending on OSes and implementations, strict binding may not be possible (implementation reason) or not allowed (administrative reasons), and the function will fail in that case.

When retrieving the binding of a process, this flag checks whether all its threads actually have the same binding. If the flag is not given, the binding of each thread will be accumulated.

Note

This flag is meaningless when retrieving the binding of a thread.

11.11.3 Function Documentation

11.11.3.1 HWLOC_DECLSPEC int hwloc_get_cpubind (hwloc_topology_t *topology,* hwloc_cpuset_t *set,* int *policy*)

Get current process or thread binding.

11.11.3.2 HWLOC_DECLSPEC int hwloc_get_proc_cpubind (hwloc_topology_t *topology,* hwloc_pid_t *pid,* hwloc_cpuset_t *set,* int *policy*)

Get the current binding of process `pid`.

Note

hwloc_pid_t is pid_t on unix platforms, and HANDLE on native Windows platforms HWLOC_CPUBIND_THREAD can not be used in `policy`.

11.11.3.3 HWLOC_DECLSPEC int hwloc_get_thread_cpubind (hwloc_topology_t *topology,* hwloc_thread_t *tid,* hwloc_cpuset_t *set,* int *policy*)

Get the current binding of thread `tid`.

Note

hwloc_thread_t is pthread_t on unix platforms, and HANDLE on native Windows platforms
HWLOC_CPUBIND_PROCESS can not be used in `policy`.

11.11.3.4 HWLOC_DECLSPEC int hwloc_set_cpubind (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*, int *policy*)

Bind current process or thread on cpus given in cpuset `set`.

Returns

ENOSYS if the action is not supported
EXDEV if the binding cannot be enforced

11.11.3.5 HWLOC_DECLSPEC int hwloc_set_proc_cpubind (hwloc_topology_t *topology*, hwloc_pid_t *pid*, hwloc_const_cpuset_t *set*, int *policy*)

Bind a process `pid` on cpus given in cpuset `set`.

Note

hwloc_pid_t is pid_t on unix platforms, and HANDLE on native Windows platforms
HWLOC_CPUBIND_THREAD can not be used in `policy`.

11.11.3.6 HWLOC_DECLSPEC int hwloc_set_thread_cpubind (hwloc_topology_t *topology*, hwloc_thread_t *tid*, hwloc_const_cpuset_t *set*, int *policy*)

Bind a thread `tid` on cpus given in cpuset `set`.

Note

hwloc_thread_t is pthread_t on unix platforms, and HANDLE on native Windows platforms
HWLOC_CPUBIND_PROCESS can not be used in `policy`.

11.12 Object Type Helpers

Functions

- static __hwloc_inline int __hwloc_attribute_pure hwloc_get_type_or_below_depth (hwloc_topology_t topology, hwloc_obj_type_t type)

  Returns the depth of objects of type `type` or below.

- static __hwloc_inline int __hwloc_attribute_pure hwloc_get_type_or_above_depth (hwloc_topology_t topology, hwloc_obj_type_t type)

  Returns the depth of objects of type `type` or above.

11.12.1 Function Documentation

11.12.1.1 static __hwloc_inline int __hwloc_attribute_pure hwloc_get_type_or_above_depth (hwloc_topology_t *topology*, hwloc_obj_type_t *type*) [static]

Returns the depth of objects of type `type` or above.

If no object of this type is present on the underlying architecture, the function returns the depth of the first "present" object typically containing `type`.

11.12.1.2 static __hwloc_inline int __hwloc_attribute_pure hwloc_get_type_or_below_depth (hwloc_topology_t *topology*, hwloc_obj_type_t *type*) [static]

Returns the depth of objects of type `type` or below.

If no object of this type is present on the underlying architecture, the function returns the depth of the first "present" object typically found inside `type`.

11.13 Basic Traversal Helpers

Functions

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_root_obj (hwloc_topology_t topology)

  Returns the top-object of the topology-tree.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_ancestor_obj_by_depth (hwloc_topology_t topology __hwloc_attribute_unused, unsigned depth, hwloc_obj_t obj)

  Returns the ancestor object of `obj` at depth `depth`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_ancestor_obj_by_type (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_obj_type_t type, hwloc_obj_t obj)

  Returns the ancestor object of `obj` with type `type`.

- static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_by_depth (hwloc_topology_t topology, unsigned depth, hwloc_obj_t prev)

  Returns the next object at depth `depth`.

- static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_by_type (hwloc_topology_t topology, hwloc_obj_type_t type, hwloc_obj_t prev)

  Returns the next object of type `type`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_pu_obj_by_os_index (hwloc_topology_t topology, unsigned os_index)

  Returns the object of type HWLOC_OBJ_PU with `os_index`.

- static __hwloc_inline hwloc_obj_t hwloc_get_next_child (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_obj_t parent, hwloc_obj_t prev)

  Return the next child.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_common_ancestor_obj (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_obj_t obj1, hwloc_obj_t obj2)

  Returns the common parent object to objects lvl1 and lvl2.

- static __hwloc_inline int __hwloc_attribute_pure hwloc_obj_is_in_subtree (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_obj_t obj, hwloc_obj_t subtree_root)

  Returns true if _obj_ is inside the subtree beginning with `subtree_root`.

11.13.1 Function Documentation

11.13.1.1 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_ancestor_obj_by_depth (hwloc_topology_t topology *__hwloc_attribute_unused,* unsigned *depth,* hwloc_obj_t *obj*) [static]

Returns the ancestor object of `obj` at depth `depth`.

11.13.1.2 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_ancestor_obj_by_type (hwloc_topology_t topology *__hwloc_attribute_unused,* hwloc_obj_type_t *type,* hwloc_obj_t *obj*) [static]

Returns the ancestor object of `obj` with type `type`.

11.13.1.3 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_common_ancestor_obj (hwloc_topology_t topology *__hwloc_attribute_unused,* hwloc_obj_t *obj1,* hwloc_obj_t *obj2*) [static]

Returns the common parent object to objects lvl1 and lvl2.

11.13.1.4 static __hwloc_inline hwloc_obj_t hwloc_get_next_child (hwloc_topology_t topology *__hwloc_attribute_unused,* hwloc_obj_t *parent,* hwloc_obj_t *prev*) [static]

Return the next child.

If `prev` is `NULL`, return the first child.

11.13.1.5 static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_by_depth (hwloc_topology_t *topology,* unsigned *depth,* hwloc_obj_t *prev*) [static]

Returns the next object at depth `depth`.

If `prev` is `NULL`, return the first object at depth `depth`.

11.13.1.6 static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_by_type (hwloc_topology_t *topology,* hwloc_obj_type_t *type,* hwloc_obj_t *prev*) [static]

Returns the next object of type `type`.

If `prev` is `NULL`, return the first object at type `type`. If there are multiple or no depth for given type, return `NULL` and let the caller fallback to hwloc_get_next_obj_by_depth().

11.13.1.7 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_pu_obj_by_os_index (hwloc_topology_t *topology,* unsigned *os_index*) [static]

Returns the object of type HWLOC_OBJ_PU with `os_index`.

Note

The `os_index` field of object should most of the times only be used for pretty-printing purpose. Type HWLOC_OBJ_PU is the only case where `os_index` could actually be useful, when manually binding to processors. However, using CPU sets to hide this complexity should often be preferred.

11.13.1.8 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_root_obj (hwloc_topology_t *topology*) [static]

Returns the top-object of the topology-tree.

Its type is typically HWLOC_OBJ_MACHINE but it could be different for complex topologies. This function replaces the old deprecated hwloc_get_system_obj().

11.13.1.9 static __hwloc_inline int __hwloc_attribute_pure hwloc_obj_is_in_subtree (hwloc_topology_t topology *__hwloc_attribute_unused,* hwloc_obj_t *obj,* hwloc_obj_t *subtree_root*) [static]

Returns true if _obj_ is inside the subtree beginning with `subtree_root`.

