IBM Parallel Environment for AIX 5L

MPI Programming Guide

Version 4 Release 3.0

SA22-7945-05

IBM Parallel Environment for AIX 5L

MPI Programming Guide

Version 4 Release 3.0

SA22-7945-05

Note
Before using this information and the product it supports, read the information in “Notices” on page 211.

Sixth Edition (October 2006)

| This edition applies to version 4, release 3, modification 0 of IBM Parallel Environment for AIX 5L (product number
| 5765-F83) and to all subsequent releases and modifications until otherwise indicated in new editions. This edition replaces SA22-7945-04. Significant changes or additions to the text and illustrations are indicated by a vertical line (|) to the left of the change.

Order publications through your IBM representative or the IBM branch office serving your locality. Publications are not stocked at the address given below.

IBM welcomes your comments. A form for your comments appears at the back of this publication. If the form has been removed, address your comments to:

IBM Corporation, Department 55JA, Mail Station P384
2455 South Road
Poughkeepsie, NY 12601-5400
United States of America

FAX (United States and Canada): 1+845+432-9405
FAX (Other Countries) Your International Access Code +1+845+432-9405

IBMLink (United States customers only): IBMUSM10(MHVRCFS)
Internet: mhvrcfs@us.ibm.com

If you would like a reply, be sure to include your name, address, telephone number, or FAX number.

Make sure to include the following in your comment or note:

- Title and order number of this book
- Page number or topic related to your comment

When you send information to IBM, you grant IBM a nonexclusive right to use or distribute the information in any way it believes appropriate without incurring any obligation to you.

Contents

Tables vii

About this book ix
Who should read this book ix
How this book is organized ix
Conventions and terminology used in this book x
Abbreviated names x
Prerequisite and related information xi
Using LookAt to look up message explanations xii
How to send your comments xii
National language support (NLS) xii
Summary of changes for Parallel Environment 4.3 xiii

Chapter 1. Performance Considerations for the MPI Library 1
Message transport mechanism considerations 1
Shared memory considerations 2
MPI IP performance considerations 2
User Space considerations 3
MPI point-to-point communication considerations 3
Eager messages 3
Rendezvous messages 5
Polling and single thread considerations 6
LAPI send side copy considerations 7
Striping considerations 8
Remote Direct Memory Access (RDMA) considerations 9
Other considerations 9

Chapter 2. Profiling message passing 11

Chapter 3. Using shared memory 15
Shared memory performance considerations 15
Reclaiming shared memory 16
Using POE with multiple Ethernet adapters and shared memory 16

Chapter 4. Performing parallel I/O with MPI 19
Features of MPI-IO 19
Considerations for MPI-IO 20
MPI-IO API user tasks 20
Working with files 20
Error handling 22
Working with Info objects 23
Using data type constructors 23
Setting the size of the data buffer 23
MPI-IO file interoperability 24

Chapter 5. Programming considerations for user applications in POE 25
The MPI library 25
Parallel Operating Environment overview 25
POE user limits 26
Exit status 26
POE job step function 27
POE additions to the user executable 27
Signal handlers 28

Handling signals 28
Do not hard code file descriptor numbers 29
Termination of a parallel job 29
Do not run your program as root 30
AIX function limitations 30
Shell execution 30
Do not rewind STDIN, STDOUT, or STDERR 30
Do not match blocking and nonblocking collectives 30
Passing string arguments to your program correctly 31
POE argument limits 31
Network tuning considerations 31
Standard I/O requires special attention 32
Reserved environment variables 33
Message catalog considerations 33
Language bindings 33
Available virtual memory segments 34
Using a switch clock as a time source 34
Running applications with large numbers of tasks 35
Running POE with MALLOCDEBUG 35
Threaded programming 35
Running single threaded applications 36
POE gets control first and handles task initialization 36
Limitations in setting the thread stack size 36
Forks are limited 37
Threadsafe libraries 37
Program and thread termination 37
Order requirement for system includes 37
Using MPI_INIT or MPI_INIT_THREAD 37
Collective communication calls 38
Support for M:N threads 38
Checkpoint and restart limitations 38
64-bit application considerations 42
MPI_WAIT_MODE: the nopoll option 43
Mixed parallelism with MPI and threads 43
Using MPI and LAPI in the same program 44
Differences between MPI in PE 3.2 and PE Version 4 44
Differences between MPI in PE 4.1 and PE 4.2 45
Other differences 45
MPI Stack Threads 45

Chapter 6. Using error handlers - predefined error handler for C++ 47

Chapter 7. Predefined MPI data types 49
Special purpose data types 49
Data types for C language bindings 49
Data types for FORTRAN language bindings 49
Data types for reduction functions (C reduction types) 50
Data types for reduction functions (FORTRAN reduction types) 50

Chapter 8. MPI reduction operations 53
Examples of MPI reduction operations 55

Chapter 9. C++ MPI constants 57
Error classes 57
Maximum sizes 58
Environment inquiry keys 58

Predefined attribute keys . . . 58
Results of communicator and group comparisons . . . 59
Topologies . . . 59
File operation constants . . . 59
MPI-IO constants . . . 59
One-sided constants . . . 59
Combiner constants used for data type decoding functions . . . 59
Assorted constants . . . 60
Collective constants . . . 60
Error handling specifiers . . . 60
Special data types for construction of derived data types . . . 60
Elementary data types (C and C++) . . . 60
Elementary data types (FORTRAN) . . . 61
Data types for reduction functions (C and C++) . . . 61
Data types for reduction functions (FORTRAN) . . . 61
Optional data types . . . 61
Collective operations . . . 61
Null handles . . . 62
Empty group . . . 62
Threads constants . . . 62
FORTRAN 90 data type matching constants . . . 62

Chapter 10. MPI size limits . . . 63
System limits . . . 63
Maximum number of tasks and tasks per node . . . 65

Chapter 11. Parallel utility subroutines . . . 67
mpc_isatty . . . 69
MP_BANDWIDTH, mpc_bandwidth . . . 71
MP_DISABLEINTR, mpc_disableintr . . . 76
MP_ENABLEINTR, mpc_enableintr . . . 79
MP_FLUSH, mpc_flush . . . 82
MP_INIT_CKPT, mpc_init_ckpt . . . 84
MP_QUERYINTR, mpc_queryintr . . . 86
MP_SET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks . . . 89
MP_STATISTICS_WRITE, mpc_statistics_write . . . 92
MP_STATISTICS_ZERO, mpc_statistics_zero . . . 95
MP_STDOUT_MODE, mpc_stdout_mode . . . 96
MP_STDOUTMODE_QUERY, mpc_stdoutmode_query . . . 99
MP_UNSET_CKPT_CALLBACKS, mpc_unset_ckpt_callbacks . . . 101
pe_dbg_breakpoint . . . 103
pe_dbg_checkpnt . . . 109
pe_dbg_checkpnt_wait . . . 113
pe_dbg_getcrid . . . 115
pe_dbg_getrtid . . . 116
pe_dbg_getvtid . . . 117
pe_dbg_read_cr_errfile . . . 118
pe_dbg_restart . . . 119

Chapter 12. Parallel task identification API subroutines . . . 123
poe_master_tasks . . . 124
poe_task_info . . . 125

Appendix A. MPE subroutine summary . . . 127

Appendix B. MPE subroutine bindings . . . 129

Bindings for nonblocking collective communication 129

Appendix C. MPI subroutine and function summary 133
Subroutines for collective communication 133
Subroutines for communicators 134
Subroutines for conversion functions 136
Subroutines for derived data types 137
Subroutines for environment management 140
Subroutines for external interfaces 141
Subroutines for group management 142
Subroutines for Info objects 143
Subroutines for memory allocation 143
Subroutines for MPI-IO 144
Subroutines for MPI_Status objects 147
Subroutines for one-sided communication 147
Subroutines for point-to-point communication 148
Subroutines for profiling control 150
Subroutines for Topologies 150

Appendix D. MPI subroutine bindings 153
Bindings for collective communication 153
Bindings for communicators 157
Bindings for conversion functions 161
Bindings for derived data types 162
Bindings for environment management 171
Bindings for external interfaces 173
Bindings for group management 176
Bindings for Info objects 178
Bindings for memory allocation 179
Bindings for MPI-IO 180
Bindings for MPI_Status objects 190
Bindings for one-sided communication 190
Bindings for point-to-point communication 194
Binding for profiling control 201
Bindings for topologies 201

Appendix E. PE MPI buffer management for eager protocol 205

Appendix F. Accessibility features for PE 209
Accessibility features 209
Keyboard navigation 209
IBM and accessibility 209

Notices 211
Trademarks 213
Acknowledgments 214

Glossary 215

Index 223

Tables

1. Typographic conventions x
2. How the clock source is determined 34
3. MPI eager limits 64
4. Task limits for parallel jobs 65

About this book

This book provides information about parallel programming, as it relates to IBM®'s implementation of the Message Passing Interface (MPI) standard for IBM Parallel Environment for AIX 5L™ (5765-F83). References to RS/6000® SP™ or SP include currently supported IBM eServer™ Cluster 1600 hardware. To make this book a little easier to read, the name *IBM Parallel Environment* has been abbreviated to *PE* throughout.

All implemented function in the PE MPI product is designed to comply with the requirements of the Message Passing Interface Forum, *MPI: A Message-Passing Interface Standard, Version 1.1*, University of Tennessee, Knoxville, Tennessee, June 6, 1995 and *MPI-2: Extensions to the Message-Passing Interface*, University of Tennessee, Knoxville, Tennessee, July 18, 1997. The second volume includes a section identified as MPI 1.2, with clarifications and limited enhancements to MPI 1.1. It also contains the extensions identified as MPI 2.0. The three sections, MPI 1.1, MPI 1.2, and MPI 2.0 taken together constitute the current standard for MPI.

PE MPI provides support for all of MPI 1.1 and MPI 1.2. PE MPI also provides support for all of the MPI 2.0 enhancements, except the contents of the chapter titled ″Process creation and management.″

If you believe that PE MPI does not comply, in any way, with the MPI standard for the portions that are implemented, please contact IBM service.

Who should read this book

This book is intended for experienced programmers who want to write parallel applications using the C, C++, or FORTRAN programming language. Readers of this book should know C , C++, or FORTRAN and should be familiar with AIX® and UNIX® commands, file formats, and special files. They should also be familiar with the MPI concepts. In addition, readers should be familiar with distributed-memory machines.

How this book is organized

This book is organized as follows:

- Chapter 1, “Performance Considerations for the MPI Library,” on page 1.
- Chapter 2, “Profiling message passing,” on page 11.
- Chapter 3, “Using shared memory,” on page 15.
- Chapter 4, “Performing parallel I/O with MPI,” on page 19.
- Chapter 5, “Programming considerations for user applications in POE,” on page 25.
- Chapter 6, “Using error handlers - predefined error handler for C++,” on page 47.
- Chapter 7, “Predefined MPI data types,” on page 49.
- Chapter 8, “MPI reduction operations,” on page 53.
- Chapter 9, “C++ MPI constants,” on page 57.
- Chapter 10, “MPI size limits,” on page 63.
- Chapter 11, “Parallel utility subroutines,” on page 67.
- Chapter 12, “Parallel task identification API subroutines,” on page 123.
- Appendix A, “MPE subroutine summary,” on page 127.

- Appendix B, “MPE subroutine bindings,” on page 129.
- Appendix C, “MPI subroutine and function summary,” on page 133.
- Appendix D, “MPI subroutine bindings,” on page 153.
- Appendix E, “PE MPI buffer management for eager protocol,” on page 205.

Conventions and terminology used in this book

Note that in this document, LoadLeveler®® is also referred to as *Tivoli® Workload Scheduler LoadLeveler* and *TWS LoadLeveler*.

This book uses the following typographic conventions:

Table 1. Typographic conventions

Convention	Usage
bold	**Bold** words or characters represent system elements that you must use literally, such as: command names, file names, flag names, path names, PE component names (**poe**, for example), and subroutines.
`constant width`	Examples and information that the system displays appear in `constant-width` typeface.
italic	*Italicized* words or characters represent variable values that you must supply. *Italics* are also used for book titles, for the first use of a glossary term, and for general emphasis in text.
[item]	Used to indicate optional items.
<Key>	Used to indicate keys you press.
\	The continuation character is used in coding examples in this book for formatting purposes.

In addition to the highlighting conventions, this manual uses the following conventions when describing how to perform tasks.

User actions appear in uppercase boldface type. For example, if the action is to enter the **tool** command, this manual presents the instruction as:

ENTER
tool

Abbreviated names

Some of the abbreviated names used in this book follow.

AIX Advanced Interactive Executive

CSM Clusters Systems Management

CSS communication subsystem

CTSEC cluster-based security

DPCL dynamic probe class library

dsh distributed shell

GUI graphical user interface

HDF Hierarchical Data Format

IP	Internet Protocol
LAPI	Low-level Application Programming Interface
MPI	Message Passing Interface
NetCDF	Network Common Data Format
PCT	Performance Collection Tool
PE	IBM® Parallel Environment for AIX®
PE MPI	IBM's implementation of the MPI standard for PE
PE MPI-IO	IBM's implementation of MPI I/O for PE
POE	parallel operating environment
pSeries®	IBM eServer pSeries
PVT	Profile Visualization Tool
RISC	reduced instruction set computer
RSCT	Reliable Scalable Cluster Technology
rsh	remote shell
STDERR	standard error
STDIN	standard input
STDOUT	standard output
UTE	Unified Trace Environment
System x	IBM System x

Prerequisite and related information

The Parallel Environment for AIX library consists of:

- IBM Parallel Environment: Introduction, SA22-7947
- IBM Parallel Environment: Installation, GA22-7943
- IBM Parallel Environment: Operation and Use, Volume 1, SA22-7948
- IBM Parallel Environment: Operation and Use, Volume 2, SA22-7949
- IBM Parallel Environment: MPI Programming Guide, SA22-7945
- IBM Parallel Environment: MPI Subroutine Reference, SA22-7946
- IBM Parallel Environment: Messages, GA22-7944

To access the most recent Parallel Environment documentation in PDF and HTML format, refer to the IBM eServer Cluster Information Center on the Web at:

http://publib.boulder.ibm.com/infocenter/clresctr/vxrx/index.jsp

Both the current Parallel Environment books and earlier versions of the library are also available in PDF format from the IBM Publications Center Web site located at:

http://www.ibm.com/shop/publications/order/

It is easiest to locate a book in the IBM Publications Center by supplying the book's publication number. The publication number for each of the Parallel Environment books is listed after the book title in the preceding list.

