Intel® MPI Library Developer Reference for Windows* OS

Contents

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Documentation for older versions of the Intel® MPI Library are available for download only. For a list of available documentation downloads by product version, see Download Documentation for Intel Parallel Studio XE. To download the previous versions of Intel MPI Library documentation, refer to this page.

What's New

This Developer Reference provides you with the complete reference for the Intel MPI Library. It is intended to help a user fully utilize the Intel MPI Library functionality. For examples and detailed functionality description, please refer to the Intel MPI Library Developer Guide.

The following are some popular topics in the Intel MPI Library Developer Reference:

Command Reference

Command Reference provides reference information on compilation and runtime commands (cpuinfo, impi_info) and describes how to use these commands.

Environment Variable Reference

Environment Variable Reference provides syntax, arguments, and descriptions for Fabrics Control, Tuning, Autotuning, Main Thread Pinning, and I_MPI_ADJUST Family environment variables.

Hydra Global Options and Environment Variables

Describes the Global Options and provides Environment Variables used with the Hydra process manager.

Mpitune Configuration Options

Tune your MPI application with the mpitune utility.

Introduction

This Developer Reference provides you with the complete reference for the Intel® MPI Library. It is intended to help an experienced user fully utilize the Intel MPI Library functionality. You can freely redistribute this document in any desired form.

Document Organization

Section	Description
Section 1. Introduction	Introduces this document and the Intel MPI Library.
Section 2. Command Reference	Describes compilation and job startup commands and their options.
Section 3. Environment Variable Reference	Describes environment variables .

Introducing Intel® MPI Library

Intel® MPI Library is a multi-fabric message passing library that implements the Message Passing Interface, v3.1 (MPI-3.1) specification. It provides a standard library across Intel® platforms that enable adoption of MPI-3.1 functions as their needs dictate.

Intel® MPI Library enables developers to change or to upgrade processors and interconnects as new technology becomes available without changes to the software or to the operating environment.

You can get the latest information for the Intel® MPI Library at https://software.intel.com/intel-mpi-library.

What's New

This page lists changes to the product that are reflected in the documentation. For a list of all changes, refer to the Release Notes.

Intel® MPI Library 2021.6 (Intel® oneAPI 2022.2)

- No documentation changes.

Intel® oneAPI 2021.5

- Added `hcoll` argument for `I_MPI_COLL_EXTERNAL`.
- Added option to Global Options topic.
- Added `I_MPI_COLL_DIRECT` variable to I_MPI_ADJUST Family Environment Variables topic.

Intel® oneAPI 2021.4

- No documentation changes.

Intel® oneAPI 2021.3

- Changed the default pinning order to `bunch`.
- Added new value for the I_MPI_SHM variable (icx).
- Added new variable I_MPI_HYDRA_BSTRAP_KEEP_ALIVE.

Additionally, minor updates have been made to fix inaccuracies in the document and improve user experience.

Intel® oneAPI 2021.2

- No documentation changes.

Intel® oneAPI Gold

- Removed all content specific to Intel® Parallel Studio XE (see notice on title page).
- Added Intel® Ethernet 800 Series support.
- Added MPI + OpenMP offload examples.
- Added new algorithm for MPI_Sendrecv_replace (I_MPI_ADJUST_SENDRECV_REPLACE=2).
- Reworked directory layout:
  - Removed intel64/.
  - Mpivars.[c]sh and mpi modulefile moved to env/.
  - Mpivars.[c]sh renamed to vars.[c]sh.
- Removed deprecated symbolic links.
- Removed static libraries for debug configurations.

Notational Conventions

The following conventions are used in this document.

This type style	Document names
This type style	Hyperlinks
`This type style`	Commands, arguments, options, file names
`THIS_TYPE_STYLE`	Environment variables
<this type style>	Variables or placeholders for actual values
[items]	Optional items
{ item | item }	Selectable items separated by vertical bar(s)

Related Information

The following related documents that might be useful to the user:

- Product Web Site
- Intel® MPI Library Support
- Intel® Cluster Tools Products
- Intel® Software Development Products

User Authorization

The Intel® MPI Library supports several authentication methods under Windows* OS:

I_MPI_AUTH_METHOD

Select a user authorization method.

Syntax

`I_MPI_AUTH_METHOD=`*`<method>`*

Arguments

`<method>`	Define the authorization method.
`password`	Use the password-based authorization. This is the default value.
`delegate`	Use the domain-based authorization with delegation ability.
`impersonate`	Use the limited domain-based authorization. You will not be able to open files on remote machines or access mapped network drives.

Description

Set this environment variable to select a desired authorization method. If this environment variable is not defined, `mpiexec` uses the password-based authorization method by default. Alternatively, you can change the default behavior by using the `-delegate` or `-impersonate` options.

For more details, see the Developer Guide, section User Authorization.

1 Command Reference

This section provides information on different command types and how to use these commands:

- Compilation Commands lists the available Intel® MPI Library compiler commands, related options, and environment variables.
- mpiexec gives full information on commands, options and environment variables for the Hydra process manager.
- cpuinfo provides the syntax, arguments, description and output examples for the `cpuinfo` utility.
- impi_info provides information on available environment variables.
- mpitune provides information on configuration options for the `mpitune` utility.

Compiler Commands

The following table lists the available Intel® MPI Library compiler commands with their underlying compilers and programming languages.

Intel MPI Library Compiler Wrappers

Compiler Command	Underlying Compiler	Supported Languages
Common Compilers		
`mpicc.bat`	cl.exe	C
`mpicxx.bat`	cl.exe	C++
`mpifc.bat`	ifort.exe	Fortran 77/Fortran 95
Microsoft* Visual C++* Compilers		
`mpicl.bat`	cl.exe	C/C++
Intel® Fortran, C++ Compilers		
`mpiicc.bat`	icl.exe	C
`mpiicpc.bat`	icl.exe	C++
`mpiifort.bat`	ifort.exe	Fortran 77/Fortran 95

Notes on Compiler Commands

- Compiler commands are available only in the Intel MPI Library Software Development Kit (SDK).
- For the supported versions of the listed compilers, refer to the Intel® MPI Library System Requirements.
- To display mini-help of a compiler command, execute it without any parameters.
- Compiler wrapper scripts are located in the `<install-dir>\bin` directory.
- The environment settings can be established by running the `<install-dir>\env\vars.bat` file. To use a specific library configuration, pass the `release` or `debug` arguments to the script to switch to the corresponding configuration. The ordinary multi-threaded optimized library is chosen by default. Alternatively, you can use the `I_MPI_LIBRARY_KIND` environment variable to specify a configuration and source the script without arguments.
- Ensure that the corresponding underlying compiler is already in your `PATH`. If you use Intel® compilers, run the `vars.bat` file from the installation directory to set up the compiler environment.

Compilation Command Options

-profile=<profile_name>

Use this option to specify an MPI profiling library. `<profile_name>` is the name of the configuration file (profile) that loads the corresponding profiling library. The profiles are taken from `<install-dir>\etc`.

You can create your own profile as <*install-dir*>\etc\<*profile-name*>.conf. You can define the following environment variables in a configuration file:

- PROFILE_PRELIB - libraries (and paths) to load before the Intel MPI Library
- PROFILE_POSTLIB - libraries to load after the Intel MPI Library
- PROFILE_INCPATHS - C preprocessor arguments for any include files

For example, create a file <*install-dir*>\etc\myprof.conf with the following lines:

```
SET PROFILE_PRELIB=<path_to_myprof>\lib\myprof.lib
SET PROFILE_INCPATHS=-I"<paths_to_myprof>\include"
```

Use the -profile=myprof option for the relevant compiler wrapper to select this new profile.

-t or -trace

Use the -t or -trace option to link the resulting executable file against the Intel® Trace Collector library.

To use this option, include the installation path of the Intel® Trace Collector in the VT_ROOT environment variable. Source the vars. bat script provided in the Intel® Trace Analyzer and Collector installation folder.

-check_mpi

Use this option to link the resulting executable file against the Intel® Trace Collector correctness checking library. The default value is libVTmc.so.

To use this option, include the installation path of the Intel Trace Collector in the VT_ROOT environment variable. Source the vars. bat script provided in the Intel® Trace Analyzer and Collector installation folder.

-ilp64

Use this option to enable partial ILP64 support. All integer arguments of the Intel MPI Library are treated as 64-bit values in this case.

-no_ilp64

Use this option to disable the ILP64 support explicitly. This option must be used in conjunction with -i8 option of Intel® Fortran Compiler.

If you specify the -i8 option for the Intel Fortran Compiler, you still have to use the ilp64 option for linkage.

-link_mpi=<*arg*>

Use this option to always link the specified version of the Intel MPI Library. See the I_MPI_LINK environment variable for detailed argument descriptions. This option overrides all other options that select a specific library, such as-Zi.

/Zi, /Z7 or /ZI

Use these options to compile a program in debug mode and link the resulting executable against the debugging version of the Intel MPI Library. See I_MPI_DEBUG for information on how to use additional debugging features with the /Zi, /Z7, /ZI or debug builds.

The /ZI option is only valid for C/C++ compiler.

-O

Use this option to enable compiler optimization.

Setting this option triggers a call to the libirc library. Many of those library routines are more highly optimized for Intel microprocessors than for non-Intel microprocessors.

-echo

Use this option to display everything that the command script does.

-show

Use this option to learn how the underlying compiler is invoked, without actually running it. Use the following command to see the required compiler flags and options:

```
> mpiicc -show -c test.c
```

Use the following command to see the required link flags, options, and libraries:

```
> mpiicc.bat -show test.obj
```

This option is particularly useful for determining the command line for a complex build procedure that directly uses the underlying compilers.

-show_env

Use this option to see the environment settings in effect when the underlying compiler is invoked.

-{cc,cxx,fc}=<compiler>

Use this option to select the underlying compiler. The tables below list the available LLVM and IL0 compiler options and commands used to invoke them.

LLVM Compiler Options for Intel® oneAPI

Language/Model	Product Name	Compiler Driver	Compiler Wrapper	Command	Example
C	Intel® oneAPI DPC++/C++ Compiler	icx	mpiicc	-cc=icx	> mpicc -cc=icl.exe -c test.c
C++	Intel® oneAPI DPC++/C++ C	icpx	mpiicpc	-cxx=icpx	> mpiicpc -cxx=icpx -c test.cpp
SYCL*/DPC++	Intel® oneAPI DPC++/C++ Compiler	dpcpp	mpiicpc	-cxx=dpcpp	> mpiicpc -cxx=dpcpp -c test.cpp
Fortran	Intel® oneAPI Fortran Compiler	ifx	mpiifort	-fc=ifx	> mpiifort -fc=ifx -c test.

NOTE Make sure that the wrapper name is in your `PATH`. Alternatively, you can specify the full path to the compiler.

NOTE: This option works only with the `mpiicc.bat` and the `mpifc.bat` commands.

-v

Use this option to print the compiler wrapper script version.

-norpath

Use this option to disable `rpath` for the compiler wrapper for the Intel® MPI Library.

mpiexec.hydra

Launches an MPI job using the Hydra process manager.

Syntax

`mpiexec <g-options> <l-options> <executable>`

or

`mpiexec <g-options> <l-options> <executable1> : <l-options> <executable2>`

Arguments

<g-options>	Global options that apply to all MPI processes
<l-options>	Local options that apply to a single argument set
<executable>	`<name>.exe` or `path \name` of the executable file

Description

Use the `mpiexec` utility to run MPI applications using the Hydra process manager.

Use the first short command-line syntax to start all MPI processes of the *<executable>* with the single set of arguments. For example, the following command executes `test.exe` over the specified processes and hosts:

```
> mpiexec -f <hostfile> -n <# of processes> test.exe
```

where:

- *<# of processes>* specifies the number of processes on which to run the `test.exe` executable
- *<hostfile>* specifies a list of hosts on which to run the `test.exe` executable

Use the second long command-line syntax to set different argument sets for different MPI program runs. For example, the following command executes two different binaries with different argument sets:

```
> mpiexec -f <hostfile> -env <VAR1> <VAL1> -n 2 prog1.exe : ^
-env <VAR2> <VAL2> -n 2 prog2.exe
```

> **NOTE** You need to distinguish global options from local options. In a command-line syntax, place the local options after the global options.

Global Hydra Options

This section describes the global options of the Intel® MPI Library's Hydra process manager. Global options are applied to all arguments sets in the launch command. Argument sets are separated by a colon ':'.

-tune *<filename>*

Use this option to specify the file name that contains the tuning data in a binary format.

-usize *<usize>*

Use this option to set `MPI_UNIVERSE_SIZE`, which is available as an attribute of the `MPI_COMM_WORLD`.

<size>	Define the universe size
`SYSTEM`	Set the size equal to the number of cores passed to `mpiexec` through the hostfile or the resource manager.
`INFINITE`	Do not limit the size. This is the default value.

<value>	Set the size to a numeric value ≥ 0.

-hostfile <hostfile> or -f <hostfile>

Use this option to specify host names on which to run the application. If a host name is repeated, this name is used only once.

See also the I_MPI_HYDRA_HOST_FILE environment variable for more details.

NOTE Use the following options to change the process placement on the cluster nodes:

- Use the -perhost, -ppn, and -grr options to place consecutive MPI processes on every host using the round robin scheduling.
- Use the -rr option to place consecutive MPI processes on different hosts using the round robin scheduling.

-machinefile <machine file> or -machine <machine file>

Use this option to control process placement through a machine file. To define the total number of processes to start, use the -n option. For example:

```
> type machinefile
node0:2
node1:2
node0:1
```

-hosts-group

Use this option to set node ranges using brackets, commas, and dashes (like in Slurm* Workload Manager).

For more details, see the I_MPI_HYDRA_HOST_FILE environment variable in Hydra Environment Variables.

-silent-abort

Use this option to disable abort warning messages.

For more details, see the I_MPI_SILENT_ABORT environment variable in Hydra Environment Variables.

-nameserver

Use this option to specify the nameserver in the hostname:port format.

For more details, see the I_MPI_HYDRA_NAMESERVER environment variable in Hydra Environment Variables.

-genv <ENVVAR> <value>

Use this option to set the <ENVVAR> environment variable to the specified <value> for all MPI processes.

-genvall

Use this option to enable propagation of all environment variables to all MPI processes.

-genvnone

Use this option to suppress propagation of any environment variables to any MPI processes.

NOTE The option does not work for localhost.

-genvexcl *<list of env var names>*

Use this option to suppress propagation of the listed environment variables to any MPI processes.

-genvlist *<list>*

Use this option to pass a list of environment variables with their current values. *<list>* is a comma separated list of environment variables to be sent to all MPI processes.

-pmi-connect *<mode>*

Use this option to choose the caching mode of process management interface (PMI) message. Possible values for *<mode>* are:

<mode>	The caching mode to be used
nocache	Do not cache PMI messages.
cache	Cache PMI messages on the local pmi_proxy management processes to minimize the number of PMI requests. Cached information is automatically propagated to child management processes.
lazy-cache	cache mode with on-request propagation of the PMI information.
alltoall	Information is automatically exchanged between all pmi_proxy before any get request can be done. This is the default mode.

See the I_MPI_HYDRA_PMI_CONNECT environment variable for more details.

-perhost *<# of processes >*, -ppn *<# of processes >*, or -grr *<# of processes>*

Use this option to place the specified number of consecutive MPI processes on every host in the group using round robin scheduling. See the I_MPI_PERHOST environment variable for more details.

NOTE When running under a job scheduler, these options are ignored by default. To be able to control process placement with these options, disable the I_MPI_JOB_RESPECT_PROCESS_PLACEMENT variable.

-rr

Use this option to place consecutive MPI processes on different hosts using the round robin scheduling. This option is equivalent to "-perhost 1". See the I_MPI_PERHOST environment variable for more details.

-trace-pt2pt

Use this option to collect the information about point-to-point operations using Intel® Trace Analyzer and Collector. The option requires that your application be linked against the Intel® Trace Collector profiling library.

-trace-collectives

Use this option to collect the information about collective operations using Intel® Trace Analyzer and Collector. The option requires that your application be linked against the Intel® Trace Collector profiling library.

NOTE
Use the -trace-pt2pt and -trace-collectives to reduce the size of the resulting trace file or the number of message checker reports. These options work with both statically and dynamically linked applications.

-configfile <filename>

Use this option to specify the file <filename> that contains the command-line options with one executable per line. Blank lines and lines that start with '#' are ignored. Other options specified in the command line are treated as global.

You can specify global options in configuration files loaded by default (mpiexec.conf in <installdir>/etc, ~/.mpiexec.conf, and mpiexec.conf in the working directory). The remaining options can be specified in the command line.

-branch-count <num>

Use this option to restrict the number of child management processes launched by the Hydra process manager, or by each pmi_proxy management process.

See the I_MPI_HYDRA_BRANCH_COUNT environment variable for more details.

-pmi-aggregate or -pmi-noaggregate

Use this option to switch on or off, respectively, the aggregation of the PMI requests. The default value is –pmi-aggregate, which means the aggregation is enabled by default.

See the I_MPI_HYDRA_PMI_AGGREGATE environment variable for more details.

-nolocal

Use this option to avoid running the <executable> on the host where mpiexec is launched. You can use this option on clusters that deploy a dedicated main node for starting the MPI jobs and a set of dedicated compute nodes for running the actual MPI processes.

-hosts <nodelist>

Use this option to specify a particular <nodelist> on which the MPI processes should be run. For example, the following command runs the executable a.out on the hosts host1 and host2:

```
> mpiexec -n 2 -ppn 1 -hosts host1,host2 test.exe
```

NOTE If <nodelist> contains only one node, this option is interpreted as a local option. See Local Options for details.