11.14 Finding Objects Inside a CPU set

Functions

- static __hwloc_inline hwloc_obj_t hwloc_get_first_largest_obj_inside_cpuset (hwloc_topology_t topology, hwloc_const_cpuset_t set)

  Get the first largest object included in the given cpuset `set`.

- HWLOC_DECLSPEC int hwloc_get_largest_objs_inside_cpuset (hwloc_topology_t topology, hwloc_const_cpuset_t set, hwloc_obj_t *__hwloc_restrict objs, int max)

  Get the set of largest objects covering exactly a given cpuset `set`.

- static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_inside_cpuset_by_depth (hwloc_topology_t topology, hwloc_const_cpuset_t set, unsigned depth, hwloc_obj_t prev)

  Return the next object at depth `depth` included in CPU set `set`.

- static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_inside_cpuset_by_type (hwloc_topology_t topology, hwloc_const_cpuset_t set, hwloc_obj_type_t type, hwloc_obj_t prev)

  Return the next object of type `type` included in CPU set `set`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_inside_cpuset_by_depth (hwloc_topology_t topology, hwloc_const_cpuset_t set, unsigned depth, unsigned idx)

  Return the `index` -th object at depth `depth` included in CPU set `set`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_inside_cpuset_by_type (hwloc_topology_t topology, hwloc_const_cpuset_t set, hwloc_obj_type_t type, unsigned idx)

  Return the `idx` *-th object of type* `type` *included in CPU set* `set`.

- static __hwloc_inline unsigned __hwloc_attribute_pure hwloc_get_nbobjs_inside_cpuset_by_depth (hwloc_topology_t topology, hwloc_const_cpuset_t set, unsigned depth)

  Return the number of objects at depth `depth` *included in CPU set* `set`.

- static __hwloc_inline int __hwloc_attribute_pure hwloc_get_nbobjs_inside_cpuset_by_type (hwloc_topology_t topology, hwloc_const_cpuset_t set, hwloc_obj_type_t type)

  Return the number of objects of type `type` *included in CPU set* `set`.

11.14.1 Function Documentation

11.14.1.1 static __hwloc_inline hwloc_obj_t hwloc_get_first_largest_obj_inside_cpuset (hwloc_topology_t *topology,* hwloc_const_cpuset_t *set*) [static]

Get the first largest object included in the given cpuset `set`.

Returns

the first object that is included in `set` and whose parent is not.

This is convenient for iterating over all largest objects within a CPU set by doing a loop getting the first largest object and clearing its CPU set from the remaining CPU set.

11.14.1.2 HWLOC_DECLSPEC int hwloc_get_largest_objs_inside_cpuset (hwloc_topology_t *topology,* hwloc_const_cpuset_t *set,* hwloc_obj_t *__hwloc_restrict *objs,* int *max*)

Get the set of largest objects covering exactly a given cpuset `set`.

Returns

the number of objects returned in `objs`.

11.14.1.3 static __hwloc_inline unsigned __hwloc_attribute_pure hwloc_get_nbobjs_inside_cpuset_by_depth (hwloc_topology_t *topology,* hwloc_const_cpuset_t *set,* unsigned *depth*) [static]

Return the number of objects at depth `depth` included in CPU set `set`.

11.14.1.4 static __hwloc_inline int __hwloc_attribute_pure hwloc_get_nbobjs_inside_cpuset_by_type (hwloc_topology_t *topology,* hwloc_const_cpuset_t *set,* hwloc_obj_type_t *type*) [static]

Return the number of objects of type `type` included in CPU set `set`.

If no object for that type exists inside CPU set `set`, 0 is returned. If there are several levels with objects of that type inside CPU set `set`, -1 is returned.

11.14.1.5 static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_inside_cpuset_by_depth (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*, unsigned *depth*, hwloc_obj_t *prev*) [static]

Return the next object at depth `depth` included in CPU set `set`.

If `prev` is `NULL`, return the first object at depth `depth` included in `set`. The next invokation should pass the previous return value in `prev` so as to obtain the next object in `set`.

11.14.1.6 static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_inside_cpuset_by_type (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*, hwloc_obj_type_t *type*, hwloc_obj_t *prev*) [static]

Return the next object of type `type` included in CPU set `set`.

If there are multiple or no depth for given type, return `NULL` and let the caller fallback to hwloc_get_next_obj_inside_cpuset_by_depth().

11.14.1.7 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_inside_cpuset_by_depth (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*, unsigned *depth*, unsigned *idx*) [static]

Return the `index` -th object at depth `depth` included in CPU set `set`.

11.14.1.8 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_inside_cpuset_by_type (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*, hwloc_obj_type_t *type*, unsigned *idx*) [static]

Return the `idx` -th object of type `type` included in CPU set `set`.

If there are multiple or no depth for given type, return `NULL` and let the caller fallback to hwloc_get_obj_inside_cpuset_by_depth().

11.15 Finding a single Object covering at least CPU set

Functions

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_child_covering_cpuset (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_const_cpuset_t set, hwloc_obj_t parent)

  Get the child covering at least CPU set `set`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_covering_cpuset (hwloc_topology_t topology, hwloc_const_cpuset_t set)

  Get the lowest object covering at least CPU set `set`.

11.15.1 Function Documentation

11.15.1.1 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_child_covering_cpuset (hwloc_topology_t topology __*hwloc_attribute_unused,* hwloc_const_cpuset_t *set,* hwloc_obj_t *parent*) [static]

Get the child covering at least CPU set `set`.

Returns

`NULL` if no child matches or if `set` is empty.

11.15.1.2 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_covering_cpuset (hwloc_topology_t *topology,* hwloc_const_cpuset_t *set*) [static]

Get the lowest object covering at least CPU set `set`.

Returns

`NULL` if no object matches or if `set` is empty.

11.16 Finding a set of similar Objects covering at least a CPU set

Functions

- static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_covering_cpuset_by_depth (hwloc_topology_t topology, hwloc_const_cpuset_t set, unsigned depth, hwloc_obj_t prev)

  Iterate through same-depth objects covering at least CPU set `set`.

- static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_covering_cpuset_by_type (hwloc_topology_t topology, hwloc_const_cpuset_t set, hwloc_obj_type_t type, hwloc_obj_t prev)

  Iterate through same-type objects covering at least CPU set `set`.

11.16.1 Function Documentation

11.16.1.1 static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_covering_cpuset_by_depth (hwloc_topology_t *topology,* hwloc_const_cpuset_t *set,* unsigned *depth,* hwloc_obj_t *prev*) [static]

Iterate through same-depth objects covering at least CPU set `set`.

If object `prev` is `NULL`, return the first object at depth `depth` covering at least part of CPU set `set`. The next invokation should pass the previous return value in `prev` so as to obtain the next object covering at least another part of `set`.

11.16.1.2 static __hwloc_inline hwloc_obj_t hwloc_get_next_obj_covering_cpuset_by_type (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*, hwloc_obj_type_t *type*, hwloc_obj_t *prev*) [static]

Iterate through same-type objects covering at least CPU set `set`.

If object `prev` is `NULL`, return the first object of type `type` covering at least part of CPU set `set`. The next invokation should pass the previous return value in `prev` so as to obtain the next object of type `type` covering at least another part of `set`.

If there are no or multiple depths for type `type`, `NULL` is returned. The caller may fallback to hwloc_get_next_obj_covering_cpuset_by_depth() for each depth.

11.17 Cache-specific Finding Helpers

Functions

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_cache_covering_cpuset (hwloc_topology_t topology, hwloc_const_cpuset_t set)

  Get the first cache covering a cpuset `set`.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_shared_cache_covering_obj (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_obj_t obj)

  Get the first cache shared between an object and somebody else.

11.17.1 Function Documentation

11.17.1.1 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_cache_covering_cpuset (hwloc_topology_t *topology*, hwloc_const_cpuset_t *set*) [static]

Get the first cache covering a cpuset `set`.