Using LookAt to look up message explanations

LookAt is an online facility that lets you look up explanations for most of the IBM messages you encounter, as well as for some system abends and codes. You can use LookAt from the following locations to find IBM message explanations for Clusters for AIX:

- The Internet. You can access IBM message explanations directly from the LookAt Web site:

  http://www.ibm.com/eserver/zseries/zos/bkserv/lookat/
- Your wireless handheld device. You can use the LookAt Mobile Edition with a handheld device that has wireless access and an Internet browser (for example, Internet Explorer for Pocket PCs, Blazer, or Eudora for Palm OS, or Opera for Linux® handheld devices). Link to the LookAt Mobile Edition from the LookAt Web site.

How to send your comments

Your feedback is important in helping to provide the most accurate and high-quality information. If you have comments about this book or other PE documentation:

- Send your comments by e-mail to: mhvrcfs@us.ibm.com

  Be sure to include the name of the book, the part number of the book, the version of PE, and, if applicable, the specific location of the text you are commenting on (for example, a page number or table number).
- Fill out one of the forms at the back of this book and return it by mail, by fax, or by giving it to an IBM representative.

National language support (NLS)

For national language support (NLS), all PE components and tools display messages that are located in externalized message catalogs. English versions of the message catalogs are shipped with the PE licensed program, but your site may be using its own translated message catalogs. The PE components use the AIX environment variable **NLSPATH** to find the appropriate message catalog. **NLSPATH** specifies a list of directories to search for message catalogs. The directories are searched, in the order listed, to locate the message catalog. In resolving the path to the message catalog, **NLSPATH** is affected by the values of the environment variables **LC_MESSAGES** and **LANG**. If you get an error saying that a message catalog is not found and you want the default message catalog:

ENTER

```
export NLSPATH=/usr/lib/nls/msg/%L/%N

export LANG=C
```

The PE message catalogs are in English, and are located in the following directories:

/usr/lib/nls/msg/C

/usr/lib/nls/msg/En_US

/usr/lib/nls/msg/en_US

If your site is using its own translations of the message catalogs, consult your system administrator for the appropriate value of **NLSPATH** or **LANG**. For more information on NLS and message catalogs, see *AIX: General Programming Concepts: Writing and Debugging Programs*.

Summary of changes for Parallel Environment 4.3

This release of IBM Parallel Environment for AIX contains a number of functional enhancements, including:

- PE 4.3 supports only AIX 5L Version 5.3 Technology Level 5300-05, or later versions.

  AIX 5L Version 5.3 Technology Level 5300-05 is referred to as AIX 5L V5.3 TL 5300-05 or AIX 5.3.
- Support for Parallel Systems Support Programs for AIX (PSSP), the SP Switch2, POWER3™ servers, DCE, and DFS™ has been removed. PE 4.2 is the **last** release that supported these products.
- PE Benchmarker support for IBM System p5™ model 575 has been added.
- A new environment variable, **MP_TLP_REQUIRED** is available to detect the situation where a parallel job that should be using large memory pages is attempting to run with small pages.
- A new command, **rset_query**, for verifying that memory affinity assignments have been performed.
- Performance of MPI one-sided communication has been substantially improved.
- Performance improvements to some MPI collective communication subroutines.
- The default value for the **MP_BUFFER_MEM** environment variable, which specifies the size of the Early Arrival (EA) buffer, is now 64 MB for both IP and User Space. In some cases, 32 bit IP applications may need to be recompiled with more heap or run with **MP_BUFFER_MEM** of less than 64 MB. For more details, see the migration information in Chapter 1 of *IBM Parallel Environment: Operation and Use, Volume 1* and Appendix E of *IBM Parallel Environment: MPI Programming Guide*.

Chapter 1. Performance Considerations for the MPI Library

Performance considerations for the MPI library include the following topics:

- "Message transport mechanism considerations."
- "MPI point-to-point communication considerations" on page 3.
- "Polling and single thread considerations" on page 6.
- "LAPI send side copy considerations" on page 7
- "Striping considerations" on page 8.
- "Remote Direct Memory Access (RDMA) considerations" on page 9.
- "Other considerations" on page 9.

The performance of jobs when using the MPI library can be affected by setting various environment variables. The complete list is provided in *IBM Parallel Environment: Operation and Use, Volume 1*. Programs that conform to the MPI standard should run correctly with any combination of environment variables within the supported ranges.

The defaults of these environment variables are generally set to optimize the performance of the User Space library for MPI programs with one task per processor, using blocking communication. Blocking communication includes sets of nonblocking send and receive calls followed immediately by wait or waitall, as well as collectives and explicitly blocking send and receive calls. Applications that use other programming styles, in particular those that do significant computation between posting nonblocking sends or receives and calling wait or waitall, may see a performance improvement if some of the environment variables are changed.

Message transport mechanism considerations

The MPI Library conforms to the MPI-2 Standard, with the exception of the chapter on *Process Creation and Management*, which is not implemented.

The MPI library is a dynamically loaded shared object, whose symbols are linked into the user application. At run time, when MPI_Init is called by the application program, the various environment variables are read and interpreted, and the underlying transport is initialized. Depending on the setting of the transport variable **MP_EUILIB**, MPI initializes lower level protocol support for a User Space packet mode, or for a UDP/IP socket mode. By default, the shared memory mechanism for point-to-point messages (and in 64-bit applications, collective communication) is also initialized.

Three message transport mechanisms are supported:

Shared memory
Used for tasks on the same node (as processes under the same operating system image).

UDP/IP
Used for tasks on nodes that are connected with an IP network. UDP/IP involves the kernel in each node-to-node message.

User Space
An optimized use of a communication adapter in which the tasks of a parallel job are able to submit a message for a task on another node to the adapter, or get a message from another task from the adapter, both without kernel involvement.

These topics are addressed in the following sections, in detail:

- "Shared memory considerations"
- "MPI IP performance considerations."
- "User Space considerations" on page 3.

Shared memory considerations

An MPI job can use a combination of shared memory and UDP/IP message transport mechanisms, or a combination of shared memory and User Space message transport mechanisms, for intertask communication. An MPI job may not use a combination of UDP/IP and User Space message transport mechanisms.

Tasks on the same node can use operating system shared memory transport for point-to-point communication. Shared memory is used by default, but may be turned off with the environment variable **MP_SHARED_MEMORY**. In addition, 64-bit applications are provided an optimization where the MPI library uses shared memory directly for selected collective communications, rather than just mapping the collectives into point-to-point communications. The collective calls for which this optimization is provided include MPI_Barrier, MPI_Reduce, MPI_Bcast, MPI_Allreduce and others. This optimization is enabled by default, and disabled by setting environment variable **MP_SHARED_MEMORY** to **no**. For most programs, enabling the shared memory transport for point-to-point and collective calls provides better performance than using the network transport.

For more information on shared memory, see Chapter 3, "Using shared memory," on page 15.

MPI IP performance considerations

MPI IP performance is affected by the socket-buffer sizes for sending and receiving UDP data. These are defined by two network tuning parameters **udp_sendspace** and **udp_recvspace**. When the buffer for sending data is too small and quickly becomes full, UDP data transfer can be delayed. When the buffer for receiving data is too small, incoming UDP data can be dropped due to insufficient buffer space, resulting in send-side retransmission and very poor performance.

LAPI, on which MPI is running, tries to increase the size of send and receive buffers to avoid this performance degradation. However, the buffer sizes, **udp_sendspace** and **udp_recvspace**, cannot be greater than another network tuning parameter **sb_max**, which can be changed only with privileged access rights (usually root). For optimal performance, it is suggested that **sb_max** be increased to a relatively large value. For example, increase **sb_max** from the default of 1048576 to 8388608 before running MPI IP jobs.

The UDP/IP transport can be used on clustered servers where a US mode is not available. Even when a US mode is available, UDP/IP is often useful for program development or initial testing. Although the UDP/IP transport does not match User Space performance, it consumes only virtual adapter resources rather than limited real adapter resources.

MPI with UDP/IP transport should be viewed as an IP application for system performance tuning. This transport is selected by setting the environment variable **MP_EUILIB** to **ip** (must be lower case). The user may set the UDP packet size using the environment variable **MP_UDP_PACKET_SIZE**, which should be set slightly smaller than the MTU of the IP network being used. The **MP_** environment

variables can also affect performance with the IP transport, but have generally been designed with the optimized User Space transport in mind.

Details on the network tuning parameters, such as their definitions and how to change their values, can be found in the man page for the AIX **no** command.

User Space considerations

The User Space transport binds one or more real adapter resources (called User Space windows) to each MPI task. The number of windows available depends on adapter type, but it is common for systems fully loaded with production jobs to have every available window committed. User Space is selected by setting the environment variable **MP_EUILIB** to **us** (must be lower case). This is the transport for which the MPI library is optimized.

The underlying transport for MPI is LAPI, which is packaged with AIX as part of the RSCT file set. LAPI provides a one-sided message passing API, with optimizations to support MPI. Except when dealing with applications that make both MPI and direct LAPI calls, or when considering compatibility of PE and RSCT levels, there is usually little need for the MPI user to be concerned about what is in the MPI layer and what is in the LAPI layer.

MPI point-to-point communication considerations

To understand the various environment variables, it is useful to describe briefly how MPI manages point-to-point messages. Parts of this management are now in the LAPI LLP (Lower Level Protocol), which provides a reliable message delivery layer and a mechanism for asynchronous progress in MPI. Because LAPI runs above an unreliable packet layer, LAPI must deal with detecting and retransmitting any lost packet.

An MPI application program sends a message using either a blocking or a nonblocking send. A send is considered locally complete when the blocking send call returns, or when the wait associated with the nonblocking send returns. MPI defines a standard send as one that may complete before the matching receive is posted, or can delay its completion until the matching receive is posted. This definition allows the MPI library to improve performance by managing small standard sends with **eager protocol** and larger ones with **rendezvous protocol**. A small message is one no larger than the **eager limit** setting.

The eager limit is set by the **MP_EAGER_LIMIT** environment variable or the **-eager_limit** command-line flag. For more information on the **MP_EAGER_LIMIT** environment variable, see *IBM Parallel Environment: Operation and Use, Volume 1*, and Appendix E, “PE MPI buffer management for eager protocol,” on page 205.

Eager messages

An **eager send** passes its buffer pointer, communicator, destination, length, tag and data type information to a LLP reliable message delivery function. If the message is small enough, it is copied from the user’s buffer into a protocol managed buffer, and the MPI send is marked complete. This makes the user’s send buffer immediately available for reuse. A longer message is not copied, but is transmitted directly from the user’s buffer. In this second case, the send cannot be marked complete until the data has reached the destination and the packets have been acknowledged. It is because either the message itself, or a copy of it, is preserved until it can be confirmed that all packets arrived safely, that the LLP can be considered reliable.

The strategy of making temporary copies of small messages in case a retransmission is required preserves reliability while it reduces the time that a small MPI send must block.

Whenever a send is active, and at other convenient times such as during a blocking receive or wait, a message dispatcher is run. This dispatcher sends and receives messages, creating packets for and interpreting packets from the lower level packet driver (User Space or IP). Since UDP/IP and User Space are both unreliable packet transports (packets may be dropped during transport without an error being reported), the message dispatcher manages packet acknowledgment and retransmission with a **sliding window protocol**. This message dispatcher is also run on a hidden thread once every few hundred milliseconds and, if environment variable **MP_CSS_INTERRUPT** is set, upon notification of packet arrival.

On the receive side, there are two distinct cases:

- The eager message arrives before the matching receive is posted.
- The receive is posted before the eager message arrives.

When the message dispatcher recognizes the first packet of an inbound message, a header handler or **upcall** is invoked. This upcall is to a function within the MPI layer that searches a list of descriptors for posted but unmatched receives. If a match is found, the descriptor is unlinked from the unmatched receives list and data will be copied directly from the packets to the user buffer. The receive descriptor is marked by a second upcall (a completion handler), when the dispatcher detects the final packet so that the MPI application can recognize that the receive is complete.

If a receive is not found by the header handler upcall, an **early arrival buffer** is allocated by MPI and the message data will be copied to that buffer. A descriptor similar to a receive descriptor but containing a pointer to the early arrival buffer is added to an **early arrivals list**. When an application does make a receive call, the early arrivals list is searched. If a match is found:

1. The descriptor is unlinked from the early arrivals list.
2. Data is copied from the early arrival buffer to the user buffer.
3. The early arrival buffer is freed.
4. The descriptor (which is now associated with the receive) is marked so that the MPI application can recognize that the receive is complete.

The size of the early arrival buffer is controlled by the **MP_BUFFER_MEM** environment variable.

The difference between a blocking and nonblocking receive is that a blocking receive does not return until the descriptor is marked complete, whether the message is found as an early arrival or is sent later. A nonblocking receive leaves a descriptor in the posted receives list if no match is found, and returns. The subsequent wait blocks until the descriptor is marked complete.

The MPI standard requires that a send not complete until it is guaranteed that its data can be delivered to the receiver. For an eager send, this means the sender must know in advance that there is sufficient buffer space at the destination to cache the message if no posted receive is found. The PE MPI library accomplishes this by using a credit flow control mechanism. At initialization time, each source to destination pair is allocated a fixed, identical number of **message credits**. The number of credits per pair is calculated based on environment variables **MP_EAGER_LIMIT**, **MP_BUFFER_MEM**, and the total number of tasks in the job. An MPI task sends eagerly to a destination as long as it has credits for that

destination, but it costs one credit to send a message. Each receiver has enough space in its early arrival buffer to cache the messages represented by all credits held by all possible senders.

If an eager message arrives and finds a match, the credit is freed immediately because the early arrival buffer space that it represents is not needed. If data must be buffered, the credit is tied up until the matching receive call is made, which allows the early arrival buffer to be freed. PE MPI returns message flow control credits by piggybacking them on some regular message going back to the sender, if possible. If credits pile up at the destination and there are no application messages going back, MPI must send a special purpose message to return the credits. For more information on the early arrival buffer and the environment variables, **MP_EAGER_LIMIT** and **MP_BUFFER_MEM**, see *IBM Parallel Environment: Operation and Use, Volume 1* and Appendix E, “PE MPI buffer management for eager protocol,” on page 205.

Rendezvous messages

For a standard send, PE MPI makes the decision whether to use an **eager** or a **rendezvous** protocol based on the message length. For the standard MPI_Send and MPI_Isend calls, messages whose size is not greater than the eager limit are sent using eager protocol. Messages whose size is larger than the eager limit are sent using rendezvous protocol. Thus, small messages can be eagerly sent, and assuming that message credits are returned in a timely fashion, can continue to be sent using the mechanisms described above. For large messages, or small messages for which there are no message credits available, the message must be managed with a rendezvous protocol.

Recall the following:

- The MPI definition for standard send promises the user that the message data will be delivered whenever the matching receive is posted.
- Send side message completion is no indication that a matching receive was found.