-iface <interface>

Use this option to choose the appropriate network interface. For example, if the IP emulation of your InfiniBand* network is configured to ib0, you can use the following command.

```
> mpiexec -n 2 -iface ib0 test.exe
```

See the I_MPI_HYDRA_IFACE environment variable for more details.

Arguments

-l, -prepend-rank

Use this option to insert the MPI process rank at the beginning of all lines written to the standard output.

-s <spec>

Use this option to direct standard input to the specified MPI processes.

Arguments

<spec>	Define MPI process ranks
all	Use all processes.
none	Do not direct standard output to any processes.
<l>,<m>,<n>	Specify an exact list and use processes <l>, <m> and <n> only. The default value is zero.
<k>,<l>-<m>,<n>	Specify a range and use processes <k>, <l> through <m>, and <n>.

-noconf

Use this option to disable processing of the mpiexec.hydra configuration files.

-ordered-output

Use this option to avoid intermingling of data outut from the MPI processes. This option affects both the standard output and the standard error streams.

> **NOTE** When using this option, end the last output line of each process with the end-of-line '\n' character. Otherwise the application may stop responding.

-path <*directory*>

Use this option to specify the path to the executable file.

-version or -V

Use this option to display the version of the Intel® MPI Library.

-info

Use this option to display build information of the Intel® MPI Library. When this option is used, the other command line arguments are ignored.

-delegate

Use this option to enable the domain-based authorization with the delegation ability. See User Authorization for details.

-impersonate

Use this option to enable the limited domain-based authorization. You will not be able to open files on remote machines or access mapped network drives. See User Authorization for details.

-localhost

Use this option to explicitly specify the local host name for the launching node.

-localroot

Use this option to launch the root process directly from mpiexec if the host is local. You can use this option to launch GUI applications. The interactive process should be launched before any other process in a job. For example:

```
> mpiexec -n 1 -host <host2> -localroot interactive.exe : -n 1 -host <host1> background.exe
```

-localonly

Use this option to run an application on the local node only. If you use this option only for the local node, the Hydra service is not required.

-register [-username <user> -password <password>]

You can specify the user name and password using the -username and -password options after the -register option. Otherwise you will be prompted to enter your credentials.

-remove

Use this option to delete the encrypted credentials from the registry.

-validate [-host <hostname>]

Validate the encrypted credentials for the current user.

-whoami

Use this option to print the current user name.

-map *<drive:\\host\share>*

Use this option to create network mapped drive on nodes before starting executable. Network drive will be automatically removed after the job completion.

-mapall

Use this option to request creation of all user created network mapped drives on nodes before starting executable. Network drives will be automatically removed after the job completion.

-logon

Use this option to force the prompt for user credentials.

-noprompt

Use this option to suppress the prompt for user credentials.

-port/-p

Use this option to specify the port that the service is listening on. See the `I_MPI_HYDRA_SERVICE_PORT` environment variable for more details.

-verbose or -v

Use this option to print debug information from `mpiexec` , such as:

- Service processes arguments
- Environment variables and arguments passed to start an application
- PMI requests/responses during a job life cycle

See the `I_MPI_HYDRA_DEBUG` environment variable for more details.

-print-rank-map

Use this option to print out the MPI rank mapping.

-print-all-exitcodes

Use this option to print the exit codes of all processes.

Arguments

-v6

Use this option to force using the IPv6 protocol.

Local Hydra Options

This section describes the local options of the Intel® MPI Library's Hydra process manager. Local options are applied only to the argument set they are specified in. Argument sets are separated by a colon ':'.

-n <number-of-processes> or -np <number-of-processes>

Use this option to set the number of MPI processes to run with the current argument set.

-env <envar> <value>

Use this option to set the <envar> environment variable to the specified <value> for all MPI processes in the current argument set.

-envall

Use this option to propagate all environment variables in the current argument set. See the I_MPI_HYDRA_ENV environment variable for more details.

-envnone

Use this option to suppress propagation of any environment variables to the MPI processes in the current argument set.

> **NOTE** The option does not work for localhost.

-envexcl <list-of-envvar-names>

Use this option to suppress propagation of the listed environment variables to the MPI processes in the current argument set.

-envlist <list>

Use this option to pass a list of environment variables with their current values. <list> is a comma separated list of environment variables to be sent to the MPI processes.

-host <nodename>

Use this option to specify a particular <nodename> on which the MPI processes are to be run. For example, the following command executes test.exe on hosts host1 and host2:

```
> mpiexec -n 2 -host host1 test.exe : -n 2 -host host2 test.exe
```

-path <directory>

Use this option to specify the path to the <executable> file to be run in the current argument set.

-wdir <directory>

Use this option to specify the working directory in which the *<executable>* file runs in the current argument set.

cpuinfo

Provides information on processors used in the system.

Syntax

```
cpuinfo [[-]<options>]
```

Arguments

<options>	Sequence of one-letter options. Each option controls a specific part of the output data.
g	General information about single cluster node shows: • the processor product name • the number of packages/sockets on the node • core and threads numbers on the node and within each package • SMT mode enabling
i	Logical processors identification table identifies threads, cores, and packages of each logical processor accordingly. • *Processor* - logical processor number. • *ThreadId* - unique processor identifier within a core. • *CoreId* - unique core identifier within a package. • *PackageId* - unique package identifier within a node.
d	Node decomposition table shows the node contents. Each entry contains the information on packages, cores, and logical processors. • *Package Id* - physical package identifier. • *Cores Id* - list of core identifiers that belong to this package. • *Processors Id* - list of processors that belong to this package. This list order directly corresponds to the core list. A group of processors enclosed in brackets belongs to one core.
c	Cache sharing by logical processors shows information of sizes and processors groups, which share particular cache level. • Size - cache size in bytes. • Processors - a list of processor groups enclosed in the parentheses those share this cache or no sharing otherwise.
s	Microprocessor signature hexadecimal fields (Intel platform notation) show signature values: • extended family • extended model • family • model • type • stepping
f	Microprocessor feature flags indicate what features the microprocessor supports. The Intel platform notation is used.

n	Table shows the following information about NUMA nodes: • NUMA Id - NUMA node identifier. • Processors - a list of processors in this node. If the node has no processors, the node is not shown.
A	Equivalent to gidcsf
gidc	Default sequence
?	Utility usage info

Description

The cpuinfo utility prints out the processor architecture information that can be used to define suitable process pinning settings. The output consists of a number of tables. Each table corresponds to one of the single options listed in the arguments table.

NOTE
The architecture information is available on systems based on the Intel® 64 architecture.

The cpuinfo utility is available for both Intel microprocessors and non-Intel microprocessors, but it may provide only partial information about non-Intel microprocessors.

An example of the cpuinfo output:

```
> cpuinfo -gdcs
```

```
=====  Processor composition  =====
Processor name    : Intel(R) Xeon(R)  X5570
Packages(sockets) : 2
Cores             : 8
Processors(CPUs)  : 8
Cores per package : 4
Threads per core  : 1
=====  Processor identification  =====
Processor       Thread Id.      Core Id.        Package Id.
0               0               0               0
1               0               0               1
2               0               1               0
3               0               1               1
4               0               2               0
5               0               2               1
6               0               3               0
7               0               3               1
=====  Placement on packages  =====
Package Id.     Core Id.        Processors
0               0,1,2,3         0,2,4,6
1               0,1,2,3         1,3,5,7
=====  Cache sharing  =====
Cache   Size            Processors
L1      32  KB          no sharing
L2      256 KB          no sharing
L3      8   MB          (0,2,4,6)(1,3,5,7)
=====  Processor Signature  =====

 _________ _________ ______ ________ _______ __________
| xFamily | xModel | Type | Family | Model | Stepping |
```

```
|_________|________|______|________|_______|__________|
| 00      | 1      | 0    | 6      | a     | 5        |
|_________|________|______|________|_______|__________|
```

impi_info

Provides information on available Intel® MPI Library environment variables.

Syntax

`impi_info <options>`

Arguments

`<options>`	List of options.
`-a | -all`	Show all IMPI variables.
`-h | -help`	Show a help message.
`-v | -variable`	Show all available variables or description of the specified variable.
`-c | -category`	Show all available categories or variables of the specified category.
`-e | -expert`	Show all expert variables.

Description

The `impi_info` utility provides information on environment variables available in the Intel MPI Library. For each variable, it prints out the name, the default value, and the value data type. By default, a reduced list of variables is displayed. Use the `-all` option to display all available variables with their descriptions.

The example of the `impi_info` output:

```
> impi_info
```

```
| NAME                                  | DEFAULT VALUE | DATA TYPE   |
=========================================================================
| I_MPI_THREAD_SPLIT                    | 0             | MPI_INT     |
| I_MPI_THREAD_RUNTIME                  | none          | MPI_CHAR    |
| I_MPI_THREAD_MAX                      | -1            | MPI_INT     |
| I_MPI_THREAD_ID_KEY                   | thread_id     | MPI_CHAR    |
```

mpitune

Tunes the Intel® MPI Library parameters for the given MPI application.

Syntax

`mpitune <options>`

Arguments

mpitune Options	Options
`-c | --config-file <file>`	Specify a configuration file to run a tuning session.
`-d | --dump-file <file>`	Specify a file that stores the collected results. The option is used in the `analyze` mode.
`-m | --mode {collect | analyze}`	Specify the `mpitune` mode. The supported modes are `collect` and `analyze`:

mpitune Options	Options
	• the `collect` mode runs the tuning process and saves results in temporary files; • the `analyze` mode transforms temporary files into a JSON-tree, which is used by the Intel MPI Library, and generates a table that represents algorithm values in a human-readable format.
`-h | --help`	Display the help message.
`-v | --version`	Display the product version.

Description

The `mpitune` utility allows you to automatically adjust Intel MPI Library parameters, such as collective operation algorithms, to your cluster configuration or application.

The tuner iteratively launches a benchmarking application with different configurations to measure performance and stores the results of each launch. Based on these results, the tuner generates optimal values for the parameters being tuned.

> **NOTE** Starting with the Intel MPI Library 2019 Update 4 release, you must specify two mpitune configuration files, which differ in their mode and dump-file fields. A simpler alternative may be to use one of the single configuration file templates shipped with the Intel MPI Library. In this case, you must use the command line to define the mode and dump-file fields.

- The `-mode` option defines one of two possible MPI tune modes: `collect` or `analyze`.
- The `-dump-file` option defines the path to the temporary files when in `analyze` mode. This path is returned by mpitune after the first iteration.

The configuration files should specify all tuner parameters, which are passed to the tuner with the `--config-file` option. A typical configuration file consists of the main section, specifying generic options, and search space sections for specific library parameters (for example, for specific collective operations). To comment a line, use the hash symbol `#`. All configuration file examples are available at `<installdir>/etc/tune_cfg`. Please note that configuration files for Intel® MPI Benchmarks are already created.

The tuning process consists of two steps: data collection (the `collect` mode) and data analysis (the `analyze` mode):

```
> mpitune -m collect -c <path-to-config-file2>
> mpitune -m analyze -c <path-to-config-file1>
```

Another variant of the launch is:

```
> mpitune -m collect -c <path-to-config-file1> -d <path-to-dump-file>
> mpitune -m analyze -c <path-to-config-file1>
```

where the path to the dump-file received in the first step is used in the config file with templates inside.

The tuning results are presented as a JSON tree and can be added to the library with the `I_MPI_TUNING` environment variable.

MPI Options Support

The following MPI options are available within the utility:

MPI Options	Description
-f *<filename>*	Specify a file containing host names.
-hosts *<hostlist>*	Specify a comma-separated list of hosts.

-np <*value*>	Specify the number of processes.

Examples

```
> mpitune -np 2 -ppn 1 -hosts HOST1,HOST2 -m collect -c <path-to-config-file2>
> mpitune -np 2 -ppn 1 -hosts HOST1,HOST2 -m analyze -c <path-to-config-file1>
```

Configuration File Format

All tuner parameters should be specified in two configuration files, passed to the tuner with the `--config-file` option. A typical configuration file consists of the main section, specifying generic options, and search space sections for specific library parameters (for example, for specific collective operations). Configuration files differ in mode and dump-file fields only. To comment a line, use the hash symbol #.

You can also specify MPI options to simplify `mpitune` usage. MPI options are useful for Intel® MPI Benchmarks that have special templates for `mpitune` located at <*install-dir*>`/etc/tune_cfg`. The templates require no changes in configuration files to be made.

For example, to tune the `Bcast` collective algorithm, use the following option:

```
> mpiexec -np 2 -ppn 2 -hosts HOST1 -m analyze -c <path-to-Bcast.cfg>
```

Experienced users can change configuration files to use this option for other applications.

Output Format

The tuner presents results in a JSON tree view (since the 2019 release), where the `comm_id=-1` layer is added automatically for each tree:

```
{
  "coll=Reduce": {
    "ppn=2": {
      "comm_size=2": {
        "comm_id=-1": {
          "msg_size=243": {
            "REDUCE=8": {}
          },
          "msg_size=319": {
            "REDUCE=11": {}
          },
          "msg_size=8192": {
            "REDUCE=8": {}
          },
          "msg_size=28383": {
            "REDUCE=9": {}
          },
          "msg_size=-1": {
            "REDUCE=1": {}
          }
        }
      }
    }
  }
}
```

To add the resulting JSON tree to the library, use the `I_MPI_TUNING` environment variable.

Old Output Format

The old output format is only valid for Intel MPI Library 2018 and prior versions:

```
I_MPI_ADJUST_BCAST=2:0-0;1:1-64;2:65-509;1:510-8832;3:8833-0
```

Use the resulting variable value with the application launch to achieve performance gain.

See Also

MPI Tuning in the Developer Guide.

For available configuration options, refer to mpitune Configuration Options.

mpitune Configuration Options

Application Options

-app

Sets a template for the command line to be launched to gather tuning results. The command line can contain variables declared as `@<var_name>@`. The variables are defined further on using other options.

For example:

```
-app: mpirun -np @np@ -ppn @ppn@ IMB-MPI1 -msglog 0:@logmax@ -npmin @np@ @func@
```

> **NOTE** The application must produce output (in `stdout` or file or any other destination) that can be parsed by the tuner to pick the value to be tuned and other variables. See the `-app-regex` and `-app-regex-legend` options below for details.

-app-regex

Sets a regular expression to be evaluated to extract the required values from the application output. Use regular expression groups to assign the values to variables. Variables and groups associations are set using the `-app-regex-legend` option.

For example, to extract the `#bytes` and `t_max[usec]` values from this output:

```
#bytes #repetitions  t_min[usec]  t_max[usec]  t_avg[usec]
0      1000          0.06         0.06         0.06
1      1000          0.10         0.10         0.10
```

use the following configuration:

```
-app-regex: (\d+)\s+\d+\s+[\d.+-]+\s+([\d.+-]+)
```

-app-regex-legend

Specifies a list of variables extracted from the regular expression. Variables correspond to the regular expression groups. The tuner uses the last variable as the performance indicator of the launch. Use the `-tree-opt` to set the optimization direction of the indicator.

For example:

```
-app-regex-legend: size,time
```

-iter

Sets the number of iterations for each launch with a given set of parameters. Higher numbers of iterations increase accuracy of results.

For example:

```
-iter: 3
```

Search Space Options

Use these options to define a search space, which is a set of combinations of Intel® MPI Library parameters that the target application uses for launches. The library parameters are generally configured using run-time options or environment variables.

> **NOTE** A search space line can be very long, so line breaking is available for all the search space options. Use a backslash to break a line (see examples below).

-search

Defines the search space by defining variables declared with the `-app` option and by setting environment variables for the application launch.

For example:

```
-search: func=BCAST, \
np=4,ppn={1,4},{,I_MPI_ADJUST_BCAST=[1,3]},logmax=5
```

The `-app` variables are defined as `<var1>=<value1>[,<var2>=<value2>][,...]`. The following syntax is available for setting values:

Syntax	Description	Examples
<value>	Single value. Can be a number or a string.	4
{<value1>[,<value2>][,...]}	List of independent values.	{2,4}
[<start>,<end>[,<step>]]	Linear range of values with the default step of 1.	`[1,8,2]` — expands to `{1,2,4,6,8}`
(<start>,<end>[,<step>])	Exponential range with the default step of 2.	`(1,16)` — expands to `{1,2,4,8,16}`

To set environment variables for the command launch, use the following syntax:

Syntax	Description	Examples
`<variable>=<value>`	Single variable definition. Any type of the syntax above can be used for the value: single values, lists or ranges.	`I_MPI_ADJUST_BCAST=3` `I_MPI_ADJUST_BCAST=[1,3]`
`{,<variable>=<value>}`	A special case of the syntax above. When set this way, the variable default value is first used in an application launch.	`{,I_MPI_ADJUST_BCAST=[1,3]}`
`<prefix>{<value1>[,<value2>][,...]}`	Multi-value variable definition. Prefix is a common part for all the values, commonly the variable name. A value can be a singular value or a combination of values in the format: `<prefix>(<value1>[,<value2>`	`I_MPI_ADJUST_ALLREDUCE{=1,=2,(=9,_KN_RADIX=(2,8))}` See below for a more complete example.

Syntax	Description	Examples
	`][,...])`. Prefix is optional and a value in the combination is a string, which can utilize the list and range syntax above.	