Returns

`NULL` if no cache matches

11.17.1.2 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_shared_cache_covering_obj (hwloc_topology_t topology *__hwloc_attribute_unused*, hwloc_obj_t *obj*) [static]

Get the first cache shared between an object and somebody else.

Returns

`NULL` if no cache matches

11.18 Advanced Traversal Helpers

Functions

- HWLOC_DECLSPEC unsigned hwloc_get_closest_objs (hwloc_topology_t topology, hwloc_obj_t src, hwloc_obj_t *__hwloc_restrict objs, unsigned max)

  Do a depth-first traversal of the topology to find and sort.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_below_by_type (hwloc_topology_t topology, hwloc_obj_type_t type1, unsigned idx1, hwloc_obj_type_t type2, unsigned idx2)

  Find an object below another object, both specified by types and indexes.

- static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_below_array_by_type (hwloc_topology_t topology, int nr, hwloc_obj_type_t *typev, unsigned *idxv)

  Find an object below a chain of objects specified by types and indexes.

11.18.1 Function Documentation

11.18.1.1 HWLOC_DECLSPEC unsigned hwloc_get_closest_objs (hwloc_topology_t *topology,* hwloc_obj_t *src,* hwloc_obj_t *__hwloc_restrict *objs,* unsigned *max*)

Do a depth-first traversal of the topology to find and sort.

all objects that are at the same depth than `src`. Report in `objs` up to `max` physically closest ones to `src`.

Returns

the number of objects returned in `objs`.

11.18.1.2 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_below_array_by_type (hwloc_topology_t *topology,* int *nr,* hwloc_obj_type_t * *typev,* unsigned * *idxv*) [static]

Find an object below a chain of objects specified by types and indexes.

This is a generalized version of hwloc_get_obj_below_by_type().

Arrays `typev` and `idxv` must contain `nr` types and indexes.

Start from the top system object and walk the arrays `typev` and `idxv`. For each type and index couple in the arrays, look under the previously found object to find the index-th object of the given type. Indexes are specified within the parent, not withing the entire system.

For instance, if nr is 3, typev contains NODE, SOCKET and CORE, and idxv contains 0, 1 and 2, return the third core object below the second socket below the first NUMA node.

11.18.1.3 static __hwloc_inline hwloc_obj_t __hwloc_attribute_pure hwloc_get_obj_below_by_type (hwloc_topology_t *topology,* hwloc_obj_type_t *type1,* unsigned *idx1,* hwloc_obj_type_t *type2,* unsigned *idx2*) [static]

Find an object below another object, both specified by types and indexes.

Start from the top system object and find object of type `type1` and index `idx1`. Then look below this object and find another object of type `type2` and index `idx2`. Indexes are specified within the parent, not withing the entire system.

For instance, if type1 is SOCKET, idx1 is 2, type2 is CORE and idx2 is 3, return the fourth core object below the third socket.

11.19 Binding Helpers

Functions

- static __hwloc_inline void hwloc_distribute (hwloc_topology_t topology, hwloc_obj_t root, hwloc_-cpuset_t *cpuset, unsigned n)

  Distribute `n` items over the topology under `root`.

11.19.1 Function Documentation

11.19.1.1 static __hwloc_inline void hwloc_distribute (hwloc_topology_t *topology*, hwloc_obj_t *root*, hwloc_cpuset_t * *cpuset*, unsigned *n*) [static]

Distribute `n` items over the topology under `root`.

Array `cpuset` will be filled with `n` cpusets distributed linearly over the topology under `root` .

This is typically useful when an application wants to distribute `n` threads over a machine, giving each of them as much private cache as possible and keeping them locally in number order.

The caller may typically want to also call hwloc_cpuset_singlify() before binding a thread so that it does not move at all.

11.20 Cpuset Helpers

Functions

- static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_-complete_cpuset (hwloc_topology_t topology)
- static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_-topology_cpuset (hwloc_topology_t topology)
- static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_online_-cpuset (hwloc_topology_t topology)

  Get online CPU set.

- static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_-allowed_cpuset (hwloc_topology_t topology)

  Get allowed CPU set.

11.20.1 Function Documentation

11.20.1.1 static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_allowed_cpuset (hwloc_topology_t *topology*) [static]

Get allowed CPU set.

Returns

the CPU set of allowed logical processors of the system. If the topology is the result of a combination of several systems, NULL is returned.

Note

The returned cpuset is not newly allocated and should thus not be changed or freed, hwloc_cpuset_dup must be used to obtain a local copy.

11.20.1.2 static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_complete_cpuset (hwloc_topology_t *topology*) [static]

11.20.1.3 static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_online_cpuset (hwloc_topology_t *topology*) [static]

Get online CPU set.

Returns

the CPU set of online logical processors of the system. If the topology is the result of a combination of several systems, NULL is returned.

Note

The returned cpuset is not newly allocated and should thus not be changed or freed; hwloc_cpuset_dup must be used to obtain a local copy.

11.20.1.4 static __hwloc_inline hwloc_const_cpuset_t __hwloc_attribute_pure hwloc_topology_get_topology_cpuset (hwloc_topology_t *topology*) [static]

11.21 The Cpuset API

Defines

- #define hwloc_cpuset_foreach_begin(cpu, set)

  Loop macro iterating on CPU set `set`.

- #define hwloc_cpuset_foreach_end()

  End of loop. Needs a terminating ';'.

Typedefs

- typedef struct hwloc_cpuset_s * hwloc_cpuset_t

  Set of CPUs represented as an opaque pointer to an internal bitmask.

- typedef struct hwloc_cpuset_s * hwloc_const_cpuset_t

Functions

- HWLOC_DECLSPEC hwloc_cpuset_t hwloc_cpuset_alloc (void) __hwloc_attribute_malloc

  Allocate a new empty CPU set.

- HWLOC_DECLSPEC void hwloc_cpuset_free (hwloc_cpuset_t set)

  Free CPU set `set`.

- HWLOC_DECLSPEC hwloc_cpuset_t hwloc_cpuset_dup (hwloc_const_cpuset_t set) __hwloc_attribute_malloc

  Duplicate CPU set `set` *by allocating a new CPU set and copying* `set's` *contents.*

- HWLOC_DECLSPEC void hwloc_cpuset_copy (hwloc_cpuset_t dst, hwloc_const_cpuset_t src)

  Copy the contents of CPU set `src` *into the already allocated CPU set* `dst`.

- HWLOC_DECLSPEC int hwloc_cpuset_snprintf (char *__hwloc_restrict buf, size_t buflen, hwloc_const_cpuset_t set)

  Stringify a cpuset.

- HWLOC_DECLSPEC int hwloc_cpuset_asprintf (char **strp, hwloc_const_cpuset_t set)

  Stringify a cpuset into a newly allocated string.

- HWLOC_DECLSPEC int hwloc_cpuset_from_string (hwloc_cpuset_t set, const char *__hwloc_restrict string)

  Parse a cpuset string and stores it in CPU set `set`.

- HWLOC_DECLSPEC void hwloc_cpuset_zero (hwloc_cpuset_t set)

  Empty the CPU set `set`.

- HWLOC_DECLSPEC void hwloc_cpuset_fill (hwloc_cpuset_t set)

  Fill CPU set `set` *with all possible CPUs (even if those CPUs don't exist or are otherwise unavailable).*

- HWLOC_DECLSPEC void hwloc_cpuset_from_ulong (hwloc_cpuset_t set, unsigned long mask)

  Setup CPU set `set` *from unsigned long* `mask`.

- HWLOC_DECLSPEC void hwloc_cpuset_from_ith_ulong (hwloc_cpuset_t set, unsigned i, unsigned long mask)

  Setup CPU set `set` *from unsigned long* `mask` *used as* `i` *-th subset.*

- HWLOC_DECLSPEC unsigned long hwloc_cpuset_to_ulong (hwloc_const_cpuset_t set) __hwloc_attribute_pure

  Convert the beginning part of CPU set `set` *into unsigned long* `mask`.