The decision made by an MPI implementation of standard send, to use eager protocol in some cases and rendezvous protocol in other cases is based on a need to allocate and manage buffer space for preserving eagerly sent message data in the cases were there is no receive waiting. The MPI standard’s advice that a ’safe’ programming style must not assume a standard send will return before a matching receive is found, is also based on the requirement that the MPI implementation preserve any message data that it sends eagerly.

Since a zero byte message has no message data to preserve, even an MPI implementation with no early arrival buffering should be able to complete a zero byte standard send at the send side, whether or not there is a matching receive. Thus, for PE MPI with **MP_EAGER_LIMIT** set to zero, a one byte standard send will not complete until a matching receive is found, but a zero byte standard send will complete without waiting for a rendezvous to determine whether a receive is waiting.

A rendezvous message is sent in two stages:

1. A message envelope is sent containing the information needed for matching by the receiver, and a message ID that is unique to the sender. This envelope either matches a previously posted receive, or causes a descriptor to be put in the list of early arrivals just as for an eager early arrival. Because the message data has not been sent, no early arrival buffer is needed.

Whether the matching receive is found when the envelope arrives, or the receive call is made later and matches a descriptor in the early arrivals list, an 'OK to send' response goes back to the sender after the match. This 'OK to send' contains the ID by which the sender identifies the data to send, and also an ID unique to the destination that identifies the match that was found.

2. When the sender gets an 'OK to send' message, it sends the message data, along with the destination side ID that identifies the receive that had been matched. As the data arrives, it can be copied directly into the receive buffer that was already identified as the match.

Eager messages require only one trip across the transport, while rendezvous messages require three trips, but two of the trips are fast, and the time is quickly amortized for large messages. Using the rendezvous protocol ensures that there is no need for temporary buffers to store the data, and no overhead from copying packets to temporary buffers and then on to user buffers.

Polling and single thread considerations

A blocking send or receive, or an MPI wait call, causes MPI to invoke the message dispatcher in a polling loop, processing packets as available until the specified message is complete. This is generally the lowest latency programming model, since packets are processed on the calling thread as soon as they arrive. The MPI library also supports an interrupt mode, specified by the environment variable **MP_CSS_INTERRUPT**, which causes an interrupt whenever a message packet arrives at the receiving network port or window.

In User Space, this interrupt is implemented as an operating system dispatch of a service thread that is created within each task at initialization time and is waiting on such an event. This thread calls the message dispatcher to process the packet, including invoking any upcalls to MPI for message matching or completion. Thus, while packets are being processed, other user threads may continue to perform computations. This is particularly useful if there are otherwise idle processors on the node, but that situation is not common. It is more likely to be useful with algorithms that allow communication to be scheduled well before the data is needed, and have computations to be done using data that is already available from a prior set of communications.

If all the processors are busy, enabling interrupt mode causes thread context switching and contention for processors, which might cause the application to run slower than it would in polling mode.

The behavior of the MPI library during message polling can also be affected by the setting of the environment variable **MP_WAIT_MODE**. If set to **sleep** or **yield**, the MPI thread, in an unsatisfied blocking MPI call, sleeps or yields periodically to allow the operating system dispatcher to schedule other activity on the processor. Perhaps more useful is setting **MP_WAIT_MODE** to **nopoll**, which polls the message dispatcher for a short time (less than one millisecond) and then goes into a thread wait for either an interrupt or a time expiration. In general, if **MP_WAIT_MODE** is set to **nopoll**, it is suggested that **MP_CSS_INTERRUPT** be set to **yes**. This may be appropriate when the blocking MPI calls are part of a command processor thread. An alternate way of implementing this behavior is with an MPI test command and user-invoked sleep or yield (or some other mechanism to release a processor).

As mentioned above, packets are transferred during polling and when an interrupt is recognized (which invokes the message dispatcher). The message dispatcher is

also invoked periodically, based on the operating system timer support. The time interval between brief polls of the message dispatcher is controlled by environment variable **MP_POLLING_INTERVAL**, specified in microseconds.

The MPI library supports multiple threads simultaneously issuing MPI calls, and provides appropriate internal locking to make sure that the library is threadsafe with respect to these calls. If the application makes MPI calls on only one thread (or is a non-threaded program), and does not use the nonstandard MPE_I nonblocking collectives, MPI-IO, or MPI one-sided features, the user may wish to skip the internal locking by setting the environment variable **MP_SINGLE_THREAD** to **yes**. Do not set **MP_SINGLE_THREAD** to **yes** unless you are **certain** that the application is single threaded. Setting **MP_SINGLE_THREAD** to **yes** is unlikely to give significant performance gains except in applications that do extremely frequent small message sends and receives.

IMPORTANT NOTE

Making **MP_SINGLE_THREAD=yes** a system default, or setting it for any application without certainty that there is only one message passing thread, can be dangerous. If any threaded application is run with **MP_SINGLE_THREAD=yes**, it may fail in unpredictable and inconsistent ways, based on varying outcome of race conditions. PE MPI is unable to detect this situation and, as a result, cannot provide users any warning.

LAPI send side copy considerations

Some applications may benefit from changing the parameters controlling the send side copy mechanism. Because the send side buffering occurs at the level below MPI, the effect as seen by an MPI user must allow for headers used by MPI. To help you understand this as an MPI user, we must discuss it from a LAPI perspective.

LAPI send side guarantees making a copy of any LAPI level message of up to 128 bytes, letting the send complete locally. An MPI message sent by an application will have a header (or envelope) prepended by PE MPI before being sent as a LAPI message. Therefore, the application message size from the MPI perspective is less than from the LAPI perspective. The message envelope is no larger than 32 bytes. LAPI also maintains a limited pool of retransmission buffers larger than 128 bytes. If the application message plus MPI envelope exceeds 128 bytes, but is small enough to fit a retransmission buffer, LAPI tries (but cannot guarantee) to copy it to a retransmission buffer, allowing the MPI send to complete locally.

The size of the retransmission buffers is controlled by the environment variable **MP_REXMIT_BUF_SIZE**, defaulting to a LAPI level message size of 16352 bytes. The supported MPI application message size is reduced by the number of bytes needed for the MPI envelope, which is 24 bytes for a 32-bit executable, or 32 bytes for a 64-bit executable.

The number of retransmission buffers is controlled by the environment variable **MP_REXMIT_BUF_CNT**. The retransmission buffers are pooled, and are not assigned to a particular destination, so the appropriate number of buffers to achieve a balance between performance gain and memory cost is affected by the nature of the application and the system load.

If the message is successfully copied to a retransmission buffer, the local completion of the MPI send is immediate. If the message is too large to fit in the retransmission buffer, or if all the retransmission buffers are full (awaiting packet acknowledgement from their destination), the send does not complete locally until all message data has been received by the destination and acknowledged. Programs that do a group of blocking sends of a large number of messages that are expected to be sent eagerly may benefit from increasing the number of retransmission buffers. If memory allocation is of special concern, applications should set the retransmission buffer size to be no larger than the MPI eager limit plus the size of the MPI header.

For more information on the **MP_EAGER_LIMIT** environment variable, see *IBM Parallel Environment: Operation and Use, Volume 1* and Appendix E, “PE MPI buffer management for eager protocol,” on page 205.

Striping considerations

Protocol striping is supported for HPS switch adapters (striping, failover, and recovery are not supported over non-HPS adapters such as Gigabit Ethernet). If the windows (or UDP ports) are on multiple adapters and one adapter or link fails, the corresponding windows are closed and the remaining windows are used to send messages. When the adapter or link is restored (assuming that the node itself remains operational), the corresponding windows are added back to the list of windows used for striping.

Striping is enabled when multiple instances are selected for communication. On a multi-network system, one way to do this is by choosing the composite device (set environment variable **MP_EUIDEVICE** to **sn_all** or **csss**), which requests allocation of one window on each network available on the node. For a node with two adapter links in a configuration where each link is part of a separate network, the result is a window on each of the two networks. For short messages and messages using the User Space FIFO mechanism, the CPU and memory bandwidth limits for copying user buffer data to the User Space FIFO packet buffers for transmission limits the achievable communication performance. Therefore, striping user space FIFO messages provides no performance benefit other than possibly better load balancing of the message traffic between the two networks. However, striping messages that use the Remote Direct Memory Access (RDMA) or bulk transfer mechanism can result in significant performance gains, since the data transfer function is off-loaded to the adapters, and there is very little CPU involvement in the communication.

For single network configurations, striping, failover, and recovery can still be used by requesting multiple instances (setting the environment variable **MP_INSTANCES** to a value greater than 1). However, unless the system is configured with multiple adapters on the network, and window resources are available on more than one adapter, failover and recovery is not necessarily possible, because both windows may end up on the same adapter. Similarly, improved striping performance using RDMA can be seen only if windows are allocated from multiple adapters on the single network.

There are some considerations that users of 32-bit applications must take into account before deciding to use the striping, failover, and recovery function. A 32-bit application is limited to 16 segments. The standard AIX memory model for 32-bit applications claims five of these, and expects the application to allocate up to eight segments (2 GB) for application data (the heap, specified with compile option **-bmaxdata**). For example, **-bmaxdata:0x80000000** allocates the maximum eight

segments, each of which is 256 MB. The communication subsystem takes an additional, variable number of segments, depending on options chosen at run time.

In some circumstances, for 32-bit applications the total demand for segments can be greater than 16 and a job will be unable to start, or will run with reduced performance. If your application is using a very large heap and you consider enabling striping, see section *User Space striping with failover* in the chapter *Managing POE jobs* of *IBM Parallel Environment: Operation and Use, Volume 1*.

Remote Direct Memory Access (RDMA) considerations

Some MPI applications benefit from the use of the bulk transfer mode. This transfer mode is enabled by setting the LoadLeveler keyword **@bulkxfer** to **yes** or setting the environment variable **MP_USE_BULK_XFER** to **yes** for interactive jobs. This transparently causes portions of the user's virtual address space to be pinned and mapped to a communications adapter. The low level communication protocol will then use Remote Direct Memory Access (RDMA, also known as bulk transfer) to copy (pull) data from the send buffer to the receive buffer as part of the MPI receive. The minimum message size for which RDMA will be used can be adjusted by setting environment variable **MP_BULK_MIN_MSG_SIZE**.

This especially benefits applications that either transfer relatively large amounts of data (greater than 150 KB) in a single MPI call, or overlap computation and communication, since the CPU is no longer required to copy data. RDMA operations are considerably more efficient when large (16 MB) pages are used rather than small (4 KB) pages, especially for large transfers. In order to use the bulk transfer mode, the system administrator must enable RDMA communication and LoadLeveler must be configured to use RDMA. Not all communications adapters support RDMA.

For a quick overview of the RDMA feature, and the steps that a system administrator must take to enable or disable the RDMA feature, see *Switch Network Interface for @serverpSeries High Performance Switch Guide and Reference*.

For information on using LoadLeveler with bulk data transfer, see these sections in *Tivoli® Workload Scheduler LoadLeveler: Using and Administering*:

- The chapter: *Configuring the LoadLeveler environment*, section *Enabling support for bulk data transfer*.
- The chapter: *Building and submitting jobs*, section *Using bulk data transfer*.

Other considerations

The information provided about performance considerations and the controlling variables, applies to most applications. There are a few others that are useful in special circumstances. These circumstances may be identified by setting the **MP_STATISTICS** environment variable to **print** and examining the task statistics at the end of an MPI job.

MP_ACK_THRESH
This environment variable changes the threshold for the update of the packet ACK sliding window. Reducing the value causes more frequent update of the window, but generates additional message traffic.

MP_CC_SCRATCH_BUFFER
MPI collectives normally pick from more than one algorithm based on the impact of message size, task count, and other factors on expected performance.

Normally, the algorithm that is predicted to be fastest is selected, but in some cases the preferred algorithm depends on PE MPI allocation of scratch buffer space. This environment variable instructs PE to use the collective communication algorithm that takes less or even no scratch buffer space, even if this algorithm is predicted to be slower. Most applications have no reason to use this variable.

MP_RETRANSMIT_INTERVAL
This environment variable changes the frequency of checking for unacknowledged packets. Lowering this value too much generates more switch traffic and can lead to an increase in dropped packets. The packet statistics are part of the end of job statistics displayed when **MP_STATISTICS** is set to **print**.

MP_PRIORITY
This environment variable causes the invocation of the PE coscheduler function, if it is enabled by the system administrator. The value of this environment variable is highly application-dependent.

MP_TASK_AFFINITY
This environment variable applies to nodes that have more than one multi-chip module (MCM) under control by AIX. It forces tasks to run exclusively on one MCM, which allows them to take advantage of the memory local to that MCM. This applies to IBM POWER4™ and IBM System p5 servers. For more information, see *Managing task affinity on large SMP nodes* in *IBM Parallel Environment: Operation and Use, Volume 1*.

Chapter 2. Profiling message passing

If you use the **gprof**, **prof**, or **xprofiler** command and the appropriate compiler command (such as **cc_r** or **mpcc_r**) with the **-p** or **-pg** flag, you can profile your program. For information about using:

- **cc_r**, **gprof**, and **prof**, see *IBM Parallel Environment: Operation and Use, Volume 2*.
- **mpcc_r** and related compiler commands, see *IBM Parallel Environment: Operation and Use, Volume 1*.
- **xprofiler**, which is part of the AIX operating system, see the *AIX: Performance Tools Guide and Reference*.

The message passing library is not enabled for **gprof** or **prof** profiling counts. You can obtain profiling information by using the nameshifted MPI functions provided.

These steps describe how to use **nameshift profiling** routines that are either written to the C bindings with an MPI program written in C, or that are written to the FORTRAN bindings with an MPI program written in FORTRAN.

Programs that use the C MPI language bindings can easily create profiling libraries using the nameshifted interface.

- If you are both the creator and user of the profiling library and you are not using FORTRAN, follow steps 1 through 6. If you are using FORTRAN, follow steps 1 through 4, then steps 7 through 14.
- If you are the creator of the profiling library, follow steps 1 through 4. You also need to provide the user with the file created in step 2.
- If you are the user of the profiling library and you are not using FORTRAN, follow steps 5 and 6. If you are using FORTRAN, start at step 7. You will need to make sure that you have the file generated by the creator in step 2.

To perform MPI nameshift profiling, follow the appropriate steps:

1. Create a source file that contains profiling versions of all the MPI subroutines you want to profile. For example, create a source file called **myprof_r.c** that contains the following code:

   ```
   #include <pthread.h>
   #include <stdio.h>
   #include <mpi.h>
   int MPI_Init(int *argc, char ***argv) {
     int rc;

     printf("hello from profiling layer MPI_Init...\n");
     rc = PMPI_Init(argc, argv);
     printf("goodbye from profiling layer MPI_Init...\n");
     return(rc);
   }
   ```

2. Create an export file that contains all of the symbols your profiling library will export. Begin this file with the name of your profiling library and the name of the **.o** file that will contain the object code of your profiling routines. For example, create a file called **myprof_r.exp** that contains this statement:

   ```
   MPI_Init
   ```

3. Compile the source file that contains your profiling MPI routines. For example:

   ```
   cc_r -c myprof_r.c -I/usr/lpp/ppe.poe/include
   ```

   The **-I** flag defines the location of **mpi.h**.