The following example shows a more complex option definition:

```
I_MPI_ADJUST_BCAST{=1,=2,(=9,_KN_RADIX=(2,8)),(={10,11},_SHM_KN_RADIX=[2,8,2])}
```

This directive consecutively runs the target application with the following environment variables set:

```
I_MPI_ADJUST_BCAST=1
I_MPI_ADJUST_BCAST=2
I_MPI_ADJUST_BCAST=9,I_MPI_ADJUST_BCAST_KN_RADIX=2
I_MPI_ADJUST_BCAST=9,I_MPI_ADJUST_BCAST_KN_RADIX=4
I_MPI_ADJUST_BCAST=9,I_MPI_ADJUST_BCAST_KN_RADIX=8
I_MPI_ADJUST_BCAST=10,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=2
I_MPI_ADJUST_BCAST=10,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=4
I_MPI_ADJUST_BCAST=10,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=6
I_MPI_ADJUST_BCAST=10,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=8
I_MPI_ADJUST_BCAST=11,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=2
I_MPI_ADJUST_BCAST=11,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=4
I_MPI_ADJUST_BCAST=11,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=6
I_MPI_ADJUST_BCAST=11,I_MPI_ADJUST_BCAST_SHM_KN_RADIX=8
```

-search-excl

Excludes certain combinations from the search space. The syntax is identical to that of the `-search` option. For example:

```
-search-excl: I_MPI_ADJUST_BCAST={1,2}
```

or

```
-search-excl: func=BCAST,np=4,ppn=1,I_MPI_ADJUST_BCAST=1
```

-search-only

Defines a subset of the search space to search in. Only this subset is used for application launches. The syntax is identical to the `-search` option.

This option is useful for the second and subsequent tuning sessions on a subset of parameters from the original session, without creating a separate configuration file.

Output Options

Use these options to customize the output. The tuner can produce output of two types:

- table— useful for verifying the tuning results, contains values from all the application launches
- tree— an internal output format, contains the optimal values

-table

Defines the layout for the resulting output table. The option value is a list of variables declared with the `-app` option, which are joined in colon-separated groups. Each group denotes a specific part of the table.

For example:

```
-table: func:ppn,np:size:*:time
```

The last group variables (`time`) are rendered in table cells. The second last group variables are used for building table columns (`*`, denotes all the variables not present the other variable groups). The third last group variables are used for building table rows (`size`). All other variable groups are used to make up the table label. Groups containing several variables are complex groups and produce output based on all the value combinations.

For example, the option definition above can produce the following output:

```
Label: "func=BCAST,ppn=2,np=2"


Legend:
set 0: ""
set 1: "I_MPI_ADJUST_BCAST=1"
set 2: "I_MPI_ADJUST_BCAST=2"
set 3: "I_MPI_ADJUST_BCAST=3"
Table:
           | set 0       | set 1       | set 2       | set 3
-----------|-------------|-------------|-------------|------------
"size=0"   | "time=0.10" | "time=0.08" | "time=0.11" | "time=0.10"
           | "time=0.12" | "time=0.09" | "time=0.12" | "time=0.11"
           |             | "time=0.10" |             |
-----------|-------------|-------------|-------------|------------
"size=4"   | "time=1.12" | "time=1.11" | "time=1.94" | "time=1.72"
           | "time=1.35" | "time=1.18" | "time=1.97" | "time=1.81"
           | "time=1.38" | "time=1.23" | "time=2.11" | "time=1.89"
-----------|-------------|-------------|-------------|------------
"size=8"   | "time=1.21" | "time=1.10" | "time=1.92" | "time=1.72"
           | "time=1.36" | "time=1.16" | "time=2.01" | "time=1.75"
           | "time=1.37" | "time=1.17" | "time=2.24" | "time=1.87"
-----------|-------------|-------------|-------------|------------
...
```

Cells include only unique values from all the launches for the given parameter combination. The number of launches is set with the `-iter` option.

-table-ignore

Specifies the variables to ignore from the `-table` option definition.

-tree

Defines the layout for the resulting tree of optimal values of the parameter that is tuned (for example, collective operation algorithms). The tree is rendered as a JSON structure. The option value is a list of variables declared with the `-app` option, which are joined in colon-separated groups. Each group denotes a specific part of the tree. Groups containing several variables are complex groups and produce output based on all the value combinations.

Example:

```
-tree: func:ppn,np:size:*:time
```

The first two groups (`func` and `ppn,np`) make up the first two levels of the tree. The last group variables (`time`) are used as the optimization criteria and are not rendered. The second last group contains variables to be optimized (`*`, denotes all the variables not present the other variable groups). The third last group variables are used to split the search space into intervals based on the optimal values of parameters from the next group (for example, `I_MPI_ADJUST_<operation>` algorithm numbers).

For example, the option definition above can produce the following output:

```
{
    "func=BCAST":
    {
        "ppn=1,np=4":
        {
            "size=0":
                {"I_MPI_ADJUST_BCAST": "3"},
            "size=64":
                {"I_MPI_ADJUST_BCAST": "1"},
            "size=512":
                {"I_MPI_ADJUST_BCAST": "2"},
            ...
        }
    }
}
```

This tree representation is an intermediate format of tuning results and is ultimately converted to a string that the library can understand. The conversion script is specified with `-tree-postprocess` option.

-tree-ignore

Specifies the variables to ignore from the `-tree` option definition.

-tree-intervals

Specifies the maximum number of intervals where the optimal parameter value is applied. If not specified, any number of intervals is allowed.

-tree-tolerance

Specifies the tolerance level. Non-zero tolerance (for example, 0.03 for 3%) joins resulting intervals with the performance indicator value varying by the specified tolerance.

-tree-postprocess

Specifies an executable to convert the resulting JSON tree to a custom format.

-tree-opt

Specifies the optimization direction. The available values are `max` (default) and `min`.

-tree-file

Specifies a log file where the tuning results are saved.

-tree-view

Specify the mode to present the json-tree. The available values are “simple” and “default”. The “default” mode enables an interpolation mechanism; the “simple” mode disables the interpolation mechanism. The resulting tree contains message sizes used during the launch.

-mode

Specifies the mpitune mode. The available values are “collect” for gathering data and “analyze” for converting this data to a JSON-tree. Note that the -mode field can be defined in the configuration file as macros @-mode@, although the real value must be defined in the command line.

-dump-file

Specifies the path for the dump-file, which is returned by mpitune after the first iteration. The first iteration can be initialized by way of “” (an nempty string). Note that the -dump-file field can be defined in the configuration file as macros @-dump-file@, although the real value must be defined in the command line.

Environment Variable Reference 2

This section provides information on different variables:

Compilation Environment Variables

I_MPI_{CC,CXX,FC,F77,F90}_PROFILE

Specify the default profiling library.

Syntax

`I_MPI_CC_PROFILE=<profile-name>`

`I_MPI_CXX_PROFILE=<profile-name>`

`I_MPI_FC_PROFILE=<profile-name>`

`I_MPI_F77_PROFILE=<profile-name>`

`I_MPI_F90_PROFILE=<profile-name>`

Argument

<profile-name>	Specify a default profiling library.

Description

Set this environment variable to select a specific MPI profiling library to be used by default. This has the same effect as using `-profile=<profile-name>` as an argument for `mpiicc` or another Intel® MPI Library compiler wrapper.

I_MPI_{CC,CXX,FC,F77,F90}

Set the path/name of the underlying compiler to be used.

Syntax

`I_MPI_CC=<compiler>`

`I_MPI_CXX=<compiler>`

`I_MPI_FC=<compiler>`

`I_MPI_F77=<compiler>`

`I_MPI_F90=<compiler>`

Arguments

<compiler>	Specify the full path/name of compiler to be used.

Description

Set this environment variable to select a specific compiler to be used. Specify the full path to the compiler if it is not located in the search path.

NOTE Some compilers may require additional command line options.

I_MPI_ROOT

Set the Intel MPI Library installation directory path.

Syntax

`I_MPI_ROOT=<path>`

Arguments

<path>	Specify the installation directory of the Intel MPI Library.

Description

Set this environment variable to specify the installation directory of the Intel MPI Library.

NOTE If you are using the Visual Studio integration, you may need to use `I_MPI_ONEAPI_ROOT`.

VT_ROOT

Set Intel® Trace Collector installation directory path.

Syntax

`VT_ROOT=<path>`

Arguments

<path>	Specify the installation directory of the Intel Trace Collector.

Description

Set this environment variable to specify the installation directory of the Intel Trace Collector.

I_MPI_COMPILER_CONFIG_DIR

Set the location of the compiler configuration files.

Syntax

`I_MPI_COMPILER_CONFIG_DIR=<path>`

Arguments

<path>	Specify the location of the compiler configuration files. The default value is *<install-dir>*`\etc`

Description

Set this environment variable to change the default location of the compiler configuration files.

I_MPI_LINK

Select a specific version of the Intel MPI Library for linking.

Syntax

`I_MPI_LINK=<arg>`

Arguments

Argument	Library Version
`opt`	Multi-threaded optimized library. This is the default value
`dbg`	Multi-threaded debug library

Description

Set this variable to always link against the specified version of the Intel MPI Library.

Hydra Environment Variables

I_MPI_HYDRA_HOST_FILE

Set the host file to run the application.

Syntax

`I_MPI_HYDRA_HOST_FILE=<arg>`

Argument

<arg>	String parameter
<hostsfile>	The full or relative path to the host file

Description

Set this environment variable to specify the hosts file.

I_MPI_HYDRA_HOSTS_GROUP

Set node ranges using brackets, commas, and dashes.

Syntax

`I_MPI_HYDRA_HOSTS_GROUP=<arg>`

Argument

<arg>	Set a node range.

Description

Set this variable to be able to set node ranges using brackets, commas, and dashes (like in Slurm* Workload Manager). For example:

```
I_MPI_HYDRA_HOSTS_GROUP="hostA[01-05],hostB,hostC[01-05,07,09-11]"
```

You can set node ranges with the `-hosts-group` option.

I_MPI_HYDRA_DEBUG

Print out the debug information.

Syntax

`I_MPI_HYDRA_DEBUG=<arg>`

Argument

<arg>	Binary indicator
`enable | yes | on | 1`	Turn on the debug output
`disable | no | off | 0`	Turn off the debug output. This is the default value

Description

Set this environment variable to enable the debug mode.

I_MPI_HYDRA_ENV

Control the environment propagation.

Syntax

`I_MPI_HYDRA_ENV=<arg>`

Argument

<arg>	String parameter
`all`	Pass all environment to all MPI processes

Description

Set this environment variable to control the environment propagation to the MPI processes. By default, the entire launching node environment is passed to the MPI processes. Setting this variable also overwrites environment variables set by the remote shell.

I_MPI_JOB_TIMEOUT

Set the timeout period for `mpiexec` .

Syntax

`I_MPI_JOB_TIMEOUT=<timeout>`

`I_MPI_MPIEXEC_TIMEOUT=<timeout>`

Argument

<timeout>	Define `mpiexec` timeout period in seconds
<n> ≥ 0	The value of the timeout period. The default timeout value is zero, which means no timeout.

Description

Set this environment variable to make `mpiexec` terminate the job in *<timeout>* seconds after its launch. The *<timeout>* value should be greater than zero. Otherwise the environment variable setting is ignored.

I_MPI_JOB_STARTUP_TIMEOUT

Set the `mpiexec` job startup timeout.

Syntax

`I_MPI_JOB_STARTUP_TIMEOUT=<timeout>`

Argument

<timeout>	Define `mpiexec` startup timeout period in seconds
<n> ≥ 0	The value of the timeout period. The default timeout value is zero, which means no timeout.

Description

Set this environment variable to make `mpiexec` terminate the job in *<timeout>* seconds if some processes are not launched. The *<timeout>* value should be greater than zero.

I_MPI_HYDRA_BOOTSTRAP

Set the bootstrap server.

Syntax

`I_MPI_HYDRA_BOOTSTRAP=<arg>`

Argument

<arg>	String parameter
`service`	Use hydra service agent
lsf	Use the LSF blaunch command

Description

Set this environment variable to specify the bootstrap server.

> **NOTE** LSF bootstrap is chosen automatically if LSF environment variables are found. If the -hosts option is specified, LSF bootstrap will not be chosen by default. Set I_MPI_HYDRA_BOOTSTRAP=lsf for this case.

I_MPI_HYDRA_BOOTSTRAP_EXEC

Set the executable file to be used as a bootstrap server.

Syntax

`I_MPI_HYDRA_BOOTSTRAP_EXEC=<arg>`

Argument

<arg>	String parameter
<executable>	The name of the executable file

Description

Set this environment variable to specify the executable file to be used as a bootstrap server.

I_MPI_HYDRA_PMI_CONNECT

Define the processing method for PMI messages.

Syntax

`I_MPI_HYDRA_PMI_CONNECT=<value>`

Argument

<value>	The algorithm to be used
`nocache`	Do not cache PMI messages
`cache`	Cache `PMI` messages on the local `pmi_proxy` management processes to minimize the number of `PMI` requests. Cached information is automatically propagated to child management processes.
`lazy-cache`	`cache` mode with on-demand propagation.
`alltoall`	Information is automatically exchanged between all `pmi_proxy` before any get request can be done. This is the default value.

Description

Use this environment variable to select the PMI messages processing method.

I_MPI_PERHOST

Define the default behavior for the `-perhost` option of the `mpiexec` command.

Syntax

`I_MPI_PERHOST=<value>`

Argument

`<value>`	Define a value used for `-perhost` by default
`integer > 0`	Exact value for the option
`all`	All logical CPUs on the node
`allcores`	All cores (physical CPUs) on the node. This is the default value.

Description

Set this environment variable to define the default behavior for the `-perhost` option. Unless specified explicitly, the `-perhost` option is implied with the value set in `I_MPI_PERHOST`.

> **NOTE**
> When running under a job scheduler, this environment variable is ignored by default. To control process placement with `I_MPI_PERHOST`, disable the `I_MPI_JOB_RESPECT_PROCESS_PLACEMENT` variable.

I_MPI_HYDRA_BRANCH_COUNT

Set the hierarchical branch count.

Syntax

`I_MPI_HYDRA_BRANCH_COUNT =<num>`

Argument

`<num>`	Number
`<n> >= 0`	The default value is 16. This value means that hierarchical structure is enabled if the number of nodes is more than 16. If I_MPI_HYDRA_BRANCH_COUNT=0, then there is no hierarchical structure. If I_MPI_HYDRA_BRANCH_COUNT=-1, then branch count is equal to default value.

Description

Set this environment variable to restrict the number of child management processes launched by the `mpiexec` operation or by each `pmi_proxy` management process.

I_MPI_HYDRA_PMI_AGGREGATE

Turn on/off aggregation of the PMI messages.

Syntax

`I_MPI_HYDRA_PMI_AGGREGATE=<arg>`

Argument

`<arg>`	Binary indicator

enable | yes | on | 1	Enable PMI message aggregation. This is the default value.
disable | no | off | 0	Disable PMI message aggregation.

Description

Set this environment variable to enable/disable aggregation of PMI messages.

I_MPI_HYDRA_IFACE

Set the network interface.

Syntax

`I_MPI_HYDRA_IFACE=<arg>`

Argument

<arg>	String parameter
<network interface>	The network interface configured in your system

Description

Set this environment variable to specify the network interface to use. For example, use "`-iface ib0`", if the IP emulation of your InfiniBand* network is configured on `ib0`.

I_MPI_TMPDIR

Specify a temporary directory.

Syntax

`I_MPI_TMPDIR=<arg>`

Argument

<arg>	String parameter
<path>	Temporary directory. The default value is `/tmp`

Description

Set this environment variable to specify a directory for temporary files.

I_MPI_JOB_RESPECT_PROCESS_PLACEMENT

Specify whether to use the process-per-node placement provided by the job scheduler, or set explicitly.

Syntax

`I_MPI_JOB_RESPECT_PROCESS_PLACEMENT=<arg>`

Argument

<value>	Binary indicator
enable | yes | on | 1	Use the process placement provided by job scheduler. This is the default value
disable | no | off | 0	Do not use the process placement provided by job scheduler

Description

If the variable is set, the Hydra process manager uses the process placement provided by job scheduler (default). In this case the `-ppn` option and its equivalents are ignored. If you disable the variable, the Hydra process manager uses the process placement set with `-ppn` or its equivalents.

I_MPI_PORT_RANGE

Specify a range of allowed port numbers.

Syntax

`I_MPI_PORT_RANGE=<range>`

Argument

<range>	String parameter
<min>:<max>	Allowed port range

Description

Set this environment variable to specify a range of the allowed port numbers for the Intel® MPI Library.

I_MPI_HYDRA_SERVICE_PORT

Set the port on which the hydra service is installed.

Syntax

`I_MPI_HYDRA_SERVICE_PORT=<int>`

Argument

<int>	Define the port number

Description

Set this environment variable to inform `mpiexec.hydra`, on which port the hydra service is installed. Use this variable if you want to run a number of services on different ports.

To be able to run a number of hydra services, follow these steps:

1. Start `cmd` and run hydra services:

```
> start hydra_service -p <port1> -d> start hydra_service -p <port2> -d
```

2. Set the environment variable to choose the service to be used:

```
set I_MPI_HYDRA_SERVICE_PORT=”port2”
```

3. Run `mpiexec` as usual

I_MPI_SILENT_ABORT

Control abort warning messages.

Syntax

`I_MPI_SILENT_ABORT=<arg>`

Argument

<arg>	Binary indicator
`enable | yes | on | 1`	Do not print abort warning message
`disable | no | off | 0`	Print abort warning message. This is the default value

Description

Set this variable to disable printing of abort warning messages. The messages are printed in case of the MPI_Abort call.