- HWLOC_DECLSPEC unsigned long hwloc_cpuset_to_ith_ulong (hwloc_const_cpuset_t set, unsigned i) __hwloc_attribute_pure

  Convert the `i` -th subset of CPU set `set` into unsigned long mask.

- HWLOC_DECLSPEC void hwloc_cpuset_cpu (hwloc_cpuset_t set, unsigned cpu)

  Empty the CPU set `set` and add CPU `cpu`.

- HWLOC_DECLSPEC void hwloc_cpuset_all_but_cpu (hwloc_cpuset_t set, unsigned cpu)

  Empty the CPU set `set` and add all but the CPU `cpu`.

- HWLOC_DECLSPEC void hwloc_cpuset_set (hwloc_cpuset_t set, unsigned cpu)

  Add CPU `cpu` in CPU set `set`.

- HWLOC_DECLSPEC void hwloc_cpuset_set_range (hwloc_cpuset_t set, unsigned begincpu, unsigned endcpu)

  Add CPUs from `begincpu` to `endcpu` in CPU set `set`.

- HWLOC_DECLSPEC void hwloc_cpuset_clr (hwloc_cpuset_t set, unsigned cpu)

  Remove CPU `cpu` from CPU set `set`.

- HWLOC_DECLSPEC void hwloc_cpuset_clr_range (hwloc_cpuset_t set, unsigned begincpu, unsigned endcpu)

  Remove CPUs from `begincpu` to `endcpu` in CPU set `set`.

- HWLOC_DECLSPEC int hwloc_cpuset_isset (hwloc_const_cpuset_t set, unsigned cpu) __hwloc_attribute_pure

  Test whether CPU `cpu` is part of set `set`.

- HWLOC_DECLSPEC int hwloc_cpuset_iszero (hwloc_const_cpuset_t set) __hwloc_attribute_pure

  Test whether set `set` is empty.

- HWLOC_DECLSPEC int hwloc_cpuset_isfull (hwloc_const_cpuset_t set) __hwloc_attribute_pure

  Test whether set `set` is completely full.

- HWLOC_DECLSPEC int hwloc_cpuset_isequal (hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2) __hwloc_attribute_pure

  Test whether set `set1` is equal to set `set2`.

- HWLOC_DECLSPEC int hwloc_cpuset_intersects (hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2) __hwloc_attribute_pure

  Test whether sets `set1` and `set2` intersects.

- HWLOC_DECLSPEC int hwloc_cpuset_isincluded (hwloc_const_cpuset_t sub_set, hwloc_const_cpuset_t super_set) __hwloc_attribute_pure

  Test whether set `sub_set` is part of set `super_set`.

- HWLOC_DECLSPEC void hwloc_cpuset_or (hwloc_cpuset_t res, hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2)

  Or sets `set1` and `set2` and store the result in set `res`.

- HWLOC_DECLSPEC void hwloc_cpuset_and (hwloc_cpuset_t res, hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2)

  And sets `set1` and `set2` and store the result in set `res`.

- HWLOC_DECLSPEC void hwloc_cpuset_andnot (hwloc_cpuset_t res, hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2)

  And set `set1` and the negation of `set2` and store the result in set `res`.

- HWLOC_DECLSPEC void hwloc_cpuset_xor (hwloc_cpuset_t res, hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2)

  Xor sets `set1` and `set2` and store the result in set `res`.

- HWLOC_DECLSPEC void hwloc_cpuset_not (hwloc_cpuset_t res, hwloc_const_cpuset_t set)

  Negate set `set` and store the result in set `res`.

- HWLOC_DECLSPEC int hwloc_cpuset_first (hwloc_const_cpuset_t set) __hwloc_attribute_pure

  Compute the first CPU (least significant bit) in CPU set `set`.

- HWLOC_DECLSPEC int hwloc_cpuset_last (hwloc_const_cpuset_t set) __hwloc_attribute_pure

  Compute the last CPU (most significant bit) in CPU set `set`.

- HWLOC_DECLSPEC int hwloc_cpuset_next (hwloc_const_cpuset_t set, unsigned prev_cpu) __hwloc_attribute_pure

  Compute the next CPU in CPU set `set` which is after CPU `prev_cpu`.

- HWLOC_DECLSPEC void hwloc_cpuset_singlify (hwloc_cpuset_t set)

  Keep a single CPU among those set in CPU set `set`.

- HWLOC_DECLSPEC int hwloc_cpuset_compare_first (hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2) __hwloc_attribute_pure

  Compare CPU sets `set1` and `set2` using their lowest index CPU.

- HWLOC_DECLSPEC int hwloc_cpuset_compare (hwloc_const_cpuset_t set1, hwloc_const_cpuset_t set2) __hwloc_attribute_pure

  Compare CPU sets `set1` and `set2` using their highest index CPU.

- HWLOC_DECLSPEC int hwloc_cpuset_weight (hwloc_const_cpuset_t set) __hwloc_attribute_pure

  Compute the "weight" of CPU set `set` (i.e., number of CPUs that are in the set).

11.21.1 Detailed Description

For use in hwloc itself, a hwloc_cpuset_t represents a set of logical processors.

Note

cpusets are indexed by OS logical processor physical number.

11.21.2 Define Documentation

11.21.2.1 #define hwloc_cpuset_foreach_begin(*cpu*, *set*)

Loop macro iterating on CPU set `set`.

`cpu` is the loop variable; it should be an unsigned int. The first iteration will set `cpu` to the lowest index CPU in the set. Successive iterations will iterate through, in order, all remaining CPUs that in the set. To be specific: each iteration will return a value for `cpu` such that hwloc_cpuset_isset(set, cpu) is true.

11.21.2.2 #define hwloc_cpuset_foreach_end( )

End of loop. Needs a terminating ';'.

See also

hwloc_cpuset_foreach_begin

11.21.3 Typedef Documentation

11.21.3.1 typedef struct hwloc_cpuset_s* hwloc_const_cpuset_t

11.21.3.2 typedef struct hwloc_cpuset_s* hwloc_cpuset_t

Set of CPUs represented as an opaque pointer to an internal bitmask.

11.21.4 Function Documentation

11.21.4.1 HWLOC_DECLSPEC void hwloc_cpuset_all_but_cpu (hwloc_cpuset_t *set*, unsigned *cpu*)

Empty the CPU set `set` and add all but the CPU `cpu`.

11.21.4.2 HWLOC_DECLSPEC hwloc_cpuset_t hwloc_cpuset_alloc (void)

Allocate a new empty CPU set.

Returns

A valid CPU set or NULL.

The CPU set should be freed by a corresponding call to hwloc_cpuset_free().

11.21.4.3 HWLOC_DECLSPEC void hwloc_cpuset_and (hwloc_cpuset_t *res*, hwloc_const_cpuset_t *set1*, hwloc_const_cpuset_t *set2*)

And sets `set1` and `set2` and store the result in set `res`.

11.21.4.4 HWLOC_DECLSPEC void hwloc_cpuset_andnot (hwloc_cpuset_t *res*, hwloc_const_cpuset_t *set1*, hwloc_const_cpuset_t *set2*)

And set `set1` and the negation of `set2` and store the result in set `res`.

11.21.4.5 HWLOC_DECLSPEC int hwloc_cpuset_asprintf (char ** *strp*, hwloc_const_cpuset_t *set*)

Stringify a cpuset into a newly allocated string.

Returns

the number of character that were actually written (not including the ending \0).

11.21.4.6 HWLOC_DECLSPEC void hwloc_cpuset_clr (hwloc_cpuset_t *set*, unsigned *cpu*)

Remove CPU `cpu` from CPU set `set`.

11.21.4.7 HWLOC_DECLSPEC void hwloc_cpuset_clr_range (hwloc_cpuset_t *set*, unsigned *begincpu*, unsigned *endcpu*)

Remove CPUs from `begincpu` to `endcpu` in CPU set `set`.