4. Create a shared library called **libmyprof_r.a** that contains the profiled versions, exporting their symbols and linking with the PE MPI library, using **myprof_r.exp** as shown. For example:

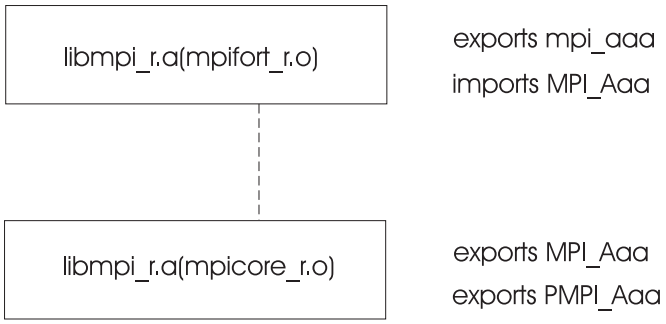
```
ld -o newmyprof_r.o myprof_r.o -bM:SRE -H512 -T512 -bnoentry
  -bE:myprof_r.exp -lc -lmpi_r -L/usr/lpp/ppe.poe/lib -lpthreads
ar rv libmyprof_r.a newmyprof_r.o
```

5. Link your user program:

```
mpcc_r -o test1 test1.c -L. -lmyprof_r
```

6. Run the resulting executable.
7. Programs that use the FORTRAN MPI language bindings need to do some additional steps to use the profiling libraries created above. This is because the FORTRAN bindings are contained in a separate shared object from the C bindings.

   The shipped product has a library structure that looks like this:



   You need to change it into the following structure by rebuilding the **mpifort_r.o** shared object:
   To do this, first extract **mpifort_r.o** from **libmpi_r.a**:


```
ar -xv /usr/lpp/ppe.poe/lib/libmpi_r.a mpifort_r.o
```

8. Then, construct a script to rebuild **mpifort_r.o**, using the AIX **rtl_enable** command:

```
rtl_enable -o newmpifort_r.o -s mpifort_r.o -L. -L/usr/lpp/ppe.poe/lib
  -lmyprof_r -lmpi_r -lc_r -lpthreads
```

9. The **rtl_enable** command creates a script called **mpifort_r.sh** and import and export files that reflect the original binding with **libmpi_r.a(mpicore_r.o)**. To break this binding and rebind, remove the reference to the import file:

   ```
   sed "s/-bI:mpifort_r.imp//" < mpifort_r.sh > mpifort_r.newsh
   ```

10. Make **mpifort_r.newsh** executable and run it:

    ```
    chmod +x mpifort_r.newsh
    mpifort_r.newsh
    ```

11. Archive the new shared object:

    ```
    ar rv libpmpi_r.a newmpifort_r.o
    ```

12. Create a program that uses an MPI function that you have profiled. For example, a file called **hwinit.f** could contain these statements:

    ```
    c -------------------------------------
          program  hwinit
          include 'mpif.h'
          integer forterr
     c
          call MPI_INIT(forterr)
     c
     c  Write comments to screen.
     c
          write(6,*)'Hello from task '
     c
          call MPI_FINALIZE(forterr)
     c
          stop
          end
     c
    ```

13. Link your FORTRAN executable with the new library:

    ```
    mpxlf_r -o hwinit hwinit.f -L. -lpmpi_r
    ```

14. Run the resulting executable.

Chapter 3. Using shared memory

MPI programs with more than one task on the same computing node may benefit from using shared memory to send messages between same node tasks.

This support is controlled by the **MP_SHARED_MEMORY** environment variable. The default setting is **yes**. In this case, shared memory is used for message passing. Message passing between tasks on different nodes continues to use User Space or IP protocol.

Setting this variable to **no** directs MPI to not use a shared-memory protocol for message passing between any two tasks of a job running on the same node.

For the 32-bit libraries, shared memory exploitation always allocates a 256 MB virtual memory address segment that is not available for any other use. As a result, programs that are already using all available segments on IBM POWER™ architecture cannot use this option. This applies to pSeries servers only (not xSeries® servers). For more information, see “Available virtual memory segments” on page 34.

For 64-bit libraries, there are so many segments in the address space that there is no conflict between library and end user segment use. This applies to pSeries servers only (not xSeries servers).

Shared memory support is available for both IP and User Space MPI protocols. For programs on which *all* tasks are on the same node, shared memory is used exclusively for all MPI communication (unless **MP_SHARED_MEMORY** is set to **no**).

Setting the **MP_SHARED_MEMORY** environment variable to **yes** also directs the PE implementation of MPI to use an optimization of certain collective communication routines. This optimization uses an additional shared memory segment. The collective communication optimization is available only to 64-bit executables, where segment registers are abundant.

For collectives in 64-bit executables that are enhanced to use shared memory, the algorithms used for smaller message sizes involve copying data from user buffers to scratch buffers in shared memory, and then allowing tasks that are interested in that data to work with the copy in shared memory. The algorithms used for larger messages involve exposing the user buffer itself to other tasks that have an interest in it. The effect is that for smaller messages, some tasks may return from a collective call as soon as their data is copied to shared memory, sometimes before tasks needing access to the data even enter the collective operation.

For larger messages, the algorithms are more strongly synchronizing, because a task that directly exposes a user buffer to other tasks cannot return to the user until the interested tasks have completed their access to the data.

Shared memory performance considerations

Be aware of these performance considerations:

1. The best performance is achieved when all message buffers are contiguous.
2. The large message support for some collectives involves exposing the memory of one task to the address space of another task. There is a limit of 4096

concurrent operations of this kind on a node. There is also a limit of 32 GB for the address range of a message that can use this technique.

If there are more than 4096 concurrent operations, or a buffer has an address range greater than 32 GB, performance abnormalities may be encountered.

This applies only to 64-bit executables.

3. A hang may occur if you match blocking and nonblocking collectives in the same application. For a full description, see “Do not match blocking and nonblocking collectives” on page 30.
4. 32-bit applications linked to use the maximum heap (8 segments) may not have enough available segments to effectively use shared memory for large messages. MPI will quietly use whatever resources are available, but performance may be impacted. This applies to pSeries servers only (not xSeries servers).

Reclaiming shared memory

Occasionally, shared memory is not reclaimed. If this happens, you can use the **ipcrm** command, or contact the system administrator to reclaim the shared memory segments.

POE's Partition Manager Daemon (PMD) attempts to clean up any allocated shared memory segments when a program exits normally. However, if a PMD process (named **pmdv4**) is killed with signals or with the **llcancel** command, shared memory segments may not be cleaned up properly. For this reason, when shared memory is used, users should not kill or cancel a PMD process.

Using POE with multiple Ethernet adapters and shared memory

The following method can be used to run a non-LoadLeveler POE job that uses multiple Ethernet adapters and shared memory. If this method is not used for these jobs, POE cannot correctly determine which tasks are running on the same node, and shared memory key collisions will occur, resulting in unpredictable behavior. This method consists of an extra **poe** invocation before running the real POE job, and the use of a script that overrides an environment variable setting before executing the parallel task.

1. With **MP_PROCS** set correctly in the environment (or with **-procs** set as part of the **poe** invocation), run

   ```
   poe hostname -stdoutmode ordered -ilevel 0 > hostnames
   ```

   using the hostfile (either as host list in the directory where POE is run, or by specifying **MP_HOSTFILE** or **-hostfile**) that contains the names of the Ethernet adapters.
2. If a shared file system is not used, copy the original hostfile and the **addr_fix** script below to the nodes where the parallel tasks will run. The **addr_fix** script must be copied to the directory with the same name as the current directory on the POE home node (from which you ran **poe** in step 1.)
3. Run your real POE job with whatever settings you were using, except:
   - Use the hostnames file from step 1 as the **MP_HOSTFILE** or **-hostfile** that is specified to POE.
   - Set the environment variable **ADDR_FIX_HOSTNAME** to the name of the hostfile that contains the names of the Ethernet adapters, used in step 1.
   - Instead of invoking the job as:

     ```
     poe my_exec my_args poe_flags
     ```

invoke it as:

```
poe ./addr_fix my_exec my_args poe_flags
```

The **addr_fix** script follows.

```
=====================================================================
#!/bin/ksh93

# Determine file index based on taskid
my_index=`expr $MP_CHILD + 1`

# Index into the file to get the ethernet name that this task will run on.
my_name=`cat $ADDR_FIX_HOSTNAME  | awk NR==$my_index'{print $0}'`

# Convert my_name to a dot decimal address.
my_addr=`host $my_name | awk '{print $3}' | tr ',' ' '`

# Set environment variable that MPI will use as address for IP communication
export MP_CHILD_INET_ADDR=@1:$my_addr,ip

# Execute what was passed in
$*
=====================================================================
```

This script assumes that striping is not used.

If LAPI is used, set **MP_LAPI_INET_ADDR** in the script instead. If both MPI and LAPI are used, set both environment variables.

Chapter 4. Performing parallel I/O with MPI

Performing parallel I/O with MPI includes the following topics:

- "Features of MPI-IO."
- "Considerations for MPI-IO" on page 20.
- "MPI-IO API user tasks" on page 20.
- "MPI-IO file interoperability" on page 24.

The I/O component of MPI-2, or *MPI-IO*, provides a set of interfaces that are aimed at performing portable and efficient parallel file input and file output operations.

MPI-IO allows a parallel program to express its I/O in a portable way that reflects the program's inherent parallelism. MPI-IO uses many of the concepts already provided by MPI to express this parallelism. MPI data types are used to express the layout and partitioning of data, which is represented in a file shared by several tasks. An extension of the MPI communicator concept, referred to as an *MPI_File*, is used to describe a set of tasks and a file that these tasks will use in some integrated manner. Collective operations on an MPI_File allow efficient physical I/O on a data structure that is distributed across several tasks for computation, but possibly stored contiguously in the underlying file.

Features of MPI-IO

The primary features of MPI-IO are:

1. **Portability**: As part of MPI-2, programs written to use MPI-IO must be portable across MPI-2 implementations and across hardware and software platforms. The MPI-IO API ensures portability at the source code level.
2. **Versatility**: The PE MPI-IO implementation provides support for:
   - basic file manipulations (open, close, delete, sync)
   - get and set file attributes (view, size, group, mode, info)
   - blocking data access operations with explicit offsets (both independent and collective)
   - nonblocking data access operations with explicit offsets (independent only)
   - blocking and nonblocking data access operations with file pointers (individual and shared)
   - split collective data access operations
   - any derived data type for memory and file mapping
   - file interoperability through data representations (internal, external, user-defined)
   - atomic mode for data accesses.
3. **Robustness**: PE MPI-IO performs as robustly as possible in the event of error occurrences. Because the default behavior, as required by the MPI-2 standard, is for I/O errors to return, PE MPI-IO tries to prevent any deadlock that might result from an I/O error returning. The intent of the *errors return* default is that the type of errors considered almost routine in doing I/O should not be fatal in MPI. The kind of errors that the MPI application might tolerate are ones involving file system status or application user error. Some examples are: *file not found*, *file system full* or *permission denied*.

However, deadlocks resulting from erroneous user codes cannot be entirely avoided. Users of MPI-IO routines should always check return codes and be prepared to terminate the job if the error is not of the file system related type that the application can work around.

An application that fails in trying to create a file, fails every time it tries to write, and fails again closing the file, will run to completion with no sign of a problem, if return codes are not checked. The common practice of ignoring return codes on MPI calls trusting MPI to trap the failure does not work with MPI-IO calls.

Considerations for MPI-IO

MPI-IO will not operate if the **MP_SINGLE_THREAD** environment variable is set to **yes**. A call to MPI_INIT, when **MP_SINGLE_THREAD** set to **yes**, is equivalent to what might be expected with a call to MPI_INIT_THREAD specifying MPI_THREAD_FUNNELED. A call, when **MP_SINGLE_THREAD** is set to **no**, is equivalent to using MPI_THREAD_MULTIPLE. The default setting of **MP_SINGLE_THREAD** is **no**, therefore the default behavior of the threads library is MPI_THREAD_MULTIPLE.

Note: In PE MPI, thread behavior is determined before calling MPI_INIT or MPI_INIT_THREAD. A call to MPI_INIT_THREAD with MPI_THREAD_FUNNELED will not actually mimic **MP_SINGLE_THREAD**.

MPI-IO is intended to be used with the IBM General Parallel File System (GPFS) for production use. File access through MPI-IO normally requires that a single GPFS file system image be available across all tasks of an MPI job. Shared file systems such as AFS® and NFS do not meet this requirement when used across multiple nodes. PE MPI-IO can be used for program development on any other file system that supports a POSIX interface (AFS, JFS, or NFS) as long as all tasks run on a single node or workstation, but this is not expected to be a useful model for production use of MPI-IO.

In MPI-IO, whether an individual task performs I/O is **not** determined by whether that task issues MPI-IO calls. By default, MPI-IO performs I/O through an agent at each task of the job. I/O agents can be restricted to specific nodes by using an I/O node file. This should be done any time there is not a single GPFS file system available to all nodes on which tasks are to run. PE MPI-IO can be used without all tasks having access to a single file system image by using the **MP_IONODEFILE** environment variable. See *IBM Parallel Environment: Operation and Use, Volume 1* for information about **MP_IONODEFILE**.

MPI-IO API user tasks

To use the MPI-IO API effectively, you need to understand:

- Basic file management tasks such as opening, closing, and deleting files.
- How to use Info objects to provide information (such as the structure of an application) to some MPI-IO operations.
- The type constructors you can use to create data types that describe the data layout of arrays and subarrays.
- How to set the size of data buffers used by the MPI-IO agents.

Working with files

MPI_FILE_OPEN is used to open a file. When MPI-IO is used correctly, a file name will refer to the same file system at every task of the job, not just at every task that

issues the **MPI_FILE_OPEN**. In one detectable error situation, a file will appear to be on different file system types. For example, a particular file could be visible to some tasks as a GPFS file and to others as NFS-mounted.

Use of a file that is local to (that is, distinct at) each task or node, is not valid and cannot be detected as an error by MPI-IO. Issuing **MPI_FILE_OPEN** on a file in **/tmp** may look valid to the MPI library, but will not produce valid results.

The default for **MP_CSS_INTERRUPT** is **no**. If you do not override the default, MPI-IO enables interrupts while files are open. If you have forced interrupts to **yes** or **no**, MPI-IO does not alter your selection.