You can also disable printing of these messages with the `-silent-abort` option.

I_MPI_HYDRA_NAMESERVER

Specify the nameserver.

Syntax

`I_MPI_HYDRA_NAMESERVER=<arg>`

Argument

<arg>	String parameter
<hostname>:<port>	Set the hostname and the port.

Description

Set this variable to specify the nameserver for your MPI application in the following format:

```
I_MPI_HYDRA_NAMESERVER = hostname:port
```

You can set the nameserver with the `-nameserver` option.

I_MPI_HYDRA_BSTRAP_KEEP_ALIVE

Set this variable to keep `hydra_bstrap_proxy` alive after launching `hydra_pmi_proxy`.

Syntax

`I_MPI_HYDRA_BSTRAP_KEEP_ALIVE=<arg>`

Argument

<arg>	Binary indicator
`enable | yes | on | 1`	Do not close `hydra_bstrap_proxy`.
`disable | no | off | 0`	Close `hydra_bstrap_proxy`. This is the default value.

Description

Set this variable to keep `hydra_bstrap_proxy` alive after launching `hydra_pmi_proxy`. It allows you to keep full process tree (`mpiexec` —> `hydra_bstrap_proxy` —> `hydra_pmi_proxy` —> app) connected on localhost. The default value closes `hydra_bstrap_proxy` to reduce the number of running processes.

I_MPI_ADJUST Family Environment Variables

I_MPI_ADJUST_<opname>

Control collective operation algorithm selection.

Syntax

`I_MPI_ADJUST_<opname>="<presetid>[:<conditions>][;<presetid>:<conditions>[...]]"`

Arguments

<presetid>	Preset identifier
`>= 0`	Set a number to select the desired algorithm. The value 0 uses basic logic of the collective algorithm selection.

<conditions>	A comma separated list of conditions. An empty list selects all message sizes and process combinations
<l>	Messages of size *<l>*
<l>-<m>	Messages of size from *<l>* to *<m>*, inclusive
<l>@<p>	Messages of size *<l>* and number of processes *<p>*

<l>-<m>@<p>-<q>	Messages of size from *<l>* to *<m>* and number of processes from *<p>* to *<q>*, inclusive

Description

Set this environment variable to select the desired algorithm(s) for the collective operation *<opname>* under particular conditions. Each collective operation has its own environment variable and algorithms.

Environment Variables, Collective Operations, and Algorithms

Environment Variable	Collective Operation	Algorithms
I_MPI_ADJUST_ALLGATHER	MPI_Allgather	**1.** Recursive doubling **2.** Bruck's **3.** Ring **4.** Topology aware Gatherv + Bcast **5.** Knomial
I_MPI_ADJUST_ALLGATHERV	MPI_Allgatherv	**1.** Recursive doubling **2.** Bruck's **3.** Ring **4.** Topology aware Gatherv + Bcast
I_MPI_ADJUST_ALLREDUCE	MPI_Allreduce	**1.** Recursive doubling **2.** Rabenseifner's **3.** Reduce + Bcast **4.** Topology aware Reduce + Bcast **5.** Binomial gather + scatter **6.** Topology aware binominal gather + scatter **7.** Shumilin's ring **8.** Ring **9.** Knomial **10.** Topology aware SHM-based flat **11.** Topology aware SHM-based Knomial **12.** Topology aware SHM-based Knary
I_MPI_ADJUST_ALLTOALL	MPI_Alltoall	**1.** Bruck's **2.** Isend/Irecv + waitall **3.** Pair wise exchange **4.** Plum's
I_MPI_ADJUST_ALLTOALLV	MPI_Alltoallv	**1.** Isend/Irecv + waitall **2.** Plum's
I_MPI_ADJUST_ALLTOALLW	MPI_Alltoallw	Isend/Irecv + waitall
I_MPI_ADJUST_BARRIER	MPI_Barrier	**1.** Dissemination **2.** Recursive doubling **3.** Topology aware dissemination

Environment Variable	Collective Operation	Algorithms
		4. Topology aware recursive doubling **5.** Binominal gather + scatter **6.** Topology aware binominal gather + scatter **7.** Topology aware SHM-based flat **8.** Topology aware SHM-based Knomial **9.** Topology aware SHM-based Knary
I_MPI_ADJUST_BCAST	MPI_Bcast	**1.** Binomial **2.** Recursive doubling **3.** Ring **4.** Topology aware binomial **5.** Topology aware recursive doubling **6.** Topology aware ring **7.** Shumilin's **8.** Knomial **9.** Topology aware SHM-based flat **10.** Topology aware SHM-based Knomial **11.** Topology aware SHM-based Knary **12.** NUMA aware SHM-based (SSE4.2) **13.** NUMA aware SHM-based (AVX2) **14.** NUMA aware SHM-based (AVX512)
I_MPI_ADJUST_EXSCAN	MPI_Exscan	**1.** Partial results gathering **2.** Partial results gathering regarding layout of processes
I_MPI_ADJUST_GATHER	MPI_Gather	**1.** Binomial **2.** Topology aware binomial **3.** Shumilin's **4.** Binomial with segmentation
I_MPI_ADJUST_GATHERV	MPI_Gatherv	**1.** Linear **2.** Topology aware linear **3.** Knomial
I_MPI_ADJUST_REDUCE_SCATTER	MPI_Reduce_scatter	**1.** Recursive halving **2.** Pair wise exchange **3.** Recursive doubling **4.** Reduce + Scatterv **5.** Topology aware Reduce + Scatterv

Environment Variable	Collective Operation	Algorithms
I_MPI_ADJUST_REDUCE	MPI_Reduce	**1.** Shumilin's **2.** Binomial **3.** Topology aware Shumilin's **4.** Topology aware binomial **5.** Rabenseifner's **6.** Topology aware Rabenseifner's **7.** Knomial **8.** Topology aware SHM-based flat **9.** Topology aware SHM-based Knomial **10.** Topology aware SHM-based Knary **11.** Topology aware SHM-based binomial
I_MPI_ADJUST_SCAN	MPI_Scan	**1.** Partial results gathering **2.** Topology aware partial results gathering
I_MPI_ADJUST_SCATTER	MPI_Scatter	**1.** Binomial **2.** Topology aware binomial **3.** Shumilin's
I_MPI_ADJUST_SCATTERV	MPI_Scatterv	**1.** Linear **2.** Topology aware linear
I_MPI_ADJUST_SENDRECV_REPLACE	MPI_Sendrecv_replace	1. Generic 2. Uniform (with restrictions)
I_MPI_ADJUST_IALLGATHER	MPI_Iallgather	**1.** Recursive doubling **2.** Bruck’s **3.** Ring
I_MPI_ADJUST_IALLGATHERV	MPI_Iallgatherv	**1.** Recursive doubling **2.** Bruck’s **3.** Ring
I_MPI_ADJUST_IALLREDUCE	MPI_Iallreduce	**1.** Recursive doubling **2.** Rabenseifner’s **3.** Reduce + Bcast **4.** Ring (patarasuk) **5.** Knomial **6.** Binomial **7.** Reduce scatter allgather **8.** SMP **9.** Nreduce
I_MPI_ADJUST_IALLTOALL	MPI_Ialltoall	**1.** Bruck’s **2.** Isend/Irecv + Waitall **3.** Pairwise exchange
I_MPI_ADJUST_IALLTOALLV	MPI_Ialltoallv	Isend/Irecv + Waitall

Environment Variable	Collective Operation	Algorithms
I_MPI_ADJUST_IALLTOALLW	MPI_Ialltoallw	Isend/Irecv + Waitall
I_MPI_ADJUST_IBARRIER	MPI_Ibarrier	Dissemination
I_MPI_ADJUST_IBCAST	MPI_Ibcast	**1.** Binomial **2.** Recursive doubling **3.** Ring **4.** Knomial **5.** SMP **6.** Tree knominal **7.** Tree kary
I_MPI_ADJUST_IEXSCAN	MPI_Iexscan	**1.** Recursive doubling **2.** SMP
I_MPI_ADJUST_IGATHER	MPI_Igather	**1.** Binomial **2.** Knomial
I_MPI_ADJUST_IGATHERV	MPI_Igatherv	**1.** Linear **2.** Linear ssend
I_MPI_ADJUST_IREDUCE_SCATTER	MPI_Ireduce_scatter	**1.** Recursive halving **2.** Pairwise **3.** Recursive doubling
I_MPI_ADJUST_IREDUCE	MPI_Ireduce	**1.** Rabenseifner's **2.** Binomial **3.** Knomial
I_MPI_ADJUST_ISCAN	MPI_Iscan	**1.** Recursive Doubling **2.** SMP
I_MPI_ADJUST_ISCATTER	MPI_Iscatter	**1.** Binomial **2.** Knomial
I_MPI_ADJUST_ISCATTERV	MPI_Iscatterv	Linear

The message size calculation rules for the collective operations are described in the table. In the following table, "n/a" means that the corresponding interval *<l>-<m>* should be omitted.

NOTE The I_MPI_ADJUST_SENDRECV_REPLACE=2 ("Uniform") algorithm can be used only in the case when datatype and objects count are the same across all ranks.

To get the maximum number (range) of presets available for each collective operation, use the `impi_info` command:

```
> impi_info -v I_MPI_ADJUST_ALLREDUCE
I_MPI_ADJUST_ALLREDUCE
  MPI Datatype:
    MPI_CHAR
  Description:
    Control selection of MPI_Allreduce algorithm presets.
    Arguments
    <presetid> - Preset identifier
    range: 0-27
```

Message Collective Functions

Collective Function	Message Size Formula
MPI_Allgather	recv_count*recv_type_size
MPI_Allgatherv	total_recv_count*recv_type_size
MPI_Allreduce	count*type_size
MPI_Alltoall	send_count*send_type_size
MPI_Alltoallv	n/a
MPI_Alltoallw	n/a
MPI_Barrier	n/a
MPI_Bcast	count*type_size
MPI_Exscan	count*type_size
MPI_Gather	recv_count*recv_type_size if MPI_IN_PLACE is used, otherwise send_count*send_type_size
MPI_Gatherv	n/a
MPI_Reduce_scatter	total_recv_count*type_size
MPI_Reduce	count*type_size
MPI_Scan	count*type_size
MPI_Scatter	send_count*send_type_size if MPI_IN_PLACE is used, otherwise recv_count*recv_type_size
MPI_Scatterv	n/a

Examples

Use the following settings to select the second algorithm for `MPI_Reduce` operation:
`I_MPI_ADJUST_REDUCE=2`

Use the following settings to define the algorithms for `MPI_Reduce_scatter` operation:
`I_MPI_ADJUST_REDUCE_SCATTER="4:0-100,5001-10000;1:101-3200;2:3201-5000;3"`

In this case. algorithm 4 is used for the message sizes between 0 and 100 bytes and from 5001 and 10000 bytes, algorithm 1 is used for the message sizes between 101 and 3200 bytes, algorithm 2 is used for the message sizes between 3201 and 5000 bytes, and algorithm 3 is used for all other messages.

I_MPI_ADJUST_<opname>_LIST

Syntax

`I_MPI_ADJUST_<opname>_LIST=<presetid1>[-<presetid2>][,<presetid3>][,<presetid4>-<presetid5>]`

Description

Set this environment variable to specify the set of algorithms to be considered by the Intel MPI runtime for a specified `<opname>`. This variable is useful in autotuning scenarios, as well as tuning scenarios where users would like to select a certain subset of algorithms.

> **NOTE** Setting an empty string disables autotuning for the `<opname>` collective.

I_MPI_COLL_INTRANODE

Syntax

`I_MPI_COLL_INTRANODE=<mode>`

Arguments

<mode>	Intranode collectives type
pt2pt	Use only point-to-point communication-based collectives
shm	Enables shared memory collectives. This is the default value

Description

Set this environment variable to switch intranode communication type for collective operations. If there is large set of communicators, you can switch off the SHM-collectives to avoid memory overconsumption.

I_MPI_COLL_INTRANODE_SHM_THRESHOLD

Syntax

`I_MPI_COLL_INTRANODE_SHM_THRESHOLD=<nbytes>`

Arguments

<nbytes>	Define the maximal data block size processed by shared memory collectives
> 0	Use the specified size. The default value is 16384 bytes.

Description

Set this environment variable to define the size of shared memory area available for each rank for data placement. Messages greater than this value will *not* be processed by SHM-based collective operation, but will be processed by point-to-point based collective operation. The value must be a multiple of 4096.

I_MPI_COLL_EXTERNAL

Syntax

`I_MPI_COLL_EXTERNAL=<arg>`

Arguments

<arg>	Description
enable | yes | on | 1	Enable the external collective operations functionality using available collectives libraries.
disable | no | off | 0	Disable the external collective operations functionality. This is the default value.
hcoll	Enable the external collective operations functionality using HCOLL library.

Description

Set this environment variable to enable external collective operations. For reaching better performance, use an autotuner after enabling `I_MPI_COLL_EXTERNAL`. This process gets the optimal collectives settings.

To force external collective operations usage, use the following `I_MPI_ADJUST_<opname>` values: I_MPI_ADJUST_ALLREDUCE=24, I_MPI_ADJUST_BARRIER=11, I_MPI_ADJUST_BCAST=16, I_MPI_ADJUST_REDUCE=13, I_MPI_ADJUST_ALLGATHER=6, I_MPI_ADJUST_ALLTOALL=5, I_MPI_ADJUST_ALLTOALLV=5, I_MPI_ADJUST_SCAN=3, I_MPI_ADJUST_EXSCAN=3, I_MPI_ADJUST_GATHER=5, I_MPI_ADJUST_GATHERV=4, I_MPI_ADJUST_SCATTER=5, I_MPI_ADJUST_SCATTERV=4, I_MPI_ADJUST_ALLGATHERV=5, I_MPI_ADJUST_ALLTOALLW=2, I_MPI_ADJUST_REDUCE_SCATTER=6, I_MPI_ADJUST_REDUCE_SCATTER_BLOCK=4, I_MPI_ADJUST_IALLGATHER=5, I_MPI_ADJUST_IALLGATHERV=5, I_MPI_ADJUST_IGATHERV=3, I_MPI_ADJUST_IALLREDUCE=9, I_MPI_ADJUST_IALLTOALLV=2, I_MPI_ADJUST_IBARRIER=2, I_MPI_ADJUST_IBCAST=5, I_MPI_ADJUST_IREDUCE=4.

For more information on HCOLL tuning, refer to NVIDIA* documentation.

I_MPI_COLL_DIRECT

Syntax

I_MPI_COLL_DIRECT=<arg>

Arguments

<arg>	Description
on	Enable direct collectives. This is the default value.
off	Disable direct collectives.

Description

Set this environment variable to control direct collectives usage. Disable this variable to eliminate OFI* usage for intra-node communications in case of shm:ofi fabric.

I_MPI_CBWR

Control reproducibility of floating-point operations results across different platforms, networks, and topologies in case of the same number of processes.

Syntax

I_MPI_CBWR=<*arg*>

Arguments

<*arg*>	CBWR compatibility mode	Description
0	None	Do not use CBWR in a library-wide mode. CNR-safe communicators may be created with MPI_Comm_dup_with_info explicitly. This is the default value.
1	Weak mode	Disable topology aware collectives. The result of a collective operation does not depend on the rank placement. The mode guarantees results reproducibility across different runs on the same cluster (independent of the rank placement).
2	Strict mode	Disable topology aware collectives, ignore CPU architecture, and interconnect during algorithm selection. The mode guarantees results reproducibility across different runs on different clusters (independent of the rank placement, CPU architecture, and interconnection)

Description

Conditional Numerical Reproducibility (CNR) provides controls for obtaining reproducible floating-point results on collectives operations. With this feature, Intel MPI collective operations are designed to return the same floating-point results from run to run in case of the same number of MPI ranks.

Control this feature with the `I_MPI_CBWR` environment variable in a library-wide manner, where all collectives on all communicators are guaranteed to have reproducible results. To control the floating-point operations reproducibility in a more precise and per-communicator way, pass the `{"I_MPI_CBWR", "yes"}` key-value pair to the `MPI_Comm_dup_with_info` call.

> **NOTE**
> Setting the `I_MPI_CBWR` in a library-wide mode using the environment variable leads to performance penalty.

CNR-safe communicators created using `MPI_Comm_dup_with_info` always work in the strict mode. For example:

```
MPI_Info hint;
MPI_Comm cbwr_safe_world, cbwr_safe_copy;
MPI_Info_create(&hint);
MPI_Info_set(hint, "I_MPI_CBWR", "yes");
MPI_Comm_dup_with_info(MPI_COMM_WORLD, hint, & cbwr_safe_world);
MPI_Comm_dup(cbwr_safe_world, & cbwr_safe_copy);
```

In the example above, both cbwr_safe_world and cbwr_safe_copy are CNR-safe. Use cbwr_safe_world and its duplicates to get reproducible results for critical operations.

Note that `MPI_COMM_WORLD` itself may be used for performance-critical operations without reproducibility limitations.

Tuning Environment Variables

I_MPI_TUNING_MODE

Select the tuning method.

Syntax

`I_MPI_TUNING_MODE=<arg>`

Arguments

<arg>	**Description**
none	Disable tuning modes. This is the default value.
`auto`	Enable autotuner.
`auto:application`	Enable autotuner with application focused strategy (alias for auto).
`auto:cluster`	Enable autotuner without application specific logic. This is typically performed with the help of benchmarks (for example, IMB-MPI1) and proxy applications.