11.21.4.8 HWLOC_DECLSPEC int hwloc_cpuset_compare (hwloc_const_cpuset_t *set1*, hwloc_const_cpuset_t *set2*)

Compare CPU sets `set1` and `set2` using their highest index CPU.

Higher most significant bit is higher. The empty CPU set is considered lower than anything.

11.21.4.9 HWLOC_DECLSPEC int hwloc_cpuset_compare_first (hwloc_const_cpuset_t *set1*, hwloc_const_cpuset_t *set2*)

Compare CPU sets `set1` and `set2` using their lowest index CPU.

Smaller least significant bit is smaller. The empty CPU set is considered higher than anything.

11.21.4.10 HWLOC_DECLSPEC void hwloc_cpuset_copy (hwloc_cpuset_t *dst*, hwloc_const_cpuset_t *src*)

Copy the contents of CPU set `src` into the already allocated CPU set `dst`.

11.21.4.11 HWLOC_DECLSPEC void hwloc_cpuset_cpu (hwloc_cpuset_t *set*, unsigned *cpu*)

Empty the CPU set `set` and add CPU `cpu`.

11.21.4.12 HWLOC_DECLSPEC hwloc_cpuset_t hwloc_cpuset_dup (hwloc_const_cpuset_t *set*)

Duplicate CPU set `set` by allocating a new CPU set and copying `set's` contents.

11.21.4.13 HWLOC_DECLSPEC void hwloc_cpuset_fill (hwloc_cpuset_t *set*)

Fill CPU set `set` with all possible CPUs (even if those CPUs don't exist or are otherwise unavailable).

11.21.4.14 HWLOC_DECLSPEC int hwloc_cpuset_first (hwloc_const_cpuset_t *set*)

Compute the first CPU (least significant bit) in CPU set `set`.

Returns

-1 if no CPU is set.

11.21.4.15 HWLOC_DECLSPEC void hwloc_cpuset_free (hwloc_cpuset_t *set*)

Free CPU set `set`.

11.21.4.16 HWLOC_DECLSPEC void hwloc_cpuset_from_ith_ulong (hwloc_cpuset_t *set,* unsigned *i,* unsigned long *mask*)

Setup CPU set `set` from unsigned long `mask` used as `i` -th subset.

11.21.4.17 HWLOC_DECLSPEC int hwloc_cpuset_from_string (hwloc_cpuset_t *set,* const char *__hwloc_restrict *string*)

Parse a cpuset string and stores it in CPU set `set`.

Must start and end with a digit.

11.21.4.18 HWLOC_DECLSPEC void hwloc_cpuset_from_ulong (hwloc_cpuset_t *set,* unsigned long *mask*)

Setup CPU set `set` from unsigned long `mask`.

11.21.4.19 HWLOC_DECLSPEC int hwloc_cpuset_intersects (hwloc_const_cpuset_t *set1,* hwloc_const_cpuset_t *set2*)

Test whether sets `set1` and `set2` intersects.

11.21.4.20 HWLOC_DECLSPEC int hwloc_cpuset_isequal (hwloc_const_cpuset_t *set1,* hwloc_const_cpuset_t *set2*)

Test whether set `set1` is equal to set `set2`.

11.21.4.21 HWLOC_DECLSPEC int hwloc_cpuset_isfull (hwloc_const_cpuset_t *set*)

Test whether set `set` is completely full.

11.21.4.22 HWLOC_DECLSPEC int hwloc_cpuset_isincluded (hwloc_const_cpuset_t *sub_set,* hwloc_const_cpuset_t *super_set*)

Test whether set `sub_set` is part of set `super_set`.

11.21.4.23 HWLOC_DECLSPEC int hwloc_cpuset_isset (hwloc_const_cpuset_t *set,* unsigned *cpu*)

Test whether CPU `cpu` is part of set `set`.

11.21.4.24 HWLOC_DECLSPEC int hwloc_cpuset_iszero (hwloc_const_cpuset_t *set*)

Test whether set `set` is empty.

11.21.4.25 HWLOC_DECLSPEC int hwloc_cpuset_last (hwloc_const_cpuset_t *set*)

Compute the last CPU (most significant bit) in CPU set `set`.

Returns

-1 if no CPU is set.

11.21.4.26 HWLOC_DECLSPEC int hwloc_cpuset_next (hwloc_const_cpuset_t *set,* unsigned *prev_cpu*)

Compute the next CPU in CPU set `set` which is after CPU `prev_cpu`.

Returns

-1 if no CPU with higher index is set.

11.21.4.27 HWLOC_DECLSPEC void hwloc_cpuset_not (hwloc_cpuset_t *res,* hwloc_const_cpuset_t *set*)

Negate set `set` and store the result in set `res`.

11.21.4.28 HWLOC_DECLSPEC void hwloc_cpuset_or (hwloc_cpuset_t *res,* hwloc_const_cpuset_t *set1,* hwloc_const_cpuset_t *set2*)

Or sets `set1` and `set2` and store the result in set `res`.

11.21.4.29 HWLOC_DECLSPEC void hwloc_cpuset_set (hwloc_cpuset_t *set,* unsigned *cpu*)

Add CPU `cpu` in CPU set `set`.

11.21.4.30 HWLOC_DECLSPEC void hwloc_cpuset_set_range (hwloc_cpuset_t *set,* unsigned *begincpu,* unsigned *endcpu*)

Add CPUs from `begincpu` to `endcpu` in CPU set `set`.

11.21.4.31 HWLOC_DECLSPEC void hwloc_cpuset_singlify (hwloc_cpuset_t *set*)

Keep a single CPU among those set in CPU set `set`.

May be useful before binding so that the process does not have a chance of migrating between multiple logical CPUs in the original mask.

11.21.4.32 HWLOC_DECLSPEC int hwloc_cpuset_snprintf (char *__hwloc_restrict *buf,* size_t *buflen,* hwloc_const_cpuset_t *set*)

Stringify a cpuset.

Up to `buflen` characters may be written in buffer `buf`.

Returns

the number of character that were actually written if not truncating, or that would have been written (not including the ending \0).

11.21.4.33 HWLOC_DECLSPEC unsigned long hwloc_cpuset_to_ith_ulong (hwloc_const_cpuset_t *set,* unsigned *i*)

Convert the `i` -th subset of CPU set `set` into unsigned long mask.

11.21.4.34 HWLOC_DECLSPEC unsigned long hwloc_cpuset_to_ulong (hwloc_const_cpuset_t *set*)

Convert the beginning part of CPU set `set` into unsigned long `mask`.

11.21.4.35 HWLOC_DECLSPEC int hwloc_cpuset_weight (hwloc_const_cpuset_t *set*)

Compute the "weight" of CPU set `set` (i.e., number of CPUs that are in the set).

Returns

the number of CPUs that are in the set.

11.21.4.36 HWLOC_DECLSPEC void hwloc_cpuset_xor (hwloc_cpuset_t *res,* hwloc_const_cpuset_t *set1,* hwloc_const_cpuset_t *set2*)

Xor sets `set1` and `set2` and store the result in set `res`.

11.21.4.37 HWLOC_DECLSPEC void hwloc_cpuset_zero (hwloc_cpuset_t *set*)

Empty the CPU set `set`.

11.22 Helpers for manipulating glibc sched affinity

Functions

- static __hwloc_inline int hwloc_cpuset_to_glibc_sched_affinity (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_const_cpuset_t hwlocset, cpu_set_t *schedset, size_t schedsetsize)

  Convert hwloc CPU set `toposet` *into glibc sched affinity CPU set* `schedset`.

- static __hwloc_inline int hwloc_cpuset_from_glibc_sched_affinity (hwloc_topology_t topology __hwloc_attribute_unused, hwloc_cpuset_t hwlocset, const cpu_set_t *schedset, size_t schedsetsize)

  Convert glibc sched affinity CPU set `schedset` *into hwloc CPU set.*

11.22.1 Function Documentation

11.22.1.1 static __hwloc_inline int hwloc_cpuset_from_glibc_sched_affinity (hwloc_topology_t topology *__hwloc_attribute_unused,* hwloc_cpuset_t *hwlocset,* const cpu_set_t * *schedset,* size_t *schedsetsize*) [static]

Convert glibc sched affinity CPU set `schedset` into hwloc CPU set.