MPI-IO depends on hidden threads that use MPI message passing. MPI-IO cannot be used with **MP_SINGLE_THREAD** set to **yes**.

For AFS, and NFS, MPI-IO uses file locking for all accesses by default. If other tasks on the same node share the file and also use file locking, file consistency is preserved. If the MPI_FILE_OPEN is done with mode MPI_MODE_UNIQUE_OPEN, file locking is not done.

For information about file hints, see MPI_FILE_OPEN in *IBM Parallel Environment: MPI Subroutine Reference*.

For information about these file tasks, see *IBM Parallel Environment: MPI Subroutine Reference*.

- Closing a file (MPI_FILE_CLOSE)
- Deleting a file (MPI_FILE_DELETE)
- Resizing a file (MPI_FILE_SET_SIZE)
- Preallocating space for a file (MPI_FILE_PREALLOCATE)
- Querying the size of a file (MPI_FILE_GET_SIZE)
- Querying file parameters (MPI_FILE_GET_AMODE, MPI_FILE_GET_GROUP)
- Querying and setting file information (MPI_FILE_GET_INFO, MPI_FILE_SET_INFO)
- Querying and setting file views (MPI_FILE_GET_VIEW, MPI_FILE_SET_VIEW)
- Positioning (MPI_FILE_GET_BYTE_OFFSET, MPI_FILE_GET_POSITION)
- Synchronizing (MPI_FILE_SYNC)
- Accessing data
  - Data access with explicit offsets:
    - MPI_FILE_READ_AT
    - MPI_FILE_READ_AT_ALL
    - MPI_FILE_WRITE_AT
    - MPI_FILE_WRITE_AT_ALL
    - MPI_FILE_IREAD_AT
    - MPI_FILE_IWRITE_AT
  - Data access with individual file pointers:
    - MPI_FILE_READ
    - MPI_FILE_READ_ALL
    - MPI_FILE_WRITE
    - MPI_FILE_WRITE_ALL
    - MPI_FILE_IREAD

- MPI_FILE_IWRITE
- MPI_FILE_SEEK

– Data access with shared file pointers:
- MPI_FILE_READ_SHARED
- MPI_FILE_WRITE_SHARED
- MPI_FILE_IREAD_SHARED
- MPI_FILE_IWRITE_SHARED
- MPI_FILE_READ_ORDERED
- MPI_FILE_WRITE_ORDERED
- MPI_FILE_SEEK
- MPI_FILE_SEEK_SHARED

– Split collective data access:
- MPI_FILE_READ_AT_ALL_BEGIN
- MPI_FILE_READ_AT_ALL_END
- MPI_FILE_WRITE_AT_ALL_BEGIN
- MPI_FILE_WRITE_AT_ALL_END
- MPI_FILE_READ_ALL_BEGIN
- MPI_FILE_READ_ALL_END
- MPI_FILE_WRITE_ALL_BEGIN
- MPI_FILE_WRITE_ALL_END
- MPI_FILE_READ_ORDERED_BEGIN
- MPI_FILE_READ_ORDERED_END
- MPI_FILE_WRITE_ORDERED_BEGIN
- MPI_FILE_WRITE_ORDERED_END

Error handling

MPI-1 treated all errors as occurring in relation to some communicator. Many MPI-1 functions were passed a specific communicator, and for the rest, it was assumed that the error context was MPI_COMM_WORLD. MPI-1 provided a default error handler named MPI_ERRORS_ARE_FATAL for each communicator, and defined functions similar to those listed below for defining and attaching alternate error handlers.

The MPI-IO operations use an MPI_File in much the way other MPI operations use an MPI_Comm, except that the default error handler for MPI-IO operations is MPI_ERRORS_RETURN. The following functions are needed to allow error handlers to be defined and attached to MPI_File objects:

- MPI_FILE_CREATE_ERRHANDLER
- MPI_FILE_SET_ERRHANDLER
- MPI_FILE_GET_ERRHANDLER
- MPI_FILE_CALL_ERRHANDLER

For information about these subroutines, see *IBM Parallel Environment: MPI Subroutine Reference*.

Logging I/O errors

Set the **MP_IO_ERRLOG** environment variable to **yes** to indicate whether to turn on error logging for I/O operations. For example:

```
export MP_IO_ERRLOG=yes
```

turns on error logging. When an error occurs, a line of information will be logged in file **/tmp/mpi_io_errdump.***app_name***.***userid***.***taskid*, recording the time the error occurs, the POSIX file system call involved, the file descriptor, and the returned error number.

Working with Info objects

The MPI-2 standard provides the following Info functions as a means for a user to construct a set of hints and pass these hints to some MPI-IO operations:

- MPI_INFO_CREATE
- MPI_INFO_DELETE
- MPI_INFO_DUP
- MPI_INFO_FREE
- MPI_INFO_GET
- MPI_INFO_GET_NKEYS
- MPI_INFO_GET_NTHKEY
- MPI_INFO_SET
- MPI_INFO_GET_VALUELEN

An *Info object* is an opaque object consisting of zero or more (key,value) pairs. Info objects are the means by which users provide hints to the implementation about things like the structure of the application or the type of expected file accesses. In MPI-2, the APIs that use Info objects span MPI-IO, MPI one-sided, and dynamic tasks. Both key and value are specified as strings, but the value may actually represent an integer, boolean or other data type. Some keys are reserved by MPI, and others may be defined by the implementation. The implementation defined keys should use a distinct prefix which other implementations would be expected to avoid. All PE MPI hints begin with **IBM**_ (see MPI_FILE_OPEN in *IBM Parallel Environment: MPI Subroutine Reference*). The MPI-2 requirement that hints, valid or not, cannot change the semantics of a program limits the risks from misunderstood hints.

By default, Info objects in PE MPI accept only PE MPI recognized keys. This allows a program to identify whether a given key is understood. If the key is not understood, an attempt to place it in an Info object will be ignored. An attempt to retrieve the key will find no key/value present. The environment variable **MP_HINTS_FILTERED** set to **no** will cause Info operations to accept arbitrary (key, value) pairs. You will need to turn off hint filtering if your application, or some non-MPI library it is using, depends on MPI Info objects to cache and retrieve its own (key, value) pairs.

Using data type constructors

The following type constructors are provided as a means for MPI programs to describe the data layout in a file and relate that layout to memory data which is distributed across a set of tasks. The functions exist only for MPI-IO.

- MPI_TYPE_CREATE_DARRAY
- MPI_TYPE_CREATE_SUBARRAY

Setting the size of the data buffer

Set the **MP_IO_BUFFER_SIZE** environment variable to indicate the default size of the data buffers used by the MPI-IO agents. For example:

```
export MP_IO_BUFFER_SIZE=16M
```

sets the default size of the MPI-IO data buffer to 16 MB. The default value of this environment variable is the number of bytes corresponding to 16 file blocks. This value depends on the block size associated with the file system storing the file.

Valid values are any positive size up to 128 MB. The size can be expressed as a number of bytes, as a number of kilobytes (1024 bytes), using **k** or **K** as a suffix, or as a number of megabytes (1024*1024 bytes), using **m** or **M** as a suffix. If necessary, PE MPI rounds the size up, to correspond to an integral number of file system blocks.

MPI-IO file interoperability

For information about the following file interoperability topics, see *IBM Parallel Environment: MPI Subroutine Reference* and the *MPI-2 Standard*:

- Data types (MPI_FILE_GET_TYPE_EXTENT)
- External data representation (external32)
- User-defined data representations (MPI_REGISTER_DATAREP)
  - Extent callback
  - Datarep conversion functions
- Matching data representations

For information about the following topics, see the *MPI-2 Standard*:

- Consistency and semantics
  - File consistency
  - Random access versus sequential files
  - Progress
  - Collective file operations
  - Type matching
  - Miscellaneous clarifications
  - MPI_Offset Type
  - Logical versus physical file layout
  - File size
  - Examples: asynchronous I/O
- I/O error handling
- I/O error classes
- Examples: double buffering with split collective I/O, subarray filetype constructor

Chapter 5. Programming considerations for user applications in POE

The limitations, restrictions, and programming considerations for user applications written to run under the IBM Parallel Environment for AIX, include these topics:

- "The MPI library."
- "Parallel Operating Environment overview."
- "POE user limits" on page 26.
- "Exit status" on page 26.
- "POE job step function" on page 27.
- "POE additions to the user executable" on page 27.
- "Threaded programming" on page 35.
- "Using MPI and LAPI in the same program" on page 44.

The MPI library

The MPI library uses hidden AIX kernel threads as well as the users' threads to move data into and out of message buffers. It supports MPI only, (not MPL, an older IBM proprietary message passing library API), and supports message passing on the main thread and on user-created threads. The MPI library includes support for both 32-bit and 64-bit applications. The hidden threads also ensure that message packets are acknowledged, and when necessary, retransmitted. User applications, when compiled with the PE Version 4 compilation scripts (**mpcc_r**, **mpCC_r**, **mpxlf_r**), will always be compiled with the threaded MPI library, although the application itself may not be threaded. The additional threads created by the MPI implementation do not normally compete for the CPU. As much as possible, MPI message progress depends on using the application threads when they make an MPI call.

Notes:

1. In PE Version 4, a single version of the message-passing library is provided. Previous releases provided two versions: a threads library, and a signal-handling library. PE Version 4 provides only a threaded version of the library, with binary compatibility for the signal-handling library functions. In addition, PE Version 4 supports only MPI functions, in both 32-bit and 64-bit applications. MPL is no longer supported.
2. In addition, the MPI library is using the Low-level communication API (LAPI) protocol as a common transport layer. For more information on this and the use of the LAPI protocol, see *IBM Reliable Scalable Cluster Technology: LAPI Programming Guide*.

Parallel Operating Environment overview

As the end user, you are encouraged to think of the Parallel Operating Environment (POE) (also referred to as the **poe** command) as an ordinary (serial) command. It accepts redirected I/O, can be run under the **nice** and **time** commands, interprets command flags, and can be invoked in shell scripts.

An *n*-task parallel job running in POE consists of: the *n* user tasks, a number of instances of the PE partition manager daemon (**pmd**) that is equal to the number of nodes, and the **poe** command running on the POE home node. There is one **pmd**

for each node. A **pmd** is started by the POE home node on each machine on which a user task runs, and serves as the point of contact between the home node and the users' tasks.

The POE home node routes standard input, standard output, and standard error streams between the home node and the users' tasks with the **pmd** daemon, using TCP/IP sockets for this purpose. The sockets are created when the POE home node starts the **pmd** daemons for the tasks of a parallel job. The POE home node and **pmd** also use the sockets to exchange control messages to provide task synchronization, exit status and signaling. These capabilities do not depend on the message passing library, and are available to control any parallel program run by the **poe** command.

POE user limits

When interactive or batch POE applications are submitted under LoadLeveler, it is possible to use the LoadLeveler class to define the user resource limits used for the duration of the job. This also allows LoadLeveler to define and modify a different set of user limits on the submit and compute nodes, using different LoadLeveler job classes.

For interactive POE applications, without using LoadLeveler, POE does not copy or replicate the user resource limits on the remote nodes where the parallel tasks are to run (the compute nodes). POE uses the user limits as defined by the **/etc/security/limits** file. If the user limits on the submitting node (home node) are different than those on the compute nodes, POE does not change the user limits on the compute nodes to match those on the submitting node.

Users should ensure that they have sufficient user resource limits on the compute nodes, when submitting interactive parallel jobs. Users may want to coordinate their user resource needs with their system administrators to ensure that proper user limits are in place, such as in the **/etc/security/limits** file on each node, or by some other means.

Exit status

The exit status is any value from 0 through 255. This value, which is returned from POE on the home node, reflects the composite exit status of your parallel application as follows:

- If MPI_ABORT(comm,nn>0,ierror) or MPI_Abort(comm,nn>0) is called, the exit status is *nn* (mod 256).
- If all tasks terminate using exit(MM>=0) or STOP MM>=0 and MM is not equal to 1 and is less than 128 for all nodes, POE provides a synchronization barrier at the exit. The exit status is the largest value of MM from any task of the parallel job (mod 256).
- If any task terminates using exit(MM =1) or STOP MM =1, POE will immediately terminate the parallel job, as if MPI_Abort(MPI_COMM_WORLD,1) had been called. This may also occur if an error is detected within a FORTRAN library because a common error response by FORTRAN libraries is to call STOP 1.
- If any task terminates with a signal (for example, a segment violation), the exit status is the signal plus 128, and the entire job is immediately terminated.
- If POE terminates before the start of the user's application, the exit status is 1.
- If the user's application cannot be loaded or fails before the user's main() is called, the exit status is 255.

- You should explicitly call exit(MM) or STOP MM to set the desired exit code. A program exiting without an explicit exit value returns unpredictable status, and may result in premature termination of the parallel application and misleading error messages. A well constructed MPI application should terminate with exit(0) or STOP 0 sometime after calling MPI_FINALIZE.

POE job step function

The POE job step function is intended for the execution of a sequence of separate yet interrelated dependent programs. Therefore, it provides you with a job control mechanism that allows both job step progression and job step termination. The job control mechanism is the program's exit code.

- Job step progression:

  POE continues the job step sequence if the program exit code is 0 or in the range of 2 through 127.
- Job-step termination:

  POE terminates the parallel job, and does not run any remaining user programs in the job step list if the program exit code is equal to 1 or greater than 127.
- Default termination:

  Any POE infrastructure detected failure (such as failure to open pipes to the child task, or an exec failure to start the user's executable) terminates the parallel job, and does not run any remaining user programs in the job step queue.

POE additions to the user executable

Legacy POE scripts **mpcc**, **mpCC**, and **mpxlf** are now symbolic links to **mpcc_r**, **mpCC_r**, and **mpxlf_r** respectively. The old command names are still used in some of the examples in the documentation.

POE links in the routines, that are described in the sections that follow, when your executable is compiled with any of the POE compilation scripts, such as: **mpcc_r** , **mpCC_r** or **mpxlf_r** . These topics are discussed:

- "Signal handlers" on page 28.
- "Handling signals" on page 28.
- "Do not hard code file descriptor numbers" on page 29.
- "Termination of a parallel job" on page 29.
- "Do not run your program as root" on page 30.
- "AIX function limitations" on page 30.
- "Shell execution" on page 30.
- "Do not rewind STDIN, STDOUT, or STDERR" on page 30.
- "Do not match blocking and nonblocking collectives" on page 30.
- "Passing string arguments to your program correctly" on page 31.
- "POE argument limits" on page 31.
- "Network tuning considerations" on page 31.
- "Standard I/O requires special attention" on page 32.
- "Reserved environment variables" on page 33.
- "Message catalog considerations" on page 33.
- "Language bindings" on page 33.
- "Available virtual memory segments" on page 34.