Description

Set this environment variable to enable the autotuner functionality and set the autotuner strategy.

I_MPI_TUNING_BIN

Specify the path to tuning settings in a binary format.

Syntax

`I_MPI_TUNING_BIN=<path>`

Argument

<*path* >	A path to a binary file with tuning settings. By default, Intel® MPI Library uses the binary tuning file located at <`$I_MPI_ONEAPI_ROOT/etc`>.

Description

Set this environment variable to load tuning settings in a binary format.

I_MPI_TUNING_BIN_DUMP

Specify the file for storing tuning settings in a binary format.

Syntax

`I_MPI_TUNING_BIN_DUMP=<`*`filename`*`>`

Argument

<*filename*>	A file name of a binary that stores tuning settings. By default, the path is not specified.

Description

Set this environment variable to store tuning settings in binary format.

I_MPI_TUNING

Load tuning settings in a JSON format.

Syntax

`I_MPI_TUNING=<`*`path`*`>`

Argument

<*path*>	A path to a JSON file with tuning settings.

Description

Set this environment variable to load tuning settings in a JSON format.

> **NOTE** The tuning settings in the JSON format are produced by the `mpitune` utility.

By default, the Intel® MPI Library loads tuning settings in a binary format. If it is not possible, the Intel MPI Library loads the tuning file in a JSON format specified through the `I_MPI_TUNING` environment variable. Thus, to enable JSON tuning, turn off the default binary tuning: `I_MPI_TUNING_BIN=""`. If it is not possible to load tuning settings from a JSON file and in a binary format, the default tuning values are used.

You do not need to turn off binary or JSON tuning settings if you use `I_MPI_ADJUST` family environment variables. The algorithms specified with `I_MPI_ADJUST` environment variables always have priority over binary and JSON tuning settings.

See Also

- Autotuning
- Environment Variables for Autotuning

Autotuning

If an application spends significant time in MPI collective operations, tuning might improve its performance.

Tuning is very dependent on the specifications of the particular platform. Autotuner searches for the best possible implementation of a collective operation during application runtime. Each collective operation has its own presets, which consist of the algorithm and its parameters, that the autotuning function goes through

and then evaluates the performance of each one. Once autotuning has evaluated the search space, it chooses the fastest implementation and uses it for the rest of the application runtime, and this improves application performance. The autotuner search space can be modified by the `I_MPI_ADJUST_<opname>_LIST` variable (see I_MPI_ADJUST Family Environment Variables).

Autotuner determines the tuning parameters and makes them available for autotuning using `I_MPI_TUNING_MODE` and the `I_MPI_TUNING_AUTO` family environment variables to find the best settings (see Tuning Environment Variables and I_MPI_TUNING_AUTO Family Environment Variables).

> **NOTE** `I_MPI_TUNING_MODE` and the `I_MPI_TUNING_AUTO` family environment variables support only Intel processors, and cannot be used on other platforms.

The collectives currently available for autotuning are: MPI_Allreduce, MPI_Bcast, MPI_Barrier, MPI_Reduce, MPI_Gather, MPI_Scatter, MPI_Alltoall, MPI_Allgatherv, MPI_Reduce_scatter, MPI_Reduce_scatter_block, MPI_Scan, MPI_Exscan, MPI_Iallreduce, MPI_Ibcast, MPI_Ibarrier, MPI_Ireduce, MPI_Igather, MPI_Iscatter, MPI_Ialltoall, MPI_Iallgatherv, MPI_Ireduce_scatter, MPI_Ireduce_scatter_block, MPI_Iscan, and MPI_Iexscan.

Using autotuner involves these steps:

1. Launch the application with autotuner enabled and specify the dump file that stores results:

   `I_MPI_TUNING_MODE=auto`

   `I_MPI_TUNING_BIN_DUMP=<tuning-results.dat>`
2. Launch the application with the tuning results generated at the previous step:

   `I_MPI_TUNING_BIN= ./tuning-results.dat`

   Or use the `-tune` Hydra option.

If you experience performance issues, see I_MPI_TUNING_AUTO Family Environment Variables.

Examples

```
• > export I_MPI_TUNING_MODE=auto
  > export I_MPI_TUNING_AUTO_SYNC=1
  > export I_MPI_TUNING_AUTO_ITER_NUM=5
  > export I_MPI_TUNING_BIN_DUMP=<tuning_results.dat>
  > mpirun -n 128 -ppn 64 IMB-MPI1 allreduce -iter 1000,800 -time 4800
• > export I_MPI_TUNING_BIN=./tuning_results.dat
   > mpirun -n 128 -ppn 64 IMB-MPI1 allreduce -iter 1000,800 -time 4800
```

> **NOTE** To tune collectives on a communicator identified with the help of Application Performance Snapshot (APS), execute the following variable at step 1:
> `I_MPI_TUNING_AUTO_COMM_LIST=comm_id_1, … , comm_id_n.`

See Also

I_MPI_TUNING_AUTO Family Environment Variables

Make HPC Clusters More Efficient Using Intel® MPI Library Tuning Utilities

I_MPI_TUNING_AUTO Family Environment Variables

> **NOTE** You must set I_MPI_TUNING_MODE to use any of the I_MPI_TUNING_AUTO family environment variables.

NOTE The I_MPI_TUNING_AUTO family environment variables support only Intel processors, and cannot be used on other platforms.

I_MPI_TUNING_AUTO_STORAGE_SIZE

Define size of the per-communicator tuning storage.

Syntax

`I_MPI_TUNING_AUTO_STORAGE_SIZE=<size>`

Argument

<size>	Specify size of the communicator tuning storage. The default size of the storage is 512 Kb.

Description

Set this environment variable to change the size of the communicator tuning storage.

I_MPI_TUNING_AUTO_ITER_NUM

Specify the number of autotuner iterations.

Syntax

`I_MPI_TUNING_AUTO_ITER_NUM=<number>`

Argument

<number>	Define the number of iterations. By default, it is 1.

Description

Set this environment variable to specify the number of autotuner iterations. The greater iteration number produces more accurate results.

NOTE To check if all possible algorithms are iterated, make sure that the total number of collective invocations for a particular message size in a target application is at least equal the value of `I_MPI_TUNING_AUTO_ITER_NUM` multiplied by the number of algorithms.

I_MPI_TUNING_AUTO_WARMUP_ITER_NUM

Specify the number of warmup autotuner iterations.

Syntax

`I_MPI_TUNING_AUTO_WARMUP_ITER_NUM=<number>`

Argument

<number>	Define the number of iterations. By default, it is 1.

Description

Set this environment variable to specify the number of autotuner warmup iterations. Warmup iterations do not impact autotuner decisions and allow to skip additional iterations, such as infrastructure preparation.

I_MPI_TUNING_AUTO_SYNC

Enable the internal barrier on every iteration of the autotuner.

Syntax

I_MPI_TUNING_AUTO_SYNC=<*arg*>

Argument

<arg>	**Binary indicator**
enable | yes | on | 1	Align the autotuner with the IMB measurement approach.
disable | no | off | 0	Do not use the barrier on every iteration of the autotuner. This is the default value.

Description

Set this environment variable to control the IMB measurement logic. Setting this variable to 1 may lead to overhead due to an additional MPI_Barrier call.

I_MPI_TUNING_AUTO_COMM_LIST

Control the scope of autotuning.

Syntax

I_MPI_TUNING_AUTO_COMM_LIST=<*comm_id_1, ..., comm_id_n*>

Argument

<*comm_id_n, ...*>	Specify communicators to be tuned.

Description

Set this environment variable to specify communicators to be tuned using their unique id. By default, the variable is not specified. In this case, all communicators in the application are involved into the tuning process.

> **NOTE** To get the list of communicators available for tuning, use the Application Performance Snapshot (APS) tool, which supports per communicator profiling starting with the 2019 Update 4 release.

I_MPI_TUNING_AUTO_COMM_DEFAULT

Mark all communicators with the default value.

Syntax

I_MPI_TUNING_AUTO_COMM_DEFAULT=<*arg*>

Argument

<arg>	**Binary indicator**
enable | yes | on | 1	Mark communicators.
disable | no | off | 0	Do not mark communicators. This is the default value.

Description

Set this environment variable to mark all communicators in an application with the default value. In this case, all communicators will have the identical default comm_id equal to -1.

I_MPI_TUNING_AUTO_COMM_USER

Enable communicator marking with a user value.

Syntax

I_MPI_TUNING_AUTO_COMM_USER=<*arg*>

Argument

<arg>	**Binary indicator**

`enable | yes | on | 1`	Enable marking of communicators.
`disable | no | off | 0`	Disable marking of communicators. This is the default value.

Description

Set this environment variable to enable communicator marking with a user value. To mark a communicator in your application, use the MPI_Info object for this communicator that contains a record with the comm_id key. The key must belong the `0...UINT64_MAX range`.

I_MPI_TUNING_AUTO_ITER_POLICY

Control the iteration policy logic.

Syntax

`_MPI_TUNING_AUTO_ITER_POLICY=<arg>`

Argument

<arg>	**Binary indicator**
`enable | yes | on | 1`	Reduce the number of iterations with a message size increase after 64Kb (by half). This is the default value.
`disable | no | off | 0`	Use the `I_MPI_TUNING_AUTO_ITER_NUM value. This value affects warmup iterations.`

Description

Set this environment variable to control the autotuning iteration policy logic.

I_MPI_TUNING_AUTO_ITER_POLICY_THRESHOLD

Control the message size limit for the `I_MPI_TUNING_AUTO_ITER_POLICY` environment variable.

Syntax

`I_MPI_TUNING_AUTO_ITER_POLICY_THRESHOLD=<arg>`

Argument

<arg>	Define the value. By default, it is 64KB.

Description

Set this environment variable to control the message size limit for the autotuning iteration policy logic (`I_MPI_TUNING_AUTO_ITER_POLICY`).

I_MPI_TUNING_AUTO_POLICY

Choose the best algorithm identification strategy.

Syntax

`I_MPI_TUNING_AUTO_POLICY=<arg>`

Argument

<arg>	**Description**
`max`	Choose the best algorithm based on a maximum time value. This is the default value.
`min`	Choose the best algorithm based on a minimum time value.
`avg`	Choose the best algorithm based on an average time value.

Description

Set this environment variable to control the autotuning strategy and choose the best algorithm based on the time value across ranks involved into the tuning process.

Main Thread Pinning

Use this feature to pin a particular MPI thread to a corresponding set of CPUs within a node and avoid undesired thread migration. This feature is available on operating systems that provide the necessary kernel interfaces.

Processor Identification

The following schemes are used to identify logical processors in a system:

- System-defined logical enumeration
- Topological enumeration based on three-level hierarchical identification through triplets (package/socket, core, thread)

The number of a logical CPU is defined as the corresponding position of this CPU bit in the kernel affinity bit-mask. Use the `cpuinfo` utility, provided with your Intel MPI Library installation

The three-level hierarchical identification uses triplets that provide information about processor location and their order. The triplets are hierarchically ordered (package, core, and thread).

See the example for one possible processor numbering where there are two sockets, four cores (two cores per socket), and eight logical processors (two processors per core).

NOTE Logical and topological enumerations are not the same.

Logical Enumeration

0	4	1	5	2	6	3	7

Hierarchical Levels

Socket	0	0	0	0	1	1	1	1
Core	0	0	1	1	0	0	1	1
Thread	0	1	0	1	0	1	0	1

Topological Enumeration

0	1	2	3	4	5	6	7

Use the `cpuinfo` utility to identify the correspondence between the logical and topological enumerations. See Processor Information Utility for more details.

Default Settings

If you do not specify values for any main thread pinning environment variables, the default settings below are used. For details about these settings, see Environment Variables and Interoperability with OpenMP API.

- `I_MPI_PIN=on`
- `I_MPI_PIN_RESPECT_CPUSET=on`
- `I_MPI_PIN_RESPECT_HCA=on`
- `I_MPI_PIN_CELL=unit`
- `I_MPI_PIN_DOMAIN=auto:compact`
- `I_MPI_PIN_ORDER=bunch`

NOTE If hyperthreading is on, the number or processes on the node is greater than the number of cores and no one process pinning environment variable is set. For better performance, the "spread" order will automatically be used instead of the default "compact" order.

Environment Variables for Main Thread Pinning

I_MPI_PIN

Turn on/off main thread pinning.

Syntax

`I_MPI_PIN=<arg>`

Arguments

<arg>	Binary indicator
`enable | yes | on | 1`	Enable main thread pinning. This is the default value.
`disable | no | off | 0`	Disable main thread pinning.

Description

Set this environment variable to control the main thread pinning feature of the Intel® MPI Library.

I_MPI_PIN_PROCESSOR_LIST (I_MPI_PIN_PROCS)

Define a processor subset and the mapping rules for MPI main threads within this subset.

This environment variable is available for both Intel and non-Intel microprocessors, but it may perform additional optimizations for Intel microprocessors than it performs for non-Intel microprocessors.

Syntax Forms

`I_MPI_PIN_PROCESSOR_LIST=<value>`

The environment variable value has three syntax forms:

1. *<proclist>*
2. `[<procset> ][:[grain=<grain> ][,shift=<shift> ][,preoffset=<preoffset> ][,postoffset=<postoffset> ]`
3. `[<procset> ][:map=<map> ]`

The following paragraphs provide detailed descriptions for each of these syntax forms.

NOTE The `postoffset` keyword has `offset` alias.

NOTE The second form of the pinning procedure has three steps:

1. Circular shift of the source processor list on `preoffset*grain` value.
2. Round robin shift of the list derived on the first step on `shift*grain` value.
3. Circular shift of the list derived on the second step on the `postoffset*grain` value.

NOTE The `grain`, `shift`, `preoffset`, and `postoffset` parameters have a unified definition style.

Syntax 1: *<proclist>*

`I_MPI_PIN_PROCESSOR_LIST=<proclist>`

Arguments

<proclist>	A comma-separated list of logical processor numbers and/or ranges of processors. The main thread with the i-th rank is pinned to the i-th processor in the list. The number should not exceed the number of processors on a node.
<l>	Processor with logical number *<l>*.
<l>-<m>	Range of processors with logical numbers from *<l>* to *<m>*.
<k>,<l>-<m>	Processors *<k>*, as well as *<l>* through *<m>*.

Syntax 2: [*<procset>*][:[grain=*<grain>*][,shift=*<shift>*][,preoffset=

I_MPI_PIN_PROCESSOR_LIST=[*<procset>*][:[grain=*<grain>*][,shift=*<shift>*][,preoffset=*<preoffset>*][,postoffset=*<postoffset>*]

Arguments

<procset>	Specify a processor subset based on the topological numeration. The default value is `allcores`.
`all`	All logical processors. Specify this subset to define the number of CPUs on a node.
`allcores`	All cores (physical CPUs). Specify this subset to define the number of cores on a node. This is the default value. If Intel® Hyper-Threading Technology is disabled, `allcores` equals to `all`.
`allsocks`	All packages/sockets. Specify this subset to define the number of sockets on a node.

<grain>	Specify the pinning granularity cell for a defined *<procset>*. The minimal *<grain>*value is a single element of the *<procset>*. The maximal *<grain>* value is the number of *<procset>* elements in a socket. The *<grain>*value must be a multiple of the *<procset>* value. Otherwise, the minimal *<grain>* value is assumed. The default value is the minimal *<grain>* value.
<shift>	Specify the granularity of the round robin scheduling shift of the cells for the *<procset>*. *<shift>*is measured in the defined *<grain>*units. The *<shift>*value must be positive integer. Otherwise, no shift is performed. The default value is no shift, which is equal to `1` normal increment.
<preoffset>	Specify the circular shift of the processor subset *<procset>*defined before the round robin shifting on the *<preoffset>*value. The value is measured in the defined *<grain>*units. The *<preoffset>*value must be non-negative integer. Otherwise, no shift is performed. The default value is no shift.
<postoffset>	Specify the circular shift of the processor subset *<procset>*derived after round robin shifting on the *<postoffset>*value. The value is measured in the defined *<grain>*units. The *<postoffset>*value must be non-negative integer. Otherwise no shift is performed. The default value is no shift.

The following table displays the values for `<grain>`, `<shift>`, `<preoffset>`, and `<postoffset>` options:

<n>	Specify an explicit value of the corresponding parameters. *<n>*is non-negative integer.
`fine`	Specify the minimal value of the corresponding parameter.
`core`	Specify the parameter value equal to the amount of the corresponding parameter units contained in one core.
`cache1`	Specify the parameter value equal to the amount of the corresponding parameter units that share an L1 cache.
`cache2`	Specify the parameter value equal to the amount of the corresponding parameter units that share an L2 cache.
`cache3`	Specify the parameter value equal to the amount of the corresponding parameter units that share an L3 cache.
`cache`	The largest value among `cache1`, `cache2`, and `cache3`.
`socket` | `sock`	Specify the parameter value equal to the amount of the corresponding parameter units contained in one physical package/socket.
`half` | `mid`	Specify the parameter value equal to `socket/2`.
`third`	Specify the parameter value equal to `socket/3`.
`quarter`	Specify the parameter value equal to `socket/4`.

octavo	Specify the parameter value equal to socket/8.

Syntax 3: **[<*procset*>][:map=<*map*>]**

I_MPI_PIN_PROCESSOR_LIST=[<*procset*>][:map=<*map*>]

Arguments

<*map*>	The mapping pattern used for main thread placement.
bunch	The main threads are mapped proportionally to sockets and the threads are ordered as close as possible on the sockets.
scatter	The main threads are mapped as remotely as possible so as not to share common resources: FSB, caches, and core.
spread	The main threads are mapped consecutively with the possibility not to share common resources.