This function may be used before calling sched_setaffinity or any other function that takes a cpu_set_t as input parameter.

`schedsetsize` should be sizeof(cpu_set_t) unless `schedset` was dynamically allocated with CPU_ALLOC

11.22.1.2 static __hwloc_inline int hwloc_cpuset_to_glibc_sched_affinity (hwloc_topology_t topology *__hwloc_attribute_unused,* hwloc_const_cpuset_t *hwlocset,* cpu_set_t * *schedset,* size_t *schedsetsize*) [static]

Convert hwloc CPU set `toposet` into glibc sched affinity CPU set `schedset`.

This function may be used before calling sched_setaffinity or any other function that takes a cpu_set_t as input parameter.

`schedsetsize` should be sizeof(cpu_set_t) unless `schedset` was dynamically allocated with CPU_ALLOC

11.23 Linux-only helpers

Functions

- HWLOC_DECLSPEC int hwloc_linux_parse_cpumap_file (FILE *file, hwloc_cpuset_t set)

  Convert a linux kernel cpumap file `file` *into hwloc CPU set.*

- HWLOC_DECLSPEC int hwloc_linux_set_tid_cpubind (hwloc_topology_t topology, pid_t tid, hwloc_const_cpuset_t set)

  Bind a thread `tid` *on cpus given in cpuset* `set`.

- HWLOC_DECLSPEC int hwloc_linux_get_tid_cpubind (hwloc_topology_t topology, pid_t tid, hwloc_cpuset_t set)

  Get the current binding of thread `tid`.

11.23.1 Detailed Description

This includes helpers for manipulating linux kernel cpumap files, and hwloc equivalents of the Linux sched_setaffinity and sched_getaffinity system calls.

11.23.2 Function Documentation

11.23.2.1 HWLOC_DECLSPEC int hwloc_linux_get_tid_cpubind (hwloc_topology_t *topology,* pid_t *tid,* hwloc_cpuset_t *set*)

Get the current binding of thread `tid`.

The behavior is exactly the same as the Linux sched_setaffinity system call, but uses a hwloc cpuset.

11.23.2.2 HWLOC_DECLSPEC int hwloc_linux_parse_cpumap_file (FILE * *file,* hwloc_cpuset_t *set*)

Convert a linux kernel cpumap file `file` into hwloc CPU set.

Might be used when reading CPU set from sysfs attributes such as topology and caches for processors, or local_cpus for devices.

11.23.2.3 HWLOC_DECLSPEC int hwloc_linux_set_tid_cpubind (hwloc_topology_t *topology,* pid_t *tid,* hwloc_const_cpuset_t *set*)

Bind a thread `tid` on cpus given in cpuset `set`.

The behavior is exactly the same as the Linux sched_setaffinity system call, but uses a hwloc cpuset.

11.24 Helpers for manipulating Linux libnuma unsigned long masks

Functions

- static __hwloc_inline int hwloc_cpuset_to_linux_libnuma_ulongs (hwloc_topology_t topology, hwloc_const_cpuset_t cpuset, unsigned long *mask, unsigned long *maxnode)

  Convert hwloc CPU set `cpuset` *into the array of unsigned long* `mask`.

- static __hwloc_inline int hwloc_cpuset_from_linux_libnuma_ulongs (hwloc_topology_t topology, hwloc_cpuset_t cpuset, const unsigned long *mask, unsigned long maxnode)

  Convert the array of unsigned long `mask` *into hwloc CPU set.*

11.24.1 Function Documentation

11.24.1.1 static __hwloc_inline int hwloc_cpuset_from_linux_libnuma_ulongs (hwloc_topology_t *topology*, hwloc_cpuset_t *cpuset*, const unsigned long * *mask*, unsigned long *maxnode*) [static]

Convert the array of unsigned long `mask` into hwloc CPU set.

`mask` is a array of unsigned long that will be read. `maxnode` contains the maximal node number that may be read in `mask`.

This function may be used after calling get_mempolicy or any other function that takes an array of unsigned long as output parameter (and possibly a maximal node number as input parameter).

11.24.1.2 static __hwloc_inline int hwloc_cpuset_to_linux_libnuma_ulongs (hwloc_topology_t *topology*, hwloc_const_cpuset_t *cpuset*, unsigned long * *mask*, unsigned long * *maxnode*) [static]

Convert hwloc CPU set `cpuset` into the array of unsigned long `mask`.

`mask` is the array of unsigned long that will be filled. `maxnode` contains the maximal node number that may be stored in `mask`. `maxnode` will be set to the maximal node number that was found, plus one.

This function may be used before calling set_mempolicy, mbind, migrate_pages or any other function that takes an array of unsigned long and a maximal node number as input parameter.

11.25 Helpers for manipulating Linux libnuma bitmask

Functions

- static __hwloc_inline struct bitmask *__hwloc_attribute_malloc hwloc_cpuset_to_linux_libnuma_bitmask (hwloc_topology_t topology, hwloc_const_cpuset_t cpuset)

  Convert hwloc CPU set `cpuset` into the returned libnuma bitmask.

- static __hwloc_inline int hwloc_cpuset_from_linux_libnuma_bitmask (hwloc_topology_t topology, hwloc_cpuset_t cpuset, const struct bitmask *bitmask)

  Convert libnuma bitmask `bitmask` into hwloc CPU set `cpuset`.

11.25.1 Function Documentation

11.25.1.1 static __hwloc_inline int hwloc_cpuset_from_linux_libnuma_bitmask (hwloc_topology_t *topology*, hwloc_cpuset_t *cpuset*, const struct bitmask * *bitmask*) [static]

Convert libnuma bitmask `bitmask` into hwloc CPU set `cpuset`.

This function may be used after calling many numa_ functions that use a struct bitmask as an output parameter.

11.25.1.2 static __hwloc_inline struct bitmask* __hwloc_attribute_malloc hwloc_cpuset_to_linux_libnuma_bitmask (hwloc_topology_t *topology*, hwloc_const_cpuset_t *cpuset*) [static, read]

Convert hwloc CPU set `cpuset` into the returned libnuma bitmask.

The returned bitmask should later be freed with numa_bitmask_free.

This function may be used before calling many numa_ functions that use a struct bitmask as an input parameter.

Returns

newly allocated struct bitmask.

11.26 Helpers for manipulating Linux libnuma nodemask_t

Functions

- static __hwloc_inline int hwloc_cpuset_to_linux_libnuma_nodemask (hwloc_topology_t topology, hwloc_const_cpuset_t cpuset, nodemask_t *nodemask)

  Convert hwloc CPU set `cpuset` into libnuma nodemask `nodemask`.

- static __hwloc_inline int hwloc_cpuset_from_linux_libnuma_nodemask (hwloc_topology_t topology, hwloc_cpuset_t cpuset, const nodemask_t *nodemask)

  Convert libnuma nodemask `nodemask` into hwloc CPU set `cpuset`.

11.26.1 Function Documentation

11.26.1.1 static __hwloc_inline int hwloc_cpuset_from_linux_libnuma_nodemask (hwloc_topology_t *topology*, hwloc_cpuset_t *cpuset*, const nodemask_t * *nodemask*) [static]

Convert libnuma nodemask `nodemask` into hwloc CPU set `cpuset`.

This function may be used before calling some old libnuma functions that use a nodemask_t as an output parameter.

11.26.1.2 static __hwloc_inline int hwloc_cpuset_to_linux_libnuma_nodemask (hwloc_topology_t *topology*, hwloc_const_cpuset_t *cpuset*, nodemask_t * *nodemask*) [static]

Convert hwloc CPU set `cpuset` into libnuma nodemask `nodemask`.

This function may be used before calling some old libnuma functions that use a nodemask_t as an input parameter.