- "Using a switch clock as a time source" on page 34.
- "Running applications with large numbers of tasks" on page 35.
- "Running POE with MALLOCDEBUG" on page 35.

Signal handlers

POE installs signal handlers for most signals that cause program termination, so that it can notify the other tasks of termination. POE then causes the program to exit normally with a code of *signal* plus 128. This is information about installing your own signal handler for synchronous signals.

Note: For information about the way POE handles asynchronous signals, see "Handling signals."

For synchronous signals, you can install your own signal handlers by using the **sigaction()** system call. If you use **sigaction()**, you can use either the *sa_handler* member or the *sa_sigaction* member in the **sigaction** structure to define the signal handling function. If you use the *sa_sigaction* member, the SA_SIGINFO flag must be set.

For the following signals, POE installs signal handlers that use the **sa_sigaction** format:
- SIGABRT
- SIGBUS
- SIGEMT
- SIGFPE
- SIGILL
- SIGSEGV
- SIGSYS
- SIGTRAP

POE catches these signals, performs some cleanup, installs the default signal handler (or lightweight core file generation), and re-raises the signal, which will terminate the task.

Users can install their own signal handlers, but they should save the address of the POE signal handler, using a call to SIGACTION. If the user program decides to terminate, it should call the POE signal handler as follows:

```
saved.sa_flags =SA_SIGINFO;
(*saved.sa_sigaction)(signo,NULL,NULL)
```

If the user program decides not to terminate, it should just return to the interrupted code.

Note: Do not issue message passing calls, including MPI_ABORT, from signal handlers. Also, many library calls are not "signal safe", and should not be issued from signal handlers. See function **sigaction()** in the *AIX Technical Reference* for a list of functions that signal handlers can call.

Handling signals

The POE runtime environment creates a thread to handle the following asynchronous signals by performing a **sigwait** on them:
- SIGDANGER
- SIGHUP
- SIGINT

- SIGPWR
- SIGQUIT
- SIGTERM

These handlers perform cleanup and exit with a code of (*signal* plus 128). You can install your own signal handler for any or all of these signals. If you want the application to exit after you catch the signal, call the function **pm_child_sig_handler(signal,NULL,NULL)**. The prototype for this function is in file **/usr/lpp/ppe.poe/include/pm_util.h**.

These asynchronous signals are given special handling by PE:

SIGALRM

Unlike the now retired signal library, the threads library does not use SIGALRM, and long system calls are not interrupted by the message passing library. For example, **sleep** runs its entire duration unless interrupted by a user-generated event.

SIGIO

SIGIO is not used by the MPI library. A user-written signal handler will **not** be called when an MPI packet arrives. The user may use SIGIO for other I/O attention purposes, as required.

SIGPIPE

Some usage environments of the now retired signal library depended on MPI use of SIGPIPE. There is no longer any use of SIGPIPE by the MPI library.

Do not hard code file descriptor numbers

Do not use hard coded file descriptor numbers beyond those specified by STDIN, STDOUT and STDERR.

POE opens several files and uses file descriptors as handles for exchanging job management messages. These are allocated before the user gets control, so the first file descriptor allocated to a user is unpredictable.

Termination of a parallel job

POE provides for orderly termination of a parallel job, so that all tasks terminate at the same time. This is accomplished in the **atexit** routine registered at program initialization. For normal exits (codes 0, and 2 through 127), the **atexit** routine sends a control message to the POE home node, and waits for a positive response. For abnormal exits and those that do not go through the **atexit** routine, the **pmd** daemon catches the exit code and sends a control message to the POE home node.

For normal exits, when POE gets a control message for every task, it responds to each node, allowing the tasks on that node to exit normally with its individual exit code. The **pmd** daemon monitors the exit code and passes it back to the POE home node for presentation to the user.

For abnormal exits and those detected by **pmd**, POE sends a message to each **pmd** asking that it send a SIGTERM signal to its tasks, thereby terminating the task. When the task finally exits, **pmd** sends its exit code back to the POE home node and exits itself.

User-initiated termination of the POE home node with SIGINT **<Ctrl-c>** or SIGQUIT **<Ctrl-\>** causes a message to be sent to **pmd** asking that the appropriate signal be sent to the parallel task. Again, **pmd** waits for the tasks to exit, then terminates itself.

Do not run your program as root

To prevent uncontrolled root access to the entire parallel job computation resource, POE checks to see that the user is not root as part of its authentication.

AIX function limitations

Use of the following AIX function may be limited:

- **getuinfo** does not show terminal information, because the user program running in the parallel partition does not have an attached terminal.

Shell execution

The program executed by POE on the parallel nodes does not run under a shell on those nodes. Redirection and piping of STDIN, STDOUT, and STDERR applies to the POE home node (POE binary), and not the user's code. If shell processing of a command line is desired on the remote nodes, invoke a shell script on the remote nodes to provide the desired preprocessing before the user's application is invoked.

You can have POE run a shell script that is loaded and run on the remote nodes as if it were a binary file.

Due to an AIX limitation, if the program being run by POE is a shell script and there are more than five tasks being run per node, the script **must** be run under **ksh93** by using:

```
#!/bin/ksh93
```

on the first line of the script.

If the POE home node task is not started under the Korn shell, mounted file system names may not be mapped correctly to the names defined for the automount daemon or AIX equivalent. See the *IBM Parallel Environment: Operation and Use, Volume 1* for a discussion of alternative name mapping techniques.

Do not rewind STDIN, STDOUT, or STDERR

The partition manager daemon (**pmd**) uses pipes to direct STDIN, STDOUT and STDERR to the user's program. Therefore, do not rewind these files.

Do not match blocking and nonblocking collectives

The future use of **MPE_I** nonblocking collectives is deprecated, but only 64-bit executables are currently affected by this limitation.

Earlier versions of PE/MPI allowed matching of blocking (MPI) with nonblocking (MPE_I) collectives. With PE Version 4, it is advised that you do not match blocking and nonblocking collectives in the same collective operation. If you do, a hang situation can occur. It is possible that some existing applications may hang, when run using PE Version 4. In the case of an unexpected hang, turn on DEVELOP mode by setting the environment variable **MP_EUIDEVELOP** to **yes**, and rerun your application. DEVELOP mode will detect and report any mismatch. If DEVELOP mode identifies a mismatch, you may continue to use the application as is, by

setting **MP_SHARED_MEMORY** to **no**. If possible, alter the application to remove the matching of nonblocking with blocking collectives.

Passing string arguments to your program correctly

Quotation marks, either single or double, used as argument delimiters are stripped away by the shell and are never seen by **poe**. Therefore, the quotation marks must be escaped to allow the quoted string to be passed correctly to the remote tasks as one argument. For example, if you want to pass the following string to the user program (including the embedded blank)

```
a b
```

you need to enter the following:

```
poe user_program \"a b\"
```

user_program is passed the following argument as one token:

```
a b
```

Without the backslashes, the string would have been treated as two arguments (a *and* b).

POE behaves like **rsh** when arguments are passed to POE. Therefore, this command:

```
poe user_program "a b"
```

is equivalent to:

```
rsh some_machine user_program "a b"
```

In order to pass the string argument as one token, the quotation marks have to be escaped using the backslash.

POE argument limits

The maximum length for POE program arguments is 24576 bytes. This is a fixed limit and cannot be changed. If this limit is exceeded, an error message is displayed and POE terminates. The length of the remote program arguments that can be passed on POE's command line is 24576 bytes minus the number of bytes that are used for POE arguments.

Network tuning considerations

Programs generating large volumes of STDOUT or STDERR may overload the home node. As described previously, STDOUT and STDERR files generated by a user's program are piped to **pmd**, then forwarded to the POE binary using a TCP/IP socket. It is possible to generate so much data that the IP message buffers on the home node are exhausted, the POE binary hangs, and possibly the entire node hangs. Note that the option **-stdoutmode** (environment variable **MP_STDOUTMODE**) controls which output stream is displayed by the POE binary, but does not limit the standard output traffic received from the remote nodes, even when set to display the output of only one node.

The POE environment variable **MP_SNDBUF** can be used to override the default network settings for the size of the TCP/IP buffers used.

If you have large volumes of standard input or output, work with your network administrator to establish appropriate TCP/IP tuning parameters. You may also want to investigate whether using named pipes is appropriate for your application.

Standard I/O requires special attention

When your program runs on the remote nodes, it has no controlling terminal. STDIN, STDOUT, and STDERR are always piped.

Running the **poe** command (or starting a program compiled with one of the POE compile scripts) causes POE to perform this sequence of events:

1. The POE binary is loaded on the machine on which you submitted the command (the POE home node).
2. The POE binary, in turn, starts a partition manager daemon (**pmd**) on each parallel node assigned to run the job, and tells that **pmd** to run one or more copies of your executable (using **fork** and **exec**).
3. The POE binary reads STDIN and passes it to each **pmd** with a TCP/IP socket connection.
4. The **pmd** on each node pipes STDIN to the parallel tasks on that node.
5. STDOUT and STDERR from the tasks are piped to the **pmd** daemon.
6. This output is sent by the **pmd** on the TCP/IP socket back to the home node POE.
7. This output is written to the POE binary's STDOUT and STDERR descriptors.

Programs that depend on piping standard input or standard output as part of a processing sequence may wish to bypass the home node POE binary. If you know that the task reading STDIN or writing STDOUT must be on the same node as the POE binary (the POE home node), named pipes can be used to bypass POE's reading and forwarding STDIN and STDOUT.

Note

Earlier versions of Parallel Environment required the use of the **MP_HOLD_STDIN** environment variable in certain cases when redirected STDIN was used. The Parallel Environment components have now been modified to control the STDIN flow internally, so the use of this environment variable is no longer required, and will have no effect on STDIN handling.

STDIN and STDOUT piping example

The following two scripts show how STDIN and STDOUT can be piped directly between preprocessing and postprocessing steps, bypassing the POE home node task. This example assumes that parallel task 0 is known or forced to be on the same node as the POE home node.

The script **compute_home** runs on the home node; the script **compute_parallel** runs on the parallel nodes (those running tasks 0 through *n*-1).

```
compute_home:
#! /bin/ksh93
# Example script compute_home runs three tasks:
#    data_generator creates/gets data and writes to stdout
#    data_processor is a parallel program that reads data
#      from stdin, processes it in parallel, and writes
#      the results to stdout.
#    data_consumer reads data from stdin and summarizes it
#
mkfifo poe_in_$$
mkfifo poe_out_$$
export MP_STDOUTMODE=0
export MP_STDINMODE=0
data_generator >poe_in_$$ |
```

```
    poe compute_parallel poe_in_$$ poe_out_$$ data_processor |
    data_consumer <poe_out_$$
rc=$?
rm poe_in_$$
rm poe_out_$$
exit rc
```

```
compute_parallel:
#! /bin/ksh93
# Example script compute_parallel is a shell script that
#    takes the following arguments:
#    1) name of input named pipe (stdin)
#    2) name of output named pipe (stdout)
#    3) name of program to be run (and arguments)
#
poe_in=$1
poe_out=$2
shift 2
$*   <$poe_in   >$poe_out
```

Reserved environment variables

Environment variables whose name begins with **MP_** are intended for use by POE, and should be set only as instructed in the documentation. POE also uses a handful of **MP_** environment variables for internal purposes, which should not be interfered with.

If the value of **MP_INFOLEVEL** is greater than or equal to **1**, POE will display any **MP_** environment variables that it does not recognize, but POE will continue working normally.

Message catalog considerations

POE assumes that the environment variable **NLSPATH** contains the appropriate POE message catalogs, even if environment variable **LANG** is set to **C** or is not set. Duplicate message catalogs are provided for languages **En_US**, **en_US**, and **C**.

Language bindings

The FORTRAN, C, and C++ bindings for MPI are contained in the same library and can be freely intermixed. The library is named **libmpi_r.a**. Because it contains both 32-bit and 64-bit objects, and the compiler and linker select between them, **libmpi_r.a** can be used for both 32-bit and 64-bit applications.

The AIX compilers support the flag **-qarch**. This option allows you to target code generation for your application to a particular processor architecture. While this option can provide performance enhancements on specific platforms, it inhibits portability. The MPI library is not targeted to a specific architecture, and is not affected by the flag **-qarch** on your compilation.

The MPI standard includes several routines that take *choice* arguments. For example **MPI_SEND** may be passed a buffer of REAL on one call, and a buffer of INTEGER on the next. The **-qextcheck** compiler option identifies this as an error. In F77, *choice* arguments are a violation of the FORTRAN standard that few compilers would complain about. In F90, *choice* arguments can be interpreted by the compiler as an attempt to use function overloading. MPI FORTRAN functions do not require genuine overloading support to give correct results and PE MPI does not define overloaded functions for all potential *choice* arguments. Because **-qextcheck** considers use of *choice* arguments to be erroneous overloads, even though the code is correct MPI, the **-qextcheck** option should not be used. Note that the

-qextcheck option is specific to XLF. However, even if you are not using XLF, this concept may still apply because there may be similar switches on alternate compilers.

Available virtual memory segments

Note: The following discussion applies only for pSeries servers.

A 32-bit application is limited to 16 segments. The OS memory model for 32-bit applications claims several of these 16 segments. The application can allocate up to eight segments (2 GB) for application data (the heap, specified with compile option **-bmaxdata**). The communication subsystem takes a variable number of segments, depending on options chosen at run time. In some circumstances, for 32-bit applications the total demand for segments can be greater than 16 and a job will be unable to start or will run with reduced performance. If your application is using a very large heap and you consider enabling striping, see the migration section in *IBM Parallel Environment: Operation and Use, Volume 1* for details.

Using a switch clock as a time source

The high performance switch interconnects that supports user space also provide a globally-synchronized counter that can be used as a source for the MPI_WTIME function, provided that all tasks are run on nodes connected to the same switch interconnect. The environment variable **MP_CLOCK_SOURCE** provides additional control.

Table 2 shows how the clock source is determined. PE MPI guarantees that the MPI attribute MPI_WTIME_IS_GLOBAL has the same value at every task, and all tasks use the same clock source (AIX or switch).

Table 2. How the clock source is determined

MP_CLOCK _SOURCE	Library version	Are all nodes on the same switch?	Source used	MPI_WTIME _IS_GLOBAL
AIX	ip	yes	AIX	false
AIX	ip	no	AIX	false
AIX	us	yes	AIX	false
AIX	us	no	Error	false
SWITCH	ip	yes*	switch	true
SWITCH	ip	no	AIX	false
SWITCH	us	yes	switch	true
SWITCH	us	no	Error	
not set	ip	yes	switch	false
not set	ip	no	AIX	false
not set	us	yes	switch	true
not set	us	no	Error	
Note: * If **MPI_WTIME_IS_GLOBAL** value is to be trusted, the user is responsible for making sure all of the nodes are connected to the **same** switch. If the job is in IP mode and **MP_CLOCK_SOURCE** is left to default, **MPI_WTIME_IS_GLOBAL** will report false even if the switch is used because MPI cannot know it is the same switch.				
In this table, ip refers to IP protocol, us refers to User Space protocol.				