Description

Set the I_MPI_PIN_PROCESSOR_LIST environment variable to define the processor placement. To avoid conflicts with different shell versions, the environment variable value may need to be enclosed in quotes.

NOTE This environment variable is valid only if I_MPI_PIN is enabled.

The I_MPI_PIN_PROCESSOR_LIST environment variable has the following different syntax variants:

- Explicit processor list. This comma-separated list is defined in terms of logical processor numbers. The relative node rank of a main thread is an index to the processor list such that the i-th main thread is pinned on i-th list member. This permits the definition of any main thread placement on the CPUs.

  For example, main thread mapping for I_MPI_PIN_PROCESSOR_LIST=p0,p1,p2,...,pn is as follows:

Rank on a node	0	1	2	...	n-1	N
Logical CPU	p0	p1	p2	...	pn-1	Pn

- grain/shift/offset mapping. This method provides circular shift of a defined grain along the processor list with steps equal to shift*grain and a single shift on offset*grain at the end. This shifting action is repeated shift times.

  For example: grain = 2 logical processors, shift = 3 grains, offset = 0.

Legend:

gray - MPI process grains

A) red - processor grains chosen on the 1st pass

B) cyan - processor grains chosen on the 2nd pass

C) green - processor grains chosen on the final 3rd pass

D) Final map table ordered by MPI ranks

A)

0 1			2 3			...	2n-2 2n-1		
0 1	2 3	4 5	6 7	8 9	10 11	...	6n-6 6n-5	6n-4 6n-3	6n-2 6n-1

B)

0 1	2n 2n+1		2 3	2n+2 2n+3		...	2n-2 2n-1	4n-2 4n-1	
0 1	2 3	4 5	6 7	8 9	10 11	...	6n-6 6n-5	6n-4 6n-3	6n-2 6n-1

C)

0 1	2n 2n+1	4n 4n+1	2 3	2n+2 2n+3	4n+2 4n+3	...	2n-2 2n-1	4n-2 4n-1	6n-2 6n-1
0 1	2 3	4 5	6 7	8 9	10 11	...	6n-6 6n-5	6n-4 6n-3	6n-2 6n-1

D)

0 1	2 3	...	2n-2 2n-1	2n 2n+1	2n+2 2n+3	...	4n-2 4n-1	4n 4n+1	4n+2 4n+3	...	6n-2 6n-1
0 1	6 7	...	6n-6 6n-5	2 3	8 9	...	6n-4 6n-3	4 5	10 11	...	6n-2 6n-1

- Predefined mapping scenario. In this case, popular main thread pinning schemes are defined as keywords selectable at runtime. There are two such scenarios: `bunch` and `scatter`.

In the `bunch` scenario the main threads are mapped proportionally to sockets as closely as possible. This mapping makes sense for partial processor loading. In this case, the number of main threads is less than the number of processors.

In the `scatter` scenario the main threads are mapped as remotely as possible so as not to share common resources: FSB, caches, and cores.

In the example, there are two sockets, four cores per socket, one logical CPU per core, and two cores per shared cache.

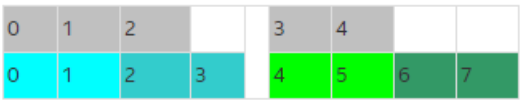
Legend:

gray - MPI processes

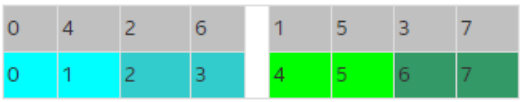
cy an - 1st socket processors

gre en - 2nd socket processors

Same color defines a processor pair sharing a cache



bunch scenario for 5 processes



scatter scenario for full loading

Examples

To pin the processes to CPU0 and CPU3 on each node globally, use the following command:

```
$ mpirun -genv I_MPI_PIN_PROCESSOR_LIST=0,3 -n <number-of-processes><executable>
```

To pin the processes to different CPUs on each node individually (CPU0 and CPU3 on host1 and CPU0, CPU1 and CPU3 on host2), use the following command:

```
$ mpirun -host host1 -env I_MPI_PIN_PROCESSOR_LIST=0,3 -n <number-of-processes> <executable> : \
-host host2 -env I_MPI_PIN_PROCESSOR_LIST=1,2,3 -n <number-of-processes> <executable>
```

To print extra debugging information about process pinning, use the following command:

```
$ mpirun -genv I_MPI_DEBUG=4 -m -host host1 \
-env I_MPI_PIN_PROCESSOR_LIST=0,3 -n <number-of-processes> <executable> :\
-host host2 -env I_MPI_PIN_PROCESSOR_LIST=1,2,3 -n <number-of-processes> <executable>
```

NOTE If the number of processes is greater than the number of CPUs used for pinning, the process list is wrapped around to the start of the processor list.

Examples

To pin the main thread to CPU0 and CPU3 on each node globally, use the following command:

```
> mpiexec -genv I_MPI_PIN_PROCESSOR_LIST=0,3 -n <number-of-main-threads><executable>
```

To pin the main thread to different CPUs on each node individually (CPU0 and CPU3 on host1 and CPU0, CPU1 and CPU3 on host2), use the following command:

```
> mpiexec -host host1 -env I_MPI_PIN_PROCESSOR_LIST=0,3 -n <number-of-main-threads>
<executable> :^
-host host2 -env I_MPI_PIN_PROCESSOR_LIST=1,2,3 -n <number-of-main-threads> <executable>
```

To print extra debug information about the main thread pinning, use the following command:

```
> mpiexec -genv I_MPI_DEBUG=4 -m -host host1 -env I_MPI_PIN_PROCESSOR_LIST=0,3 -n <number-of-
main-threads> <executable> :^
-host host2 -env I_MPI_PIN_PROCESSOR_LIST=1,2,3 -n <number-of-main-threads> <executable>
```

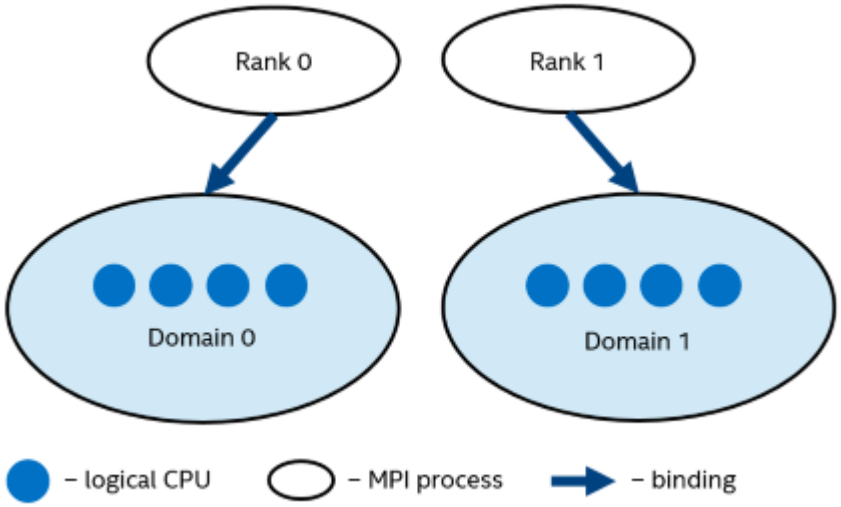
NOTE If the number of main threads is greater than the number of CPUs used for pinning, the thread list is wrapped around to the start of the processor list.

Interoperability with OpenMP* API

I_MPI_PIN_DOMAIN

Intel® MPI Library provides an additional environment variable to control main thread pinning for hybrid MPI/OpenMP* applications. This environment variable is used to define a number of non-overlapping subsets (domains) of logical processors on a node, and a set of rules on how MPI processes are bound to these domains by the following formula: *one MPI process per one domain*. See the picture below.

Figure 1 Domain Example



Each MPI process can create a number of children threads for running within the corresponding domain. The process threads can freely migrate from one logical processor to another within the particular domain.

If the `I_MPI_PIN_DOMAIN` environment variable is defined, then the `I_MPI_PIN_PROCESSOR_LIST` environment variable setting is ignored.

If the `I_MPI_PIN_DOMAIN` environment variable is not defined, then MPI main threads are pinned according to the current value of the `I_MPI_PIN_PROCESSOR_LIST` environment variable.

The `I_MPI_PIN_DOMAIN` environment variable has the following syntax forms:

- Domain description through multi-core terms *<mc-shape>*
- Domain description through domain size and domain member layout *<size>[:<layout>]*
- Explicit domain description through bit mask *<masklist>*

The following tables describe these syntax forms.

Multi-Core Shape

`I_MPI_PIN_DOMAIN=`*<mc-shape>*

<mc-shape>	Define domains through multi-core terms.
`core`	Each domain consists of the logical processors that share a particular core. The number of domains on a node is equal to the number of cores on the node.
`socket | sock`	Each domain consists of the logical processors that share a particular socket. The number of domains on a node is equal to the number of sockets on the node. This is the recommended value.

numa	Each domain consists of the logical processors that share a particular NUMA node. The number of domains on a machine is equal to the number of NUMA nodes on the machine.
node	All logical processors on a node are arranged into a single domain.
cache1	Logical processors that share a particular level 1 cache are arranged into a single domain.
cache2	Logical processors that share a particular level 2 cache are arranged into a single domain.
cache3	Logical processors that share a particular level 3 cache are arranged into a single domain.
cache	The largest domain among cache1, cache2, and cache3 is selected.

NOTE If Cluster on Die is disabled on a machine, the number of NUMA nodes equals to the number of sockets. In this case, pinning for I_MPI_PIN_DOMAIN = numa is equivalent to pinning for I_MPI_PIN_DOMAIN = socket.

Explicit Shape

I_MPI_PIN_DOMAIN=*<size>[:<layout>]*

<size>	Define a number of logical processors in each domain (domain size)
omp	The domain size is equal to the OMP_NUM_THREADS environment variable value. If the OMP_NUM_THREADS environment variable is not set, each node is treated as a separate domain.
auto	The domain size is defined by the formula size=#cpu/#proc, where #cpu is the number of logical processors on a node, and #proc is the number of the MPI processes started on a node
<n>	The domain size is defined by a positive decimal number *<n>*

<layout>	Ordering of domain members. The default value is compact
platform	Domain members are ordered according to their BIOS numbering (platform-depended numbering)
compact	Domain members are located as close to each other as possible in terms of common resources (cores, caches, sockets, and so on). This is the default value
scatter	Domain members are located as far away from each other as possible in terms of common resources (cores, caches, sockets, and so on)

Explicit Domain Mask

I_MPI_PIN_DOMAIN=*<masklist>*

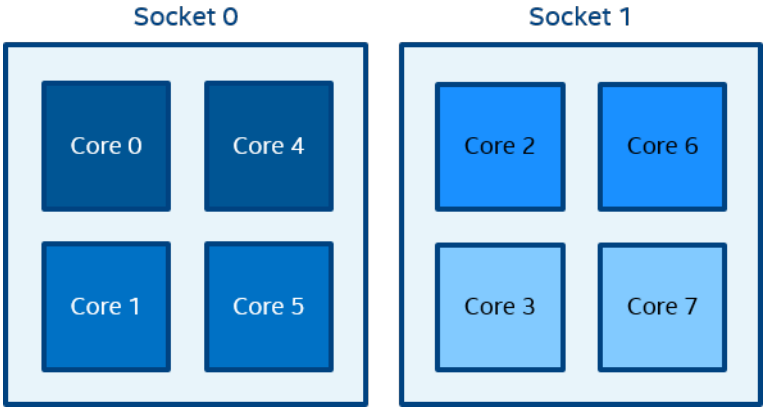
<masklist>	Define domains through the comma separated list of hexadecimal numbers (domain masks)
$[m_1,...,m_n]$	For *<masklist>*, each m_i is a hexadecimail bit mask defining an individual domain. The following rule is used: the i^{th} logical processor is included into the domain if the corresponding mi value is set to 1. All remaining processors are put into a separate domain. BIOS numbering is used.

NOTE To ensure that your configuration in `<masklist>` is parsed correctly, use square brackets to enclose the domains specified by the `<masklist>`. For example: `I_MPI_PIN_DOMAIN=[55,aa]`

NOTE These options are available for both Intel® and non-Intel microprocessors, but they may perform additional optimizations for Intel microprocessors than they perform for non-Intel microprocessors.
To pin OpenMP* processes or threads inside the domain, the corresponding OpenMP feature (for example, the `KMP_AFFINITY` environment variable for Intel® compilers) should be used.

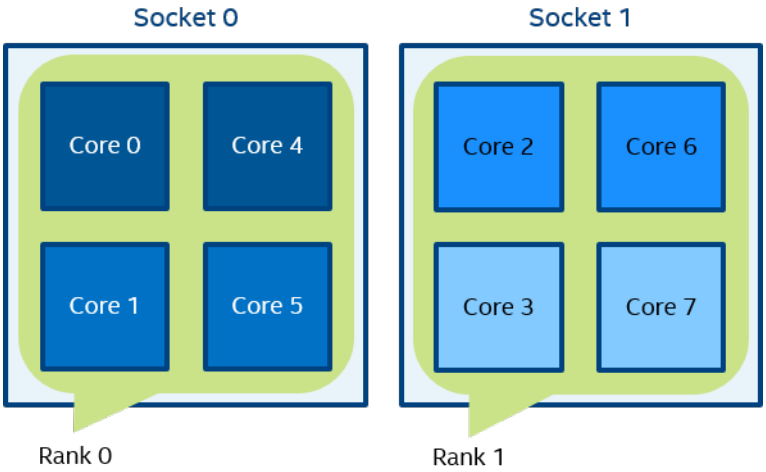
See the following model of a symmetric multiprocessing (SMP) node in the examples:

Figure 2 Model of a Node



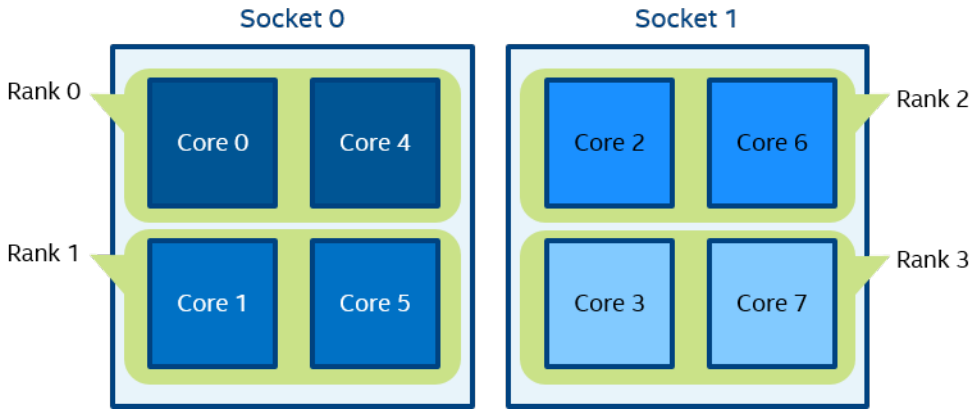
The figure above represents the SMP node model with a total of 8 cores on 2 sockets. Intel® Hyper-Threading Technology is disabled. Core pairs of the same color share the L2 cache.

Figure 3 `mpiexec -n 2 -env I_MPI_PIN_DOMAIN socket test.exe`



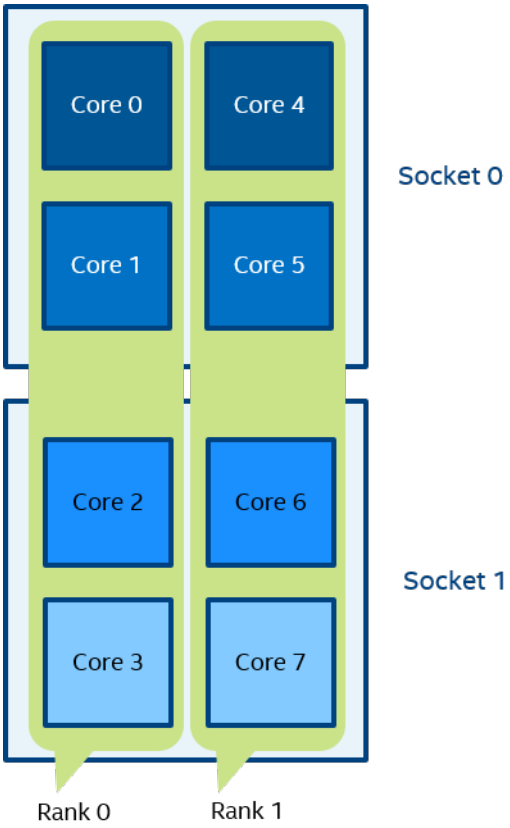
In Figure 3, two domains are defined according to the number of sockets. Process rank 0 can migrate on all cores on the 0-th socket. Process rank 1 can migrate on all cores on the first socket.