11.27 OpenFabrics-Specific Functions

Functions

- static __hwloc_inline int hwloc_ibv_get_device_cpuset (hwloc_topology_t topology __hwloc_attribute_unused, struct ibv_device *ibdev, hwloc_cpuset_t set)

  Get the CPU set of logical processors that are physically close to device `ibdev`.

11.27.1 Function Documentation

11.27.1.1 static __hwloc_inline int hwloc_ibv_get_device_cpuset (hwloc_topology_t topology __*hwloc_attribute_unused*, struct ibv_device * *ibdev*, hwloc_cpuset_t *set*) [static]

Get the CPU set of logical processors that are physically close to device `ibdev`.

For the given OpenFabrics device `ibdev`, read the corresponding kernel-provided cpumap file and return the corresponding CPU set. This function is currently only implemented in a meaningful way for Linux; other systems will simply get a full cpuset.

Chapter 12

Data Structure Documentation

12.1 hwloc_obj_attr_u::hwloc_cache_attr_s Struct Reference

Cache-specific Object Attributes.

`#include <hwloc.h>`

Data Fields

- uint64_t size

  Size of cache in bytes.

- unsigned depth

  Depth of cache.

12.1.1 Detailed Description

Cache-specific Object Attributes.

12.1.2 Field Documentation

12.1.2.1 unsigned hwloc_obj_attr_u::hwloc_cache_attr_s::depth

Depth of cache.

12.1.2.2 uint64_t hwloc_obj_attr_u::hwloc_cache_attr_s::size

Size of cache in bytes.

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

- hwloc.h

12.2 hwloc_obj_attr_u::hwloc_group_attr_s Struct Reference

Group-specific Object Attributes.

`#include <hwloc.h>`

Data Fields

- unsigned depth

  Depth of group object.

12.2.1 Detailed Description

Group-specific Object Attributes.

12.2.2 Field Documentation

12.2.2.1 unsigned hwloc_obj_attr_u::hwloc_group_attr_s::depth

Depth of group object.

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

- hwloc.h

12.3 hwloc_obj_attr_u::hwloc_machine_attr_s Struct Reference

Machine-specific Object Attributes.

`#include <hwloc.h>`

Data Fields

- char * dmi_board_vendor

  DMI board vendor name.

- char * dmi_board_name

  DMI board model name.

12.3.1 Detailed Description

Machine-specific Object Attributes.

12.3.2 Field Documentation

12.3.2.1 char* hwloc_obj_attr_u::hwloc_machine_attr_s::dmi_board_name

DMI board model name.

12.3.2.2 char* hwloc_obj_attr_u::hwloc_machine_attr_s::dmi_board_vendor

DMI board vendor name.

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

- hwloc.h

12.4 hwloc_obj Struct Reference

Structure of a topology object.

`#include <hwloc.h>`

Data Fields

- hwloc_obj_type_t type
  Type of object.
- unsigned os_index
  OS-provided physical index number.
- char * name
  Object description if any.
- struct hwloc_obj_memory_s memory
  Memory attributes.
- union hwloc_obj_attr_u * attr
  Object type-specific Attributes.
- unsigned depth
  Vertical index in the hierarchy.
- unsigned logical_index
  Horizontal index in the whole list of similar objects, could be a "cousin_rank" since it's the rank within the "cousin" list below.
- signed os_level
  OS-provided physical level, -1 if unknown or meaningless.
- struct hwloc_obj * next_cousin
  Next object of same type.

- struct hwloc_obj * prev_cousin
  Previous object of same type.
- struct hwloc_obj * parent
  Parent, `NULL` if root (system object).
- unsigned sibling_rank
  Index in parent's `children[]` array.
- struct hwloc_obj * next_sibling
  Next object below the same parent.
- struct hwloc_obj * prev_sibling
  Previous object below the same parent.
- unsigned arity
  Number of children.
- struct hwloc_obj ** children
  Children, `children[0 .. arity -1]`.
- struct hwloc_obj * first_child
  First child.
- struct hwloc_obj * last_child
  Last child.
- void * userdata
  Application-given private data pointer, initialized to `NULL`, use it as you wish.
- hwloc_cpuset_t cpuset
  CPUs covered by this object.
- hwloc_cpuset_t complete_cpuset
  The complete CPU set of logical processors of this object,.
- hwloc_cpuset_t online_cpuset
  The CPU set of online logical processors.
- hwloc_cpuset_t allowed_cpuset
  The CPU set of allowed logical processors.
- hwloc_cpuset_t nodeset
  NUMA nodes covered by this object or containing this object.
- hwloc_cpuset_t complete_nodeset
  The complete NUMA node set of this object,.
- hwloc_cpuset_t allowed_nodeset
  The set of allowed NUMA memory nodes.

12.4.1 Detailed Description

Structure of a topology object. Applications mustn't modify any field except userdata .

12.4.2 Field Documentation

12.4.2.1 hwloc_cpuset_t hwloc_obj::allowed_cpuset

The CPU set of allowed logical processors.

This includes the CPUs contained in this object which are allowed for binding, i.e. passing them to the hwloc binding functions should not return permission errors. This is usually restricted by administration rules. Some of them may however be offline so binding to them may still not be possible, see online_cpuset.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.2 hwloc_cpuset_t hwloc_obj::allowed_nodeset

The set of allowed NUMA memory nodes.

This includes the NUMA memory nodes contained in this object which are allowed for memory allocation, i.e. passing them to NUMA node-directed memory allocation should not return permission errors. This is usually restricted by administration rules.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.3 unsigned hwloc_obj::arity

Number of children.

12.4.2.4 union hwloc_obj_attr_u* hwloc_obj::attr

Object type-specific Attributes.

12.4.2.5 struct hwloc_obj** hwloc_obj::children

Children, `children`[0 .. arity -1].

12.4.2.6 hwloc_cpuset_t hwloc_obj::complete_cpuset

The complete CPU set of logical processors of this object,.

This includes not only the same as the cpuset field, but also the CPUs for which topology information is unknown or incomplete, and the CPUs that are ignored when the HWLOC_TOPOLOGY_FLAG_WHOLE_SYSTEM flag is not set. Thus no corresponding PU object may be found in the topology, because the precise position is undefined. It is however known that it would be somewhere under this object.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.7 hwloc_cpuset_t hwloc_obj::complete_nodeset

The complete NUMA node set of this object,.

This includes not only the same as the nodeset field, but also the NUMA nodes for which topology information is unknown or incomplete, and the nodes that are ignored when the HWLOC_TOPOLOGY_FLAG_-WHOLE_SYSTEM flag is not set. Thus no corresponding NODE object may be found in the topology, because the precise position is undefined. It is however known that it would be somewhere under this object.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.8 hwloc_cpuset_t hwloc_obj::cpuset

CPUs covered by this object.

This is the set of CPUs for which there are PU objects in the topology under this object, i.e. which are known to be physically contained in this object and known how (the children path between this object and the PU objects).

If the HWLOC_TOPOLOGY_FLAG_WHOLE_SYSTEM configuration flag is set, some of these CPUs may be offline, or not allowed for binding, see online_cpuset and allowed_cpuset.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.9 unsigned hwloc_obj::depth

Vertical index in the hierarchy.

12.4.2.10 struct hwloc_obj* hwloc_obj::first_child

First child.

12.4.2.11 struct hwloc_obj* hwloc_obj::last_child

Last child.

12.4.2.12 unsigned hwloc_obj::logical_index

Horizontal index in the whole list of similar objects, could be a "cousin_rank" since it's the rank within the "cousin" list below.

12.4.2.13 struct hwloc_obj_memory_s hwloc_obj::memory

Memory attributes.

12.4.2.14 char* hwloc_obj::name

Object description if any.

12.4.2.15 struct hwloc_obj* hwloc_obj::next_cousin

Next object of same type.

12.4.2.16 struct hwloc_obj* hwloc_obj::next_sibling

Next object below the same parent.