Running applications with large numbers of tasks

If you plan to run your parallel applications with a large number of tasks (more than 256), the following tips may improve stability and performance:

- To control the amount of memory made available for early arrival buffering, the environment variable **MP_BUFFER_MEM** or command-line flag **-buffer_mem** can accept the format *M1*, *M2* where each of *M1*, *M2* is a memory specification suffixed with K, M, or G.

  M1 specifies the amount of pre-allocated memory. *M2* specifies an upper bound on the amount of early arrival buffer memory that PE MPI allows the program to claim. See the entry for **MP_BUFFER_MEM** in *IBM Parallel Environment: Operation and Use, Volume 1* and Appendix E, "PE MPI buffer management for eager protocol," on page 205 for details.
- When using IP mode, use a host list file with names or addresses that belong to the parallel application communication network. If a cluster has an internal network that is dedicated to parallel application message passing, and is also tied into a wide area network that is not used for application messages, the host list addresses should be on the dedicated cluster network. IP mode does not require a dedicated cluster network, but having one will probably provide better performance than using the general purpose wider network.
- In 32-bit applications, you may avoid the problem of running out of memory by linking applications with an extended heap starting with data segment 3. For example, specifying the **-bD:0x30000000** loader option causes segments 3, 4, and 5 to be allocated to the heap. The default is to share data segment 2 between the stack and the heap.

For limitations on the number of tasks, tasks per node, and other restrictions, see Chapter 10, "MPI size limits," on page 63.

Running POE with MALLOCDEBUG

Running a POE job that uses MALLOCDEBUG with an align:n option of other than 8 may result in undefined behavior. To allow the parallel program being run by POE (**myprog**, for example) to run with an align:n option of other than 8, create the following script (called **myprog.sh**), for example:

```
MALLOCTYPE=debug
MALLOCDEBUG=align:0
myprog myprog_options
```

and then run with this command:

```
poe myprog.sh poe_options
```

instead of this command:

```
poe myprog poe_options myprog_options
```

Threaded programming

When programming in a threaded environment using POE and the MPI library, specific skills and considerations are required. It is assumed that you are familiar with POSIX threads in general, including multiple execution threads, thread condition waiting, thread-specific storage, thread creation and thread termination.

- "Running single threaded applications" on page 36.
- "POE gets control first and handles task initialization" on page 36.
- "Limitations in setting the thread stack size" on page 36.
- "Forks are limited" on page 37.

- "Threadsafe libraries" on page 37.
- "Program and thread termination" on page 37.
- "Order requirement for system includes" on page 37.
- "Using MPI_INIT or MPI_INIT_THREAD" on page 37.
- "Collective communication calls" on page 38.
- "Support for M:N threads" on page 38.
- "Checkpoint and restart limitations" on page 38.
- "64-bit application considerations" on page 42.
- "MPI_WAIT_MODE: the nopoll option" on page 43.
- "Mixed parallelism with MPI and threads" on page 43.

Running single threaded applications

PE Version 4 provides only the threaded version of the MPI library and program compiler scripts.

Applications that do not intend to use threads can continue to run as single threaded programs, despite the fact they are now compiled as threaded programs. However there are some side issues application developers should be aware of. Any application that was compiled with the signal library compiler scripts prior to PE Version 4 and not using MPE_I nonblocking collectives, is in this class.

Application performance may be impacted by locking overheads in the threaded MPI library. Users with applications that do not create additional threads and do not use the nonstandard MPE_I nonblocking collectives, MPI-IO, or MPI one-sided communication may wish to set the environment variable **MP_SINGLE_THREAD** to **yes** for a possible performance improvement. Applications that use small message sends and receives heavily are most likely to benefit. Many applications will see no obvious difference.

Do not set **MP_SINGLE_THREAD** to **yes** unless you are **certain** that the application is single threaded. Setting **MP_SINGLE_THREAD** to **yes**, and then creating additional user threads will give unpredictable results. Calling MPI_FILE_OPEN, MPI_WIN_CREATE or any MPE_I nonblocking collective in an application running with **MP_SINGLE_THREAD** set to **yes** will cause PE MPI to terminate the job. Setting **MP_SINGLE_THREAD=yes** as a system wide default may cause mysterious failures for any user who does not realize that the threadsafe guarantees of PE MPI have been disabled.

Also, applications that register signal handlers may need to be aware that the execution is in a threaded environment.

POE gets control first and handles task initialization

POE sets up its environment using the **poe_remote_main** entry point. The **poe_remote_main** entry point sets up signal handlers, initializes a thread for handling asynchronous communication, and sets up an **atexit** routine before your main program is invoked. MPI communication is established when you call MPI_INIT in your application, and not during **poe_remote_main**.

Limitations in setting the thread stack size

The main thread stack size is the same as the stack size used for non-threaded applications. Library-created service threads use a default stack size of 8K for 32-bit

applications and 16K for 64-bit applications. The default value is specified by the variable **PTHREAD_STACK_MIN**, which is defined in header file **/usr/include/limits.h**.

If you write your own MPI reduction functions to use with nonblocking collective communications, these functions may run on a service thread. If your reduction functions require significant amounts of stack space, you can use the **MP_THREAD_STACKSIZE** environment variable to cause larger stacks to be created for service threads. This does not affect the default stack size for any threads you create.

Note: The use of nonblocking collective communications functions is deprecated. Most MPI users will never have a need to alter the thread stack size.

Forks are limited

If a task forks, only the thread that forked exists in the child task. Therefore, the message passing library will not operate properly. Also, if the forked child does not exec another program, it should be aware that an **atexit** routine has been registered for the parent that is also inherited by the child. In most cases, the **atexit** routine requests that POE terminate the task (parent). A forked child should terminate with an **_exit(0)** system call to prevent the **atexit** routine from being called. Also, if the forked parent terminates before the child, the child task will not be cleaned up by POE.

Note: A forked child must **not** call the message passing library (MPI or LAPI).

Threadsafe libraries

Most programming libraries are threadsafe, such as **libc.a**. However, not all libraries have a threadsafe version. It is your responsibility to determine whether the programming libraries you use can be safely called by more than one thread.

Program and thread termination

MPI_FINALIZE terminates the MPI service threads but does not affect user-created threads. Use **pthread_exit** to terminate any user-created threads, and exit(*m*) to terminate the main program (initial thread). The value of *m* is used to set POE's exit status as explained in "Exit status" on page 26. For programs that are successful, the value for *m* should be zero.

Order requirement for system includes

For programs that explicitly use threads, AIX requires that the system include file **pthread.h** must be first, with **stdio.h** or other system includes following it. **pthread.h** defines some conditional compile variables that modify the code generation of subsequent includes, particularly **stdio.h**. Note that **pthread.h** is not required unless your program uses thread-related calls or data.

Using MPI_INIT or MPI_INIT_THREAD

Call MPI_INIT once per task, not once per thread. MPI_INIT does not have to be called on the main thread, but MPI_INIT and MPI_FINALIZE must be called on the same thread.

MPI calls on other threads must adhere to the MPI standard in regard to the following:

- A thread cannot make MPI calls until MPI_INIT has been called.

- A thread cannot make MPI calls after MPI_FINALIZE has been called.
- Unless there is a specific thread synchronization protocol provided by the application itself, you cannot rely on any specific order or speed of thread processing.

The MPI_INIT_THREAD call allows the user to request a level of thread support ranging from MPI_THREAD_SINGLE to MPI_THREAD_MULTIPLE. PE MPI ignores the request argument. If **MP_SINGLE_THREAD** is set to **yes**, MPI runs in a mode equivalent to MPI_THREAD_FUNNELED. IF **MP_SINGLE_THREAD** is set to **no**, or allowed to default, PE MPI runs in MPI_THREAD_MULTIPLE mode.

The nonstandard MPE_I nonblocking collectives, MPI-IO, and MPI one-sided communication will not operate if **MP_SINGLE_THREAD** is set to **yes**.

Collective communication calls

Collective communication calls must meet the MPI standard requirement that all participating tasks execute collective communication calls on any given communicator in the same order. If collective communications call are made on multiple threads, it is your responsibility to ensure the proper sequencing. The preferred approach is for each thread to use a distinct communicator.

Support for M:N threads

By default, AIX causes thread creation to use process scope. POE overrides this default by setting the environment variable **AIXTHREAD_SCOPE** to **S**, which has the effect that all user threads are created with system contention scope, with each user thread mapped to a kernel thread. If you explicitly set **AIXTHREAD_SCOPE** to **P**, to be able to create to your user threads with process contention scope, POE will not override your setting. In process scope, **M** number of user threads are mapped to **N** number of kernel threads. The values of the ratio **M:N** can be set by an AIX environment variable.

The service threads created by MPI, POE, and LAPI have system contention scope, that is, they are mapped 1:1 to kernel threads.

Any user-created thread that began with process contention scope, will be converted to system contention scope when it makes its first MPI call. Threads that must remain in process contention scope should not make MPI calls.

Checkpoint and restart limitations

Use of the checkpoint and restart function has certain limitations. If planning to use the checkpoint and restart function, you need to be aware of the types of programs that cannot be checkpointed. You also need to be aware of certain program, operating system, mode, and other restrictions.

Programs that cannot be checkpointed

The following programs cannot be checkpointed:

- Programs that do not have the environment variable **CHECKPOINT** set to **yes**.
- Programs that are being run under:
  - The dynamic probe class library (DPCL).
  - Any debugger that is not checkpoint/restart-capable.
- Processes that use:
  - Extended **shmat** support
  - Pinned shared memory segments

- Sets of processes in which any process is running a **setuid** program when a checkpoint occurs.
- Jobs for which POE input or output is a pipe.
- Jobs for which POE input or output is redirected, unless the job is submitted from a shell that had the **CHECKPOINT** environment variable set to **yes** before the shell was started. If POE is run from inside a shell script and is run in the background, the script must be started from a shell started in the same manner for the job to be able to be checkpointed.
- Jobs that are run using the switch or network table sample programs.
- Interactive POE jobs for which the **su** command was used prior to checkpointing or restarting the job.
- User space programs that are not run under a resource manager that communicates with POE (for example, LoadLeveler).

Program restrictions

Any program that meets both these criteria:

- is compiled with one of the threaded compile scripts provided by PE
- may be checkpointed prior to its main() function being invoked

must wait for the **0031-114** message to appear in POE's STDERR before issuing the checkpoint of the parallel job. Otherwise, a subsequent restart of the job may fail.

Note: The **MP_INFOLEVEL** environment variable, or the **-infolevel** command-line option, must be set to a value of at least 2 for this message to appear.

Any program that meets both these criteria:

- is compiled with one of the threaded compile scripts provided by PE
- may be checkpointed immediately after the parallel job is restarted

must wait for the **0031-117** message to appear in POE's STDERR before issuing the checkpoint of the restarted job. Otherwise, the checkpoint of the job may fail.

Note: The **MP_INFOLEVEL** environment variable, or the **-infolevel** command line option, must be set to a value of at least 2 for this message to appear.

AIX function restrictions

The following AIX functions will fail, with an errno of ENOTSUP, if the **CHECKPOINT** environment variable is set to **yes** in the environment of the calling program:

clock_getcpuclockid()
clock_getres()
clock_gettime()
clock_nanosleep()
clock_settime()
mlock()
mlockall()
mq_close()
mq_getattr()
mq_notify()
mq_open()
mq_receive()
mq_send()
mq_setattr()
mq_timedreceive()

mq_timedsend()
mq_unlink()
munlock()
munlockall()
nanosleep()
pthread_barrierattr_init()
pthread_barrierattr_destroy()
pthread_barrierattr_getpshared()
pthread_barrierattr_setpshared()
pthread_barrier_destroy()
pthread_barrier_init()
pthread_barrier_wait()
pthread_condattr_getclock()
pthread_condattr_setclock()
pthread_getcpuclockid()
pthread_mutexattr_getprioceiling()
pthread_mutexattr_getprotocol()
pthread_mutexattr_setprioceiling()
pthread_mutexattr_setprotocol()
pthread_mutex_getprioceiling()
pthread_mutex_setprioceiling()
pthread_mutex_timedlock()
pthread_rwlock_timedrdlock()
pthread_rwlock_timedwrlock()
pthread_setschedprio()
pthread_spin_destroy()
pthread_spin_init()
pthread_spin_lock()
pthread_spin_trylock()
pthread_spin_unlock()
sched_getparam()
sched_get_priority_max()
sched_get_priority_min()
sched_getscheduler()
sched_rr_get_interval()
sched_setparam()
sched_setscheduler()
sem_close()
sem_destroy()
sem_getvalue()
sem_init()
sem_open()
sem_post()
sem_timedwait()
sem_trywait()
sem_unlink()
sem_wait()
shm_open()
shm_unlink()
timer_create()
timer_delete()
timer_getoverrun()
timer_gettime()
timer_settime()

Node restrictions

The node on which a process is restarted must have:

- The same operating system level (including PTFs). In addition, a restarted process may not load a module that requires a system call from a kernel extension that was not present at checkpoint time.
- The same switch type as the node where the checkpoint occurred.
- The capabilities enabled in **/etc/security/user** that were enabled for that user on the node on which the checkpoint operation was performed.

If any threads in the parallel task were bound to a specific processor ID at checkpoint time, that processor ID must exist on the node where that task is restarted.

Task-related restrictions

- The number of tasks and the task geometry (the tasks that are common within a node) must be the same on a restart as it was when the job was checkpointed.
- Any regular file open in a parallel task when that task is checkpointed must be present on the node where that task is restarted, including the executable and any dynamically loaded libraries or objects.
- If any task within a parallel application uses sockets or pipes, user callbacks should be registered to save data that may be in transit when a checkpoint occurs, and to restore the data when the task is resumed after a checkpoint or restart. Similarly, any user shared memory should be saved and restored.

Pthread and atomic lock restrictions

- A checkpoint operation will not begin on a parallel task until each user thread in that task has released all pthread locks, if held.

  This can potentially cause a significant delay from the time a checkpoint is issued until the checkpoint actually occurs. Also, any thread of a process that is being checkpointed that does not hold any pthread locks and tries to acquire one will be stopped immediately. There are no similar actions performed for atomic locks (**_check_lock** and **_clear_lock**, for example).
- Atomic locks must be used in such a way that they do not prevent the releasing of pthread locks during a checkpoint.