Figure 4 `mpiexec -n 4 -env I_MPI_PIN_DOMAIN cache2 test.exe`



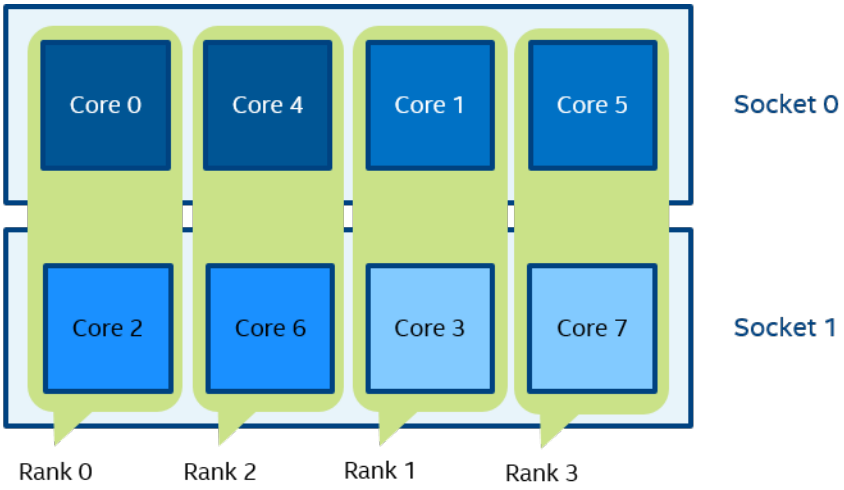
In Figure 4, four domains are defined according to the amount of common L2 caches. Process rank 0 runs on cores {0,4} that share an L2 cache. Process rank 1 runs on cores {1,5} that share an L2 cache as well, and so on.

Figure 5 `mpiexec -n 2 -env I_MPI_PIN_DOMAIN 4:platform test.exe`



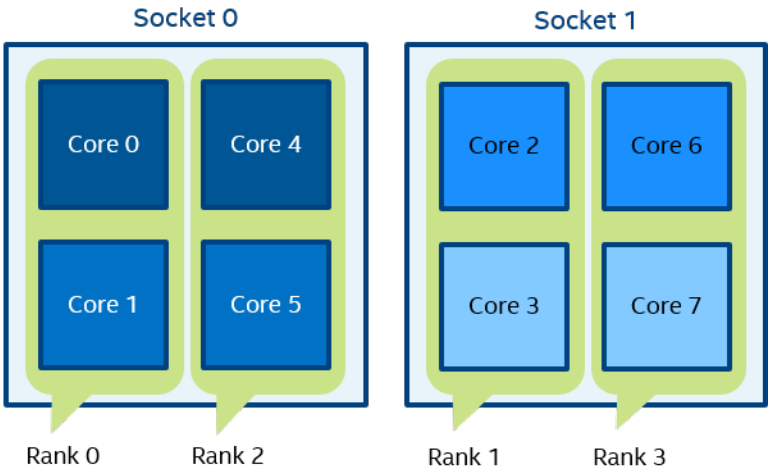
In Figure 5, two domains with size=4 are defined. The first domain contains cores {0,1,2,3}, and the second domain contains cores {4,5,6,7}. Domain members (cores) have consecutive numbering as defined by the `platform` option.

Figure 6 `mpiexec -n 4 -env I_MPI_PIN_DOMAIN auto:scatter test.exe`



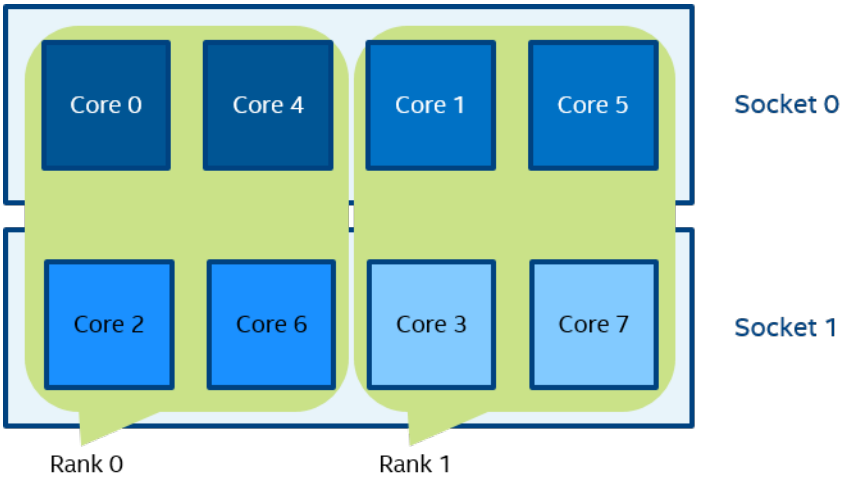
In Figure 6, domain size=2 (defined by the number of CPUs=8 / number of processes=4), `scatter` layout. Four domains {0,2}, {1,3}, {4,6}, {5,7} are defined. Domain members do not share any common resources.

Figure 7 `set OMP_NUM_THREADS=2 mpiexec -n 4 -env I_MPI_PIN_DOMAIN omp:platform test.exe`



In Figure 7, domain size=2 (defined by `OMP_NUM_THREADS=2`), `platform` layout. Four domains {0,1}, {2,3}, {4,5}, {6,7} are defined. Domain members (cores) have consecutive numbering.

Figure 8 `mpiexec -n 2 -env I_MPI_PIN_DOMAIN [55,aa] test.exe`



In Figure 8 (the example for `I_MPI_PIN_DOMAIN=<masklist>`), the first domain is defined by the 55 mask. It contains all cores with even numbers {0,2,4,6}. The second domain is defined by the AA mask. It contains all cores with odd numbers {1,3,5,7}.

I_MPI_PIN_ORDER

Set this environment variable to define the mapping order for MPI processes to domains as specified by the `I_MPI_PIN_DOMAIN` environment variable.

Syntax

`I_MPI_PIN_ORDER=<order>`

Arguments

<order>	Specify the ranking order
`range`	The domains are ordered according to the processor's BIOS numbering. This is a platform-dependent numbering.
`scatter`	The domains are ordered so that adjacent domains have minimal sharing of common resources, whenever possible.
`compact`	The domains are ordered so that adjacent domains share common resources as much as possible.
`spread`	The domains are ordered consecutively with the possibility not to share common resources.
`bunch`	The processes are mapped proportionally to sockets and the domains are ordered as close as possible on the sockets. This is the default value.

Description

The optimal setting for this environment variable is application-specific. If adjacent MPI processes prefer to share common resources, such as cores, caches, sockets, FSB, use the `compact` or `bunch` values. Otherwise, use the `scatter` or `spread` values. Use the `range` value as needed. For detail information and examples about these values, see the Arguments table and the Example section of `I_MPI_PIN_ORDER` in this topic.

The options `scatter`, `compact`, `spread` and `bunch` are available for both Intel® and non-Intel microprocessors, but they may perform additional optimizations for Intel microprocessors than they perform for non-Intel microprocessors.

Examples

For the following configuration:

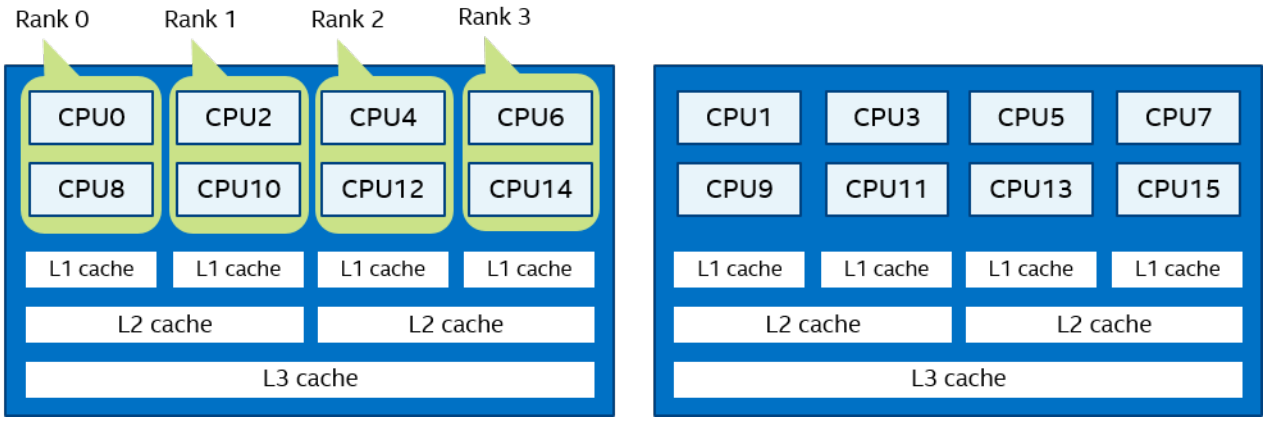
- Two socket nodes with four cores and a shared L2 cache for corresponding core pairs.

- 4 MPI processes you want to run on the node using the settings below.

Compact order:

```
I_MPI_PIN_DOMAIN=2 I_MPI_PIN_ORDER=compact
```

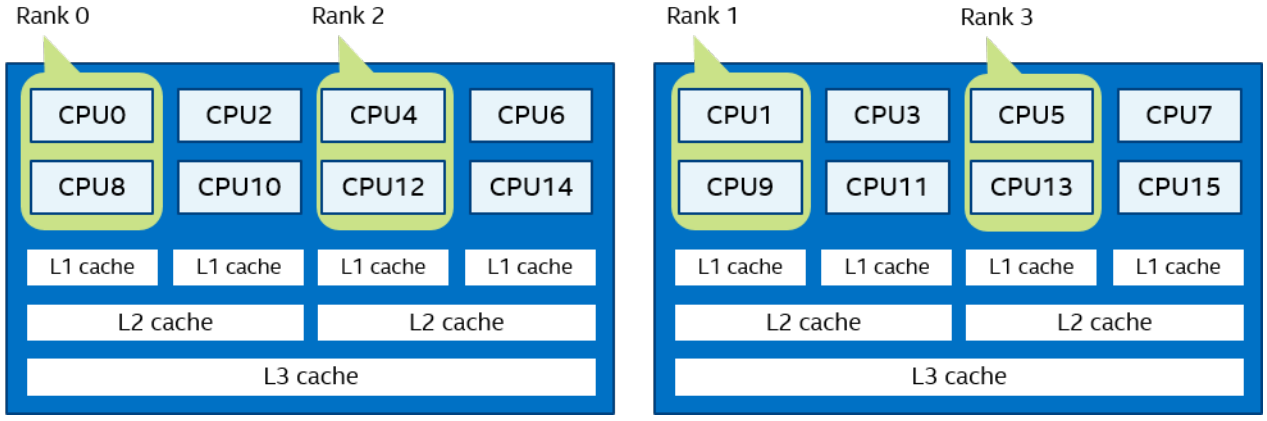
Figure 9 Compact Order Example



Scatter order:

```
I_MPI_PIN_DOMAIN=2 I_MPI_PIN_ORDER=scatter
```

Figure 10 Scatter Order Example

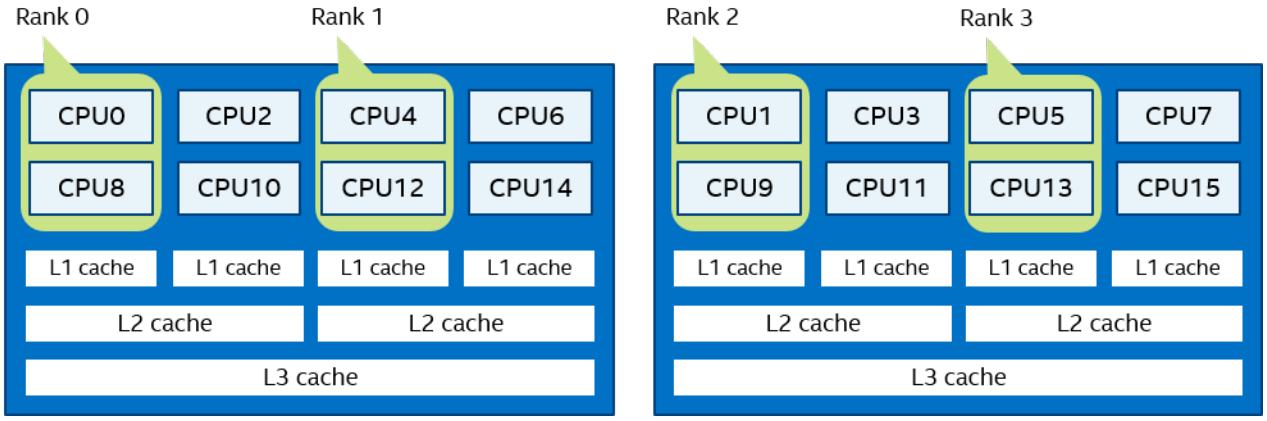


Spread order:

```
I_MPI_PIN_DOMAIN=2 I_MPI_PIN_ORDER=spread
```

> **NOTE** For I_MPI_PIN_ORDER=spread, the order will be switched to 'compact' if there are not enough CPUs to emplace all domains.

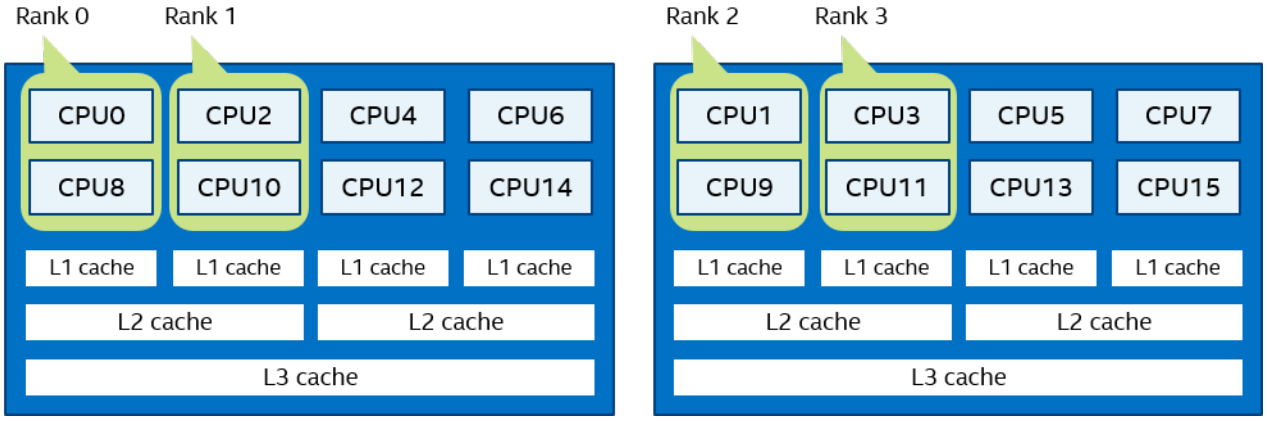
Figure 11 Spread Order Example



Bunch order:

```
I_MPI_PIN_DOMAIN=2 I_MPI_PIN_ORDER=bunch
```

Figure 12 Bunch Order Example



Environment Variables for Fabrics Control

This section provides description of the general environment variables for controlling fabrics, as well as description of variables for controlling specific fabrics:

- Communication Fabrics Control

Communication Fabrics Control

I_MPI_FABRICS

Select the particular fabrics to be used.

Syntax

```
I_MPI_FABRICS=ofi | shm
```

Arguments

<fabric>	Define a network fabric.
`shm`	Shared memory transport (used for intra-node communication only).
`ofi`	OpenFabrics Interfaces* (OFI)-capable network fabrics, such as Intel® Omni-Path Architecture, InfiniBand*, and Ethernet (through OFI API).

Description

Set this environment variable to select a specific fabric combination.

> **NOTE**
> This option is not applicable to `slurm` and `pdsh` bootstrap servers.

OFI*-capable Network Fabrics Control

I_MPI_OFI_DRECV

Control the capability of the direct receive in the OFI fabric.

Syntax

`I_MPI_OFI_DRECV=<arg>`

Arguments

<arg>	Binary indicator
`enable | yes | on | 1`	Enable direct receive. This is the default value
`disable | no | off | 0`	Disable direct receive

Description

Use the direct receive capability to block `MPI_Recv` calls only. Before using the direct receive capability, ensure that you use it for single-threaded MPI applications and check if you have selected OFI as the network fabric by setting `I_MPI_FABRICS=ofi`.

I_MPI_OFI_LIBRARY_INTERNAL

Control the usage of libfabric* shipped with the Intel® MPI Library.

Syntax

`I_MPI_OFI_LIBRARY_INTERNAL=<arg>`

Arguments

<arg>	Binary indicator
`enable | yes | on | 1`	Use libfabric from the Intel MPI Library
`disable | no | off | 0`	Do not use libfabric from the Intel MPI Library

Description

Set this environment variable to disable or enable usage of libfabric from the Intel MPI Library. The variable must be set before sourcing the `vars.bat` script.

Example

```
> set I_MPI_OFI_LIBRARY_INTERNAL=1
> call <installdir> \env\vars.bat
```

Setting this variable is equivalent to passing the `-ofi_internal` option to the `vars.bat` script.

For more information, refer to the Intel® MPI Library Developer Guide, section Libfabric* Support.

I_MPI_OFI_TAG_DYNAMIC

Enable dynamic tag partitioning.

Syntax

`I_MPI_OFI_TAG_DYNAMIC=<arg>`

Arguments

<arg>	Binary indicator
`enable | yes | on | 1`	Enable automatic OFI tag partitioning
`disable | no | off | 0`	Use static OFI tag layout. This is the default value

Description

Set this environment variable to enable dynamic OFI Netmod tag partitioning based on the run configuration. You can use it to get larger MPI tag space or to improve scalability in large-scale runs.

Environment Variables for Memory Policy Control

Intel® MPI Library supports non-uniform memory access (NUMA) nodes with high-bandwidth (HBW) memory (MCDRAM) on Intel® Xeon Phi™ processors (codenamed Knights Landing). Intel® MPI Library can attach memory of MPI processes to the memory of specific NUMA nodes. This section describes the environment variables for such memory placement control.

I_MPI_HBW_POLICY

Set the policy for MPI process memory placement for using HBW memory.