12.4.2.17 hwloc_cpuset_t hwloc_obj::nodeset

NUMA nodes covered by this object or containing this object.

This is the set of NUMA nodes for which there are NODE objects in the topology under or above this object, i.e. which are known to be physically contained in this object or containing it and known how (the children path between this object and the NODE objects).

If the HWLOC_TOPOLOGY_FLAG_WHOLE_SYSTEM configuration flag is set, some of these nodes may not be allowed for allocation, see allowed_nodeset.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.18 hwloc_cpuset_t hwloc_obj::online_cpuset

The CPU set of online logical processors.

This includes the CPUs contained in this object that are online, i.e. draw power and can execute threads. It may however not be allowed to bind to them due to administration rules, see allowed_cpuset.

Note

Its value must not be changed, hwloc_cpuset_dup must be used instead.

12.4.2.19 unsigned hwloc_obj::os_index

OS-provided physical index number.

12.4.2.20 signed hwloc_obj::os_level

OS-provided physical level, -1 if unknown or meaningless.

12.4.2.21 struct hwloc_obj* hwloc_obj::parent

Parent, NULL if root (system object).

12.4.2.22 struct hwloc_obj* hwloc_obj::prev_cousin

Previous object of same type.

12.4.2.23 struct hwloc_obj* hwloc_obj::prev_sibling

Previous object below the same parent.

12.4.2.24 unsigned hwloc_obj::sibling_rank

Index in parent's children[] array.

12.4.2.25 hwloc_obj_type_t hwloc_obj::type

Type of object.

12.4.2.26 void* hwloc_obj::userdata

Application-given private data pointer, initialized to NULL, use it as you wish.

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

- hwloc.h

12.5 hwloc_obj_attr_u Union Reference

Object type-specific Attributes.

`#include <hwloc.h>`

Data Structures

- struct hwloc_cache_attr_s

  Cache-specific Object Attributes.

- struct hwloc_group_attr_s

  Group-specific Object Attributes.

- struct hwloc_machine_attr_s

  Machine-specific Object Attributes.

Data Fields

- struct hwloc_obj_attr_u::hwloc_cache_attr_s cache
  Cache-specific Object Attributes.
- struct hwloc_obj_attr_u::hwloc_machine_attr_s machine
  Machine-specific Object Attributes.
- struct hwloc_obj_attr_u::hwloc_group_attr_s group
  Group-specific Object Attributes.

12.5.1 Detailed Description

Object type-specific Attributes.

12.5.2 Field Documentation

12.5.2.1 struct hwloc_obj_attr_u::hwloc_cache_attr_s hwloc_obj_attr_u::cache

Cache-specific Object Attributes.

12.5.2.2 struct hwloc_obj_attr_u::hwloc_group_attr_s hwloc_obj_attr_u::group

Group-specific Object Attributes.

12.5.2.3 struct hwloc_obj_attr_u::hwloc_machine_attr_s hwloc_obj_attr_u::machine

Machine-specific Object Attributes.

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

- hwloc.h

12.6 hwloc_obj_memory_s::hwloc_obj_memory_page_type_s Struct Reference

Array of local memory page types, `NULL` if no local memory and `page_types` is 0.

`#include <hwloc.h>`

Data Fields

- uint64_t size
  Size of pages.
- uint64_t count
  Number of pages of this size.

12.6.1 Detailed Description

Array of local memory page types, `NULL` if no local memory and `page_types` is 0. The array is sorted by increasing `size` fields. It contains `page_types_len` slots.

12.6.2 Field Documentation

12.6.2.1 uint64_t hwloc_obj_memory_s::hwloc_obj_memory_page_type_s::count

Number of pages of this size.

12.6.2.2 uint64_t hwloc_obj_memory_s::hwloc_obj_memory_page_type_s::size

Size of pages.

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

- hwloc.h

12.7 hwloc_obj_memory_s Struct Reference

Object memory.

`#include <hwloc.h>`

Data Structures

- struct hwloc_obj_memory_page_type_s
  Array of local memory page types, `NULL` if no local memory and `page_types` is 0.

Data Fields

- uint64_t total_memory
  Total memory (in bytes) in this object and its children.
- uint64_t local_memory
  Local memory (in bytes).
- unsigned page_types_len
  Size of array `page_types`.
- struct hwloc_obj_memory_s::hwloc_obj_memory_page_type_s * page_types
  Array of local memory page types, `NULL` if no local memory and `page_types` is 0.

12.7.1 Detailed Description

Object memory.

12.7.2 Field Documentation

12.7.2.1 uint64_t hwloc_obj_memory_s::local_memory

Local memory (in bytes).

12.7.2.2 struct hwloc_obj_memory_s::hwloc_obj_memory_page_type_s * hwloc_obj_memory_s::page_types

Array of local memory page types, `NULL` if no local memory and `page_types` is 0.

The array is sorted by increasing `size` fields. It contains `page_types_len` slots.

12.7.2.3 unsigned hwloc_obj_memory_s::page_types_len

Size of array `page_types`.

12.7.2.4 uint64_t hwloc_obj_memory_s::total_memory

Total memory (in bytes) in this object and its children.

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

- hwloc.h

12.8 hwloc_topology_cpubind_support Struct Reference

Flags describing actual binding support for this topology.

`#include <hwloc.h>`

Data Fields

- unsigned char set_thisproc_cpubind
- unsigned char get_thisproc_cpubind
- unsigned char set_proc_cpubind
- unsigned char get_proc_cpubind
- unsigned char set_thisthread_cpubind
- unsigned char get_thisthread_cpubind
- unsigned char set_thread_cpubind
- unsigned char get_thread_cpubind

12.8.1 Detailed Description

Flags describing actual binding support for this topology.

12.8.2 Field Documentation

12.8.2.1 unsigned char hwloc_topology_cpubind_support::get_proc_cpubind

Getting the binding of a whole given process is supported.

12.8.2.2 unsigned char hwloc_topology_cpubind_support::get_thisproc_cpubind

Getting the binding of the whole current process is supported.

12.8.2.3 unsigned char hwloc_topology_cpubind_support::get_thisthread_cpubind

Getting the binding of the current thread only is supported.

12.8.2.4 unsigned char hwloc_topology_cpubind_support::get_thread_cpubind

Getting the binding of a given thread only is supported.

12.8.2.5 unsigned char hwloc_topology_cpubind_support::set_proc_cpubind

Binding a whole given process is supported.

12.8.2.6 unsigned char hwloc_topology_cpubind_support::set_thisproc_cpubind

Binding the whole current process is supported.

12.8.2.7 unsigned char hwloc_topology_cpubind_support::set_thisthread_cpubind

Binding the current thread only is supported.

12.8.2.8 unsigned char hwloc_topology_cpubind_support::set_thread_cpubind

Binding a given thread only is supported.

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

- hwloc.h

12.9 hwloc_topology_discovery_support Struct Reference

Flags describing actual discovery support for this topology.

`#include <hwloc.h>`

Data Fields

- unsigned char pu

  Detecting the number of PU objects is supported.

12.9.1 Detailed Description

Flags describing actual discovery support for this topology.

12.9.2 Field Documentation

12.9.2.1 unsigned char hwloc_topology_discovery_support::pu

Detecting the number of PU objects is supported.

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

- hwloc.h

12.10 hwloc_topology_support Struct Reference

Set of flags describing actual support for this topology.

`#include <hwloc.h>`

Data Fields

- struct hwloc_topology_discovery_support * discovery
- struct hwloc_topology_cpubind_support * cpubind

12.10.1 Detailed Description

Set of flags describing actual support for this topology. This is retrieved with hwloc_topology_get_support() and will be valid until the topology object is destroyed. Note: the values are correct only after discovery.

12.10.2 Field Documentation

12.10.2.1 struct hwloc_topology_cpubind_support* hwloc_topology_support::cpubind

12.10.2.2 struct hwloc_topology_discovery_support* hwloc_topology_support::discovery

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

- hwloc.h

Index