Syntax

`I_MPI_HBW_POLICY=<user memory policy>[,<mpi memory policy>][,<win_allocate policy>]`

In the syntax:

- `<user memory policy>` - memory policy used to allocate the memory for user applications (required)
- `<mpi memory policy>` - memory policy used to allocate the internal MPI memory (optional)
- `<win_allocate policy>` - memory policy used to allocate memory for window segments for RMA operations (optional)

Each of the listed policies may have the values below:

Arguments

<value>	The memory allocation policy used.
`hbw_preferred`	Allocate the local HBW memory for each process. If the HBW memory is not available, allocate the local dynamic random access memory.
`hbw_bind`	Allocate only the local HBW memory for each process.
`hbw_interleave`	Allocate the HBW memory and dynamic random access memory on the local node in the round-robin manner.

Description

Use this environment variable to specify the policy for MPI process memory placement on a machine with HBW memory.

By default, Intel MPI Library allocates memory for a process in local DDR. The use of HBW memory becomes available only when you specify the `I_MPI_HBW_POLICY` variable.

Examples

The following examples demonstrate different configurations of memory placement:

- `I_MPI_HBW_POLICY=hbw_bind,hbw_preferred,hbw_bind`

Only use the local HBW memory allocated in user applications and window segments for RMA operations. Use the local HBW memory internally allocated in Intel® MPI Library first. If the HBW memory is not available, use the local DDR internally allocated in Intel MPI Library.

- `I_MPI_HBW_POLICY=hbw_bind,,hbw_bind`

  Only use the local HBW memory allocated in user applications and window segments for RMA operations. Use the local DDR internally allocated in Intel MPI Library.
- `I_MPI_HBW_POLICY=hbw_bind,hbw_preferred`

  Only use the local HBW memory allocated in user applications. Use the local HBW memory internally allocated in Intel MPI Library first. If the HBW memory is not available, use the local DDR internally allocated in Intel MPI Library. Use the local DDR allocated in window segments for RMA operations.

I_MPI_BIND_NUMA

Set the NUMA nodes for memory allocation.

Syntax

`I_MPI_BIND_NUMA=<value>`

Arguments

<value>	Specify the NUMA nodes for memory allocation.
`localalloc`	Allocate memory on the local node. This is the default value.
`Node_1,…,Node_k`	Allocate memory according to `I_MPI_BIND_ORDER` on the specified NUMA nodes.

Description

Set this environment variable to specify the NUMA node set that is involved in the memory allocation procedure.

I_MPI_BIND_ORDER

Set this environment variable to define the memory allocation manner.

Syntax

`I_MPI_BIND_ORDER=<value>`

Arguments

<value>	Specify the allocation manner.
`compact`	Allocate memory for processes as close as possible (in terms of NUMA nodes), among the NUMA nodes specified in `I_MPI_BIND_NUMA`. This is the default value.
`scatter`	Allocate memory among the NUMA nodes specified in `I_MPI_BIND_NUMA` using the round-robin manner.

Description

Set this environment variable to define the memory allocation manner among the NUMA nodes specified in `I_MPI_BIND_NUMA`. The variable has no effect without `I_MPI_BIND_NUMA` set.

I_MPI_BIND_WIN_ALLOCATE

Set this environment variable to control memory allocation for window segments.

Syntax

`I_MPI_BIND_WIN_ALLOCATE=<value>`

Arguments

<value>	Specify the memory allocation behavior for window segments.
localalloc	Allocate memory on the local node. This is the default value.
hbw_preferred	Allocate the local HBW memory for each process. If the HBW memory is not available, allocate the local dynamic random access memory.
hbw_bind	Allocate only the local HBW memory for each process.
hbw_interleave	Allocate the HBW memory and dynamic random access memory on a local node in the round-robin manner.
<NUMA node id>	Allocate memory on the given NUMA node.

Description

Set this environment variable to create window segments allocated in HBW memory with the help of the `MPI_Win_allocate_shared` or `MPI_Win_allocate` functions.

MPI_Info

You can control memory allocation for window segments with the help of an `MPI_Info` object, which is passed as a parameter to the `MPI_Win_allocate` or `MPI_Win_allocate_shared` function. In an application, if you specify such an object with the `numa_bind_policy` key, window segments are allocated in accordance with the value for `numa_bind_policy`. Possible values are the same as for `I_MPI_BIND_WIN_ALLOCATE`.

A code fragment demonstrating the use of `MPI_Info`:

```
MPI_Info info;
...
MPI_Info_create( &info );
MPI_Info_set( info, "numa_bind_policy", "hbw_preferred" );
...
MPI_Win_allocate_shared( size, disp_unit, info, comm, &baseptr, &win );
```

NOTE
When you specify the memory placement policy for window segments, Intel MPI Library recognizes the configurations according to the following priority:

1. Setting of `MPI_Info`.
2. Setting of `I_MPI_HBW_POLICY`, if you specified `<win_allocate policy>`.
3. Setting of `I_MPI_BIND_WIN_ALLOCATE`.

Other Environment Variables

I_MPI_DEBUG

Print out debugging information when an MPI program starts running.

Syntax

`I_MPI_DEBUG=<level>[,<flags>]`

Arguments

<level>	Indicate the level of debug information provided.
0	Output no debugging information. This is the default value.

1	Output libfabric* version and provider.
2	Output information about the tuning file used.
3	Output effective MPI rank, pid and node mapping table.
4	Output process pinning information.
5	Output environment variables specific to the Intel® MPI Library.
> 5	Add extra levels of debug information.

<*flags*>	Comma-separated list of debug flags
pid	Show process id for each debug message.
tid	Show thread id for each debug message for multithreaded library.
time	Show time for each debug message.
datetime	Show time and date for each debug message.
host	Show host name for each debug message.
level	Show level for each debug message.
scope	Show scope for each debug message.
line	Show source line number for each debug message.
file	Show source file name for each debug message.
nofunc	Do not show routine name.
norank	Do not show rank.
nousrwarn	Suppress warnings for improper use case (for example, incompatible combination of controls).
flock	Synchronize debug output from different process or threads.
nobuf	Do not use buffered I/O for debug output.

Description

Set this environment variable to print debugging information about the application.

> **NOTE** Set the same <*level*> value for all ranks.

You can specify the output file name for debug information by setting the I_MPI_DEBUG_OUTPUT environment variable.

Each printed line has the following format:

[<*identifier*>] <*message*>

where:

- <*identifier*> is the MPI process rank, by default. If you add the '+' sign in front of the <*level*> number, the <*identifier*> assumes the following format: rank#pid@hostname. Here, rank is the MPI process rank, pid is the process ID, and hostname is the host name. If you add the '–' sign, <*identifier*> is not printed at all.
- <*message*> contains the debugging output.

The following examples demonstrate possible command lines with the corresponding output:

```
> mpiexec -n 1 -env I_MPI_DEBUG=2 test.exe
...
[0] MPI startup(): shared memory data transfer mode
```

The following commands are equal and produce the same output:

```
> mpiexec -n 1 -env I_MPI_DEBUG=2,pid,host test.exe
...
[0#1986@mpicluster001] MPI startup(): shared memory data transfer mode
```

NOTE Compiling with the `/Zi`, `/ZI`, or `/Z7` option adds a considerable amount of printed debug information.

I_MPI_DEBUG_OUTPUT

Set output file name for debug information.

Syntax

`I_MPI_DEBUG_OUTPUT=<arg>`

Arguments

Argument	String Value
`stdout`	Output to `stdout`. This is the default value.
`stderr`	Output to `stderr`.
`<file_name>`	Specify the output file name for debug information (the maximum file name length is 256 symbols).

Description

Set this environment variable if you want to split output of debug information from the output produced by an application. If you use format like `%r`, `%p` or `%h`, rank, process ID or host name is added to the file name accordingly.

I_MPI_DEBUG_COREDUMP

Controls core dump files generation in case of failure during MPI application execution.

Syntax

`I_MPI_DEBUG_COREDUMP=<arg>`

Arguments

Argument	Binary Indicator
`enable|yes|on|1`	Enable coredump files generation.
`disable|no|off|0`	Do not generate coredump files. Default value.

Description

Set this environment variable to enable coredump files dumping in case of termination caused by segmentation fault. Available for both release and debug builds.

I_MPI_PMI_VALUE_LENGTH_MAX

Control the length of the value buffer in PMI on the client side.

Syntax

`I_MPI_PMI_VALUE_LENGTH_MAX=<length>`

Arguments

`<length>`	Define the value of the buffer length in bytes.
`<n> > 0`	The default value is -1, which means do not override the value received from the `PMI_KVS_Get_value_length_max()` function.

Description

Set this environment variable to control the length of the value buffer in PMI on the client side. The length of the buffer will be the lesser of `I_MPI_PMI_VALUE_LENGTH_MAX` and `PMI_KVS_Get_value_length_max()`.

I_MPI_REMOVED_VAR_WARNING

Print out a warning if a removed environment variable is set.

Syntax

`I_MPI_REMOVED_VAR_WARNING=<arg>`

Arguments

Argument	Binary Indicator
`enable | yes | on | 1`	Print out the warning. This is the default value
`disable | no | off | 0`	Do not print the warning

Description

Use this environment variable to print out a warning if a removed environment variable is set. Warnings are printed regardless of whether `I_MPI_DEBUG is set`.

I_MPI_VAR_CHECK_SPELLING

Print out a warning if an unknown environment variable is set.

Syntax

`I_MPI_VAR_CHECK_SPELLING=<arg>`

Arguments

Argument	Binary Indicator
`enable | yes | on | 1`	Print out the warning. This is the default value
`disable | no | off | 0`	Do not print the warning

Description

Use this environment variable to print out a warning if an unsupported environment variable is set. Warnings are printed in case of removed or misprinted environment variables.

I_MPI_LIBRARY_KIND

Specify the Intel® MPI Library configuration.

Syntax

`I_MPI_LIBRARY_KIND=<value>`

Arguments

Value	Description
`release`	Multi-threaded optimized library. This is the default value
`debug`	Multi-threaded debug library

Description

Use this variable to set an argument for the `vars. bat`script. This script establishes the Intel® MPI Library environment and enables you to specify the appropriate library configuration. To ensure that the desired configuration is set, check the `LD_LIBRARY_PATH` variable.

Example

```
> export I_MPI_LIBRARY_KIND=debug
```

Setting this variable is equivalent to passing an argument directly to the `vars.[c]sh` script:

Example

```
> <installdir> \env\vars.bat release
```

I_MPI_PLATFORM

Select the intended optimization platform.

Syntax

`I_MPI_PLATFORM=`*`<platform>`*

Arguments

`<platform>`	Intended optimization platform (string value)
`auto`	Use only with heterogeneous runs to determine the appropriate platform across all nodes. May slow down MPI initialization time due to collective operation across all nodes.
`ivb`	Optimize for the Intel® Xeon® Processors E3, E5, and E7 V2 series and other Intel® Architecture processors formerly code named Ivy Bridge.
`hsw`	Optimize for the Intel Xeon Processors E3, E5, and E7 V3 series and other Intel® Architecture processors formerly code named Haswell.
`bdw`	Optimize for the Intel Xeon Processors E3, E5, and E7 V4 series and other Intel Architecture processors formerly code named Broadwell.
`knl`	Optimize for the Intel® Xeon Phi™ processor and coprocessor formerly code named Knights Landing.
`skx`	Optimize for the Intel Xeon Processors E3 V5 and Intel Xeon Scalable Family series, and other Intel Architecture processors formerly code named Skylake.
`clx`	Optimize for the 2nd Generation Intel Xeon Scalable Processors, and other Intel® Architecture processors formerly code named Cascade Lake.
`clx-ap`	Optimize for the 2nd Generation Intel Xeon Scalable Processors, and other Intel Architecture processors formerly code named Cascade Lake AP Note: The explicit `clx-ap` setting is ignored if the actual platform is not Intel.

Description

Set this environment variable to use the predefined platform settings. The default value is a local platform for each node.

The variable is available for both Intel and non-Intel microprocessors, but it may utilize additional optimizations for Intel microprocessors than it utilizes for non-Intel microprocessors.

NOTE The values `auto[:min]`, `auto:max`, and `auto:most` may increase the MPI job startup time.

I_MPI_MALLOC

Control the Intel® MPI Library custom allocator of private memory.

Syntax

`I_MPI_MALLOC=<arg>`

Argument

Argument	Binary Indicator
1	Enable the Intel MPI Library custom allocator of private memory. Use the Intel MPI custom allocator of private memory for `MPI_Alloc_mem/MPI_Free_mem`.
0	Disable the Intel MPI Library custom allocator of private memory. Use the system-provided memory allocator for `MPI_Alloc_mem/MPI_Free_mem`.

Description

Use this environment variable to enable or disable the Intel MPI Library custom allocator of private memory for `MPI_Alloc_mem/MPI_Free_mem`.

By default, `I_MPI_MALLOC` is enabled if `I_MPI_ASYNC_PROGRESS` and `I_MPI_THREAD_SPLIT` are disabled.

> **NOTE** If the platform is not supported by the Intel MPI Library custom allocator of private memory, a system-provided memory allocator is used and the `I_MPI_MALLOC` variable is ignored.

I_MPI_WAIT_MODE

Control the Intel® MPI Library optimization for oversubscription mode.

Syntax

`I_MPI_WAIT_MODE=<arg>`

Arguments

Argument	Binary Indicator
0	Optimize MPI application to work in the normal mode (1 rank on 1 CPU). This is the default value if the number of processes on a computation node is less than or equal to the number of CPUs on the node.
1	Optimize MPI application to work in the oversubscription mode (multiple ranks on 1 CPU). This is the default value if the number of processes on a computation node is greater than the number of CPUs on the node.

Description

It is recommended to use this variable in the oversubscription mode.

I_MPI_THREAD_YIELD

Control the Intel® MPI Library thread yield customization during MPI busy wait time.

Syntax

`I_MPI_THREAD_YIELD=<arg>`

Arguments

Argument	Description
0	Do nothing for thread yield during the busy wait (spin wait). This is the default value when I_MPI_WAIT_MODE=0
1	Do the pause processor instruction for I_MPI_PAUSE_COUNT during the busy wait.
2	Do the SwitchToThread() system call for thread yield during the busy wait. This is the default value when I_MPI_WAIT_MODE=1
3	Do the Sleep() system call for I_MPI_THREAD_SLEEP number of milliseconds for thread yield during the busy wait.

Description

I_MPI_THREAD_YIELD=0 or I_MPI_THREAD_YIELD=1 in the normal mode and I_MPI_THREAD_YIELD=2 or I_MPI_THREAD_YIELD=3 in the oversubscription mode.

I_MPI_PAUSE_COUNT

Control the Intel® MPI Library pause count for the thread yield customization during MPI busy wait time.

Syntax

I_MPI_PAUSE_COUNT=*<arg>*

Argument

Argument	Description
>=0	Pause count for thread yield customization during MPI busy wait time. The default value is 0. Normally, the value is less than 100.

Description

This variable is applicable when I_MPI_THREAD_YIELD=1. Small values of I_MPI_PAUSE_COUNT may increase performance, while larger values may reduce energy consumption.

I_MPI_SPIN_COUNT

Control the spin count value.

Syntax

I_MPI_SPIN_COUNT=*<scount>*

Argument

<scount>	Define the loop spin count when polling fabric(s).
>=0	The default <scount> value is equal to 1 when more than one process runs per processor/core. Otherwise the value equals 2000. The maximum value is equal to 2147483647.

Description

Set the spin count limit. The loop for polling the fabric(s) spins *<scount>* times before the library releases the processes if no incoming messages are received for processing. Smaller values for *<scount>* cause the Intel® MPI Library to release the processor more frequently.

Use the `I_MPI_SPIN_COUNT` environment variable for tuning application performance. The best value for *<scount>* can be chosen on an experimental basis. It depends on the particular computational environment and application.

I_MPI_THREAD_SLEEP

Control the Intel® MPI Library thread sleep milliseconds timeout for thread yield customization while MPI busy wait progress.

Syntax

`I_MPI_THREAD_SLEEP=<arg>`

Argument

Argument	Description
`>=0`	Thread sleep microseconds timeout. The default value is 0. Normally, the value is less than 100.

Description

This variable is applicable when `I_MPI_THREAD_YIELD=3`. Small values of `I_MPI_PAUSE_COUNT` may increase performance in the normal mode, while larger values may increase performance in the oversubscription mode

I_MPI_EXTRA_FILESYSTEM

Control native support for parallel file systems.

Syntax

`I_MPI_EXTRA_FILESYSTEM=<arg>`

Argument

Argument	Binary Indicator
`enable | yes | on | 1`	Enable native support for parallel file systems.
`disable | no | off | 0`	Disable native support for parallel file systems. This is the default value.

Description

Use this environment variable to enable or disable native support for parallel file systems.

I_MPI_EXTRA_FILESYSTEM_FORCE

Syntax

`I_MPI_EXTRA_FILESYSTEM_FORCE=<ufs|nfs|gpfs|panfs|lustre>`

Description

Force filesystem recognition logic. Setting this variable is equivalent to prefixing all paths in MPI-IO calls with the selected filesystem plus colon.

I_MPI_MULTIRAIL

Syntax

`I_MPI_MULTIRAIL=<arg>`

Argument

Argument	Binary Indicator
`1`	Enable multi-rail capability.

0	Disable multi-rail capability. This is the default value.

Description

Set this variable to enable multi-rail capability and identify NICs serviced by the provider. Pick this variable on the same NUMA.

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