  For example, if a checkpoint occurs and thread 1 holds a pthread lock and is waiting for an atomic lock, and thread 2 tries to acquire a different pthread lock (and does not hold any other pthread locks) before releasing the atomic lock that thread 1 is waiting for, the checkpoint will hang.
- If a pthread lock is held when a parallel task creates a new process (either implicitly using **popen**, for example, or explicitly using **fork** or **exec**) and the releasing of the lock is contingent on some action of the new process, the **CHECKPOINT** environment variable must be set to **no** before causing the new process to be created.

  Otherwise, the parent process may be checkpointed (but not yet stopped) before the creation of the new process, which would result in the new process being checkpointed and stopped immediately.
- A parallel task must not hold a pthread lock when creating a new process (either implicitly using **popen** for example, or explicitly using **fork**) if the releasing of the lock is contingent on some action of the new process.

  Otherwise a checkpoint could occur that would cause the child process to be stopped before the parent could release the pthread lock causing the checkpoint operation to hang.
- The checkpoint operation may hang if any user pthread locks are held across:

- Any collective communication calls in MPI (or if LAPI is being used in the application, LAPI).
- Calls to **mpc_init_ckpt** or **mp_init_ckpt**.
- Any blocking MPI call that returns only after action on some other task.

Other restrictions

- Processes cannot be profiled at the time a checkpoint is taken.
- There can be no devices other than TTYs or **/dev/null** open at the time a checkpoint is taken.
- Open files must either have an absolute pathname that is less than or equal to PATHMAX in length, or must have a relative pathname that is less than or equal to PATHMAX in length from the current directory at the time they were opened. The current directory must have an absolute pathname that is less than or equal to PATHMAX in length.
- Semaphores or message queues that are used within the set of processes being checkpointed must only be used by processes within the set of processes being checkpointed.

  This condition is not verified when a set of processes is checkpointed. The checkpoint and restart operations will succeed, but inconsistent results can occur after the restart.
- The processes that create shared memory must be checkpointed with the processes using the shared memory if the shared memory is ever detached from all processes being checkpointed. Otherwise, the shared memory may not be available after a restart operation.
- The ability to checkpoint and restart a process is not supported for B1 and C2 security configurations.
- A process can checkpoint another process only if it can send a signal to the process.

  In other words, the privilege checking for checkpointing processes is identical to the privilege checking for sending a signal to the process. A privileged process (the effective user ID is **0**) can checkpoint any process. A set of processes can only be checkpointed if each process in the set can be checkpointed.
- A process can restart another process only if it can change its entire privilege state (real, saved, and effective versions of user ID, group ID, and group list) to match that of the restarted process.
- A set of processes can be restarted only if each process in the set can be restarted.

64-bit application considerations

Support for 64-bit applications is provided in the MPI library. You can choose 64-bit support by specifying **-q64** as a compiler flag, or by setting the environment variable **OBJECT_MODE** to **64** at compile and link time. **All** objects in a 64-bit environment must be compiled with **-q64**. You cannot call a 32-bit library from a 64-bit application, nor can you call a 64-bit library from a 32-bit application.

Integers passed to the MPI library are always 32 bits long. If you use the FORTRAN compiler directive **-qintsize=8** as your default integer length, you will need to type your MPI integer arguments as INTEGER*4. All integer parameters in **mpif.h** are explicitly declared INTEGER*4 to prevent **-qintsize=8** from altering their length.

As defined by the MPI standard, the *count* argument in MPI send and receive calls is a default size signed integer. In AIX, even 64-bit executables use 32-bit integers by default. To send or receive extremely large messages, you may need to construct your own data type (for example, a 'page' data type of 4096 contiguous bytes).

The FORTRAN compilation scripts **mpxlf_r**, **mpxlf90_r**, and **mpxlf95_r**, set the include path for **mpif.h** to: **/usr/lpp/ppe.poe/include/thread64** or **/usr/lpp/ppe.poe/include/thread**, as appropriate. Do not add a separate include path to **mpif.h** in your compiler scripts or make files, as an incorrect version of **mpif.h** could be picked up in compilation, resulting in subtle run time errors.

The AIX 64-bit address space is large enough to remove any limitations on the number of memory segments that can be used, so the information in "Available virtual memory segments" on page 34 does not apply to the 64-bit library.

MPI_WAIT_MODE: the nopoll option

Environment variable **MPI_WAIT_MODE** set to **nopoll** is supported as an option. It causes a blocking MPI call to go into a system wait after approximately one millisecond of polling without a message being received. **MPI_WAIT_MODE** set to **nopoll** may reduce CPU consumption for applications that post a receive call on a separate thread, and that receive call does not expect an immediate message arrival. Also, using **MPI_WAIT_MODE** set to **nopoll** may increase delay between message arrival and the blocking call's return. It is recommended that **MP_CSS_INTERRUPT** be set to **yes** when the **nopoll** wait is selected, so that the system wait can be interrupted by the arrival of a message. Otherwise, the **nopoll** wait is interrupted at the timing interval set by **MP_POLLING_INTERVAL**.

Mixed parallelism with MPI and threads

The MPI programming model provides parallelism by using multiple tasks that communicate by making message passing calls. Many of these MPI calls can block until some action occurs on another task. Examples include collective communication, collective **MPI-IO**, **MPI_SEND**, **MPI_RECV**, **MPI_WAIT**, and the synchronizations for MPI one-sided.

The threads model provides parallelism by running multiple execution streams in a single address space, and can depend on data object protection or order enforcement by mutex lock. Threads waiting for a mutex are blocked until the thread holding the mutex releases it. The thread holding the mutex will not release it until it completes whatever action it took the lock to protect. If you choose to do mutex lock protected threads parallelism and MPI task parallelism in a single application, you must be careful not to create interlocks between blocking by MPI call and blocking on mutex locks. The most obvious rule is: avoid making a blocking MPI call while holding a mutex.

OpenMP and MPI in a single application offers relative safety because the OpenMP model normally involves distinct parallel sections in which several threads are spawned at the beginning of the section and joined at the end. The communication calls occur on the main thread and outside of any parallel section, so they do not require mutex protection. This segregation of threaded epochs from communication epochs is safe and simple, whether you use OpenMP or provide your own threads parallelism. PE MPI works correctly when MPI calls are made within a parallel section, but may not match up the way you expect. If you try this, be careful.

The threads parallelism model in which some number of threads proceed in a more or less independent way, but protect critical sections (periods of protected access to a shared data object) with locks requires more care. In this model, there is much more chance you will hold a lock while doing a blocking MPI operation related to some shared data object. Many MPI communications problems can be avoided by creating distinct communicators for use by the various weakly synchronized threads.

Using MPI and LAPI in the same program

You can use MPI and LAPI concurrently in the same parallel program. Their operation is logically independent of one another, and you can specify independently whether each uses the User Space protocol or the IP protocol.

If both MPI and LAPI use the same protocol (either User Space or IP), you can choose to have them share the underlying packet protocol (User Space or UDP). You do this by setting the POE environment variable **MP_MSG_API** to **mpi_lapi**. If you do not wish to share the underlying packet protocol, set **MP_MSG_API** to **mpi,lapi**.

In User Space, running with shared resource **MP_MSG_API** set to **mpi_lapi** causes LoadLeveler to allocate only one window for the MPI/LAPI pair, rather than two windows. Since each window takes program resources (segment registers, memory for DMA send and receive FIFOs, adapter buffers and network tables), sharing the window makes sense if MPI and LAPI are communicating at different times (during different phases of the program). If MPI and LAPI are doing concurrent communication, the DMA receive buffer may be too small to contain packets from both LAPI and MPI, and packets may be dropped. This may impair performance.

The **MP_CSS_INTERRUPT** environment variable applies only to the MPI API. At MPI_INIT time, MPI sets the protocol for the LAPI instance that MPI is using, according to MPI defaults or as indicated by environment variable **MP_CSS_INTERRUPT**. In nonshared mode, MPI retains control of the LAPI instance that it is using. If there is use of the LAPI API in the same application, the LAPI_Senv() function can be used to control interrupts for the LAPI API instance, without affecting the instance that MPI is using.

In shared mode, MPI_INIT sets interrupt behavior of its LAPI instance, just as in non-shared mode, but MPI has no way to recognize or control changes to the interrupt mode of this shared instance that may occur later through the LAPI_Senv() function. Unexpected changes in interrupt mode made with the LAPI API to the LAPI instance being shared with MPI can affect MPI performance, but will not affect whether a valid MPI program runs correctly.

In IP, running with shared resource **MP_MSG_API** set to **mpi_lapi** uses only one pair of UDP ports, while running with separated resource **MP_MSG_API** set to **mpi,lapi** uses two pair of UDP ports. In the separated case, there may be a slight increase in job startup time due to the need for POE to communicate two sets of port lists.

Differences between MPI in PE 3.2 and PE Version 4

PE 3.2 MPI used an underlying transport layer called MPCI, which provided a **reliable byte stream** interface, in which user's data was copied to a **send pipe** with a size up to 64 KB, which was then broken into packets and sent to the receiver. The receiver assembled the received packets into a **receive pipe**, and populated the user's data reads from the receive pipe. For programs with large

numbers of tasks, the amount of memory allocated to pipes became quite large, and reduced the amount of storage available for user data.

In PE Version 4, MPI uses an underlying transport called LAPI, which is distributed as an AIX fileset, part of the RSCT component. In contrast to the **reliable byte stream** approach of MPCI, LAPI provides a **reliable message** protocol, which uses much less storage for jobs with a large number of tasks.

Because the underlying transport mechanism is so different, POE MPI environment variables used to tune MPCI performance are, in some cases, ignored. Also, there are new environment variables to tune the LAPI operation. The following variables, and their corresponding command-line options, are now ignored:

- **MP_INTRDELAY**, and the corresponding function **mp_intrdelay**
- **MP_SYNC_ON_CONNECT**
- **MP_PIPE_SIZE**
- **MP_ACK_INTERVAL**

The following variables are new. A brief description of their intended function is provided. For more details, see *IBM Parallel Environment: Operation and Use, Volume 1*.

MP_UDP_PACKET_SIZE
Specifies the UDP datagram size to be used for UDP/IP message transport.

MP_ACK_THRESH
Sets the threshold for return packet flow control acknowledgements.

MP_USE_BULK_XFER
Causes the use of the Remote Direct Memory Access (RDMA) capability. See "Remote Direct Memory Access (RDMA) considerations" on page 9.

Differences between MPI in PE 4.1 and PE 4.2

- Environment variable **MP_SHARED_MEMORY** now has a default of **yes**.
- Environment variable **MP_BUFFER_MEM** has been enhanced. See *IBM Parallel Environment: Operation and Use, Volume 1*.

Other differences

- Handling shared memory. See Chapter 3, "Using shared memory," on page 15.
- The MPI communication subsystem is activated at MPI_INIT and closed at MPI_FINALIZE. When MPI and LAPI share the subsystem, whichever call comes first between MPI_INIT and LAPI_INIT will provide the activation. Whichever call comes last between MPI_FINALIZE and LAPI_TERM will close it.
- Additional service threads. See "MPI Stack Threads."

MPI Stack Threads

Your parallel program is normally run under the control of POE. The communication stack includes MPI, LAPI, and the hardware interface layer. The communication stack also provides access to the global switch clock. This stack makes use of several internally spawned threads. The options under which the job is run affect which threads are created, therefore some, but not all, of the threads listed below are created in a typical application run. Most of these threads sleep in the kernel waiting for notification of some rare condition and do not compete for CPU access during normal job processing. When a job is run in polling mode, there will normally be little CPU demand by threads other than the users' application threads. Polling

mode refers to setting **MP_CSS_INTERRUPT** to *no* (off) and using blocking MPI calls when communication is required. Using one or more nonblocking MPI calls followed immediately by some form of MPI_WAIT is a blocking communication style. Having computation between the nonblocking MPI calls and the MPI_WAIT is usually a attempt to use a nonblocking style.

MPI service threads can be spawned to handle MPE_I nonblocking collective communication and MPI-IO. The threads are spawned as needed and kept for reuse. An application that uses none of these functions will not have any of these threads. An application that uses MPE_I nonblocking collective communication, MPI-IO, or MPI one-sided communication will spawn one or more MPI service threads at first need. When the operation that required the thread finishes, the thread will be left sleeping in the kernel and will be visible in the debugger. At a subsequent need, if a sleeping thread is available, it is triggered for reuse to carry out the nonblocking collective communication MPI-IO and MPI one-sided operation. While waiting to be reused, the threads do not consume significant resources. The MPE_I, MPI-IO, or MPI one-sided API call that triggers one of these service threads to run in a given task can, and usually does, come from some remote task. There can be substantial CPU usage by these threads when nonblocking collective communication MPI-IO, or MPI one-sided communication is active.

This information is provided to help you understand what you will see in a debugger when examining an MPI task. You can almost always ignore the service threads in your debugging but you may need to find your own thread (or threads) before you can understand your application behavior. The **dbx** commands **threads** and **thread current n** are useful for displaying the threads list and switching focus to the thread you need to debug.

This list shows the POE/MPI/LAPI threads that you are likely to see, in order of thread creation. The list assumes shared memory over two windows, MPI only. Simpler environments (depending on options selected) will involve fewer threads. There may also be other situations in which you will see more threads.

T1 User's main program

T2 POE asynchronous exit thread (SIGQUIT, SIGTERM, and so forth)

T3 Hardware interface layer device interrupt/timer thread

T4 Hardware interface layer fault service handler thread

T5 LAPI Completion handler thread (one default)

T6 LAPI Shared memory dispatcher (shared memory only)

T7 Switch clock service thread

T8 MPI Service threads (if MPE_I nonblocking collective communication or MPI-IO used). As many as eight are created as required.

Chapter 6. Using error handlers - predefined error handler for C++

The C++ language interface for MPI includes the predefined error handler MPI::ERRORS_THROW_EXCEPTIONS for use with MPI::Comm::Set_errhandler, MPI::File::Set_errhandler, and MPI::Win::Set_errhandler.

MPI::ERRORS_THROW_EXCEPTIONS can be set or retrieved only by C++ functions. If a non-C++ program causes an error that invokes the MPI::ERRORS_THROW_EXCEPTIONS error handler, the exception will pass up the calling stack until C++ code can catch it. If there is no C++ code to catch it, the behavior is undefined.

The error handler MPI::ERRORS_THROW_EXCEPTIONS causes an MPI::Exception to be thrown for any MPI result code other than MPI::SUCCESS.

The C++ bindings for exceptions follow:

```
namespace MPI [

Exception::Exception(int error_code);
int Exception::Get_error_code() const;
int Exception::Get_error_class() const;
const char* Exception::Get_error_string() const;

];
```

The public interface to MPI::Exception class is defined as follows:

```
namespace MPI [
  class Exception [
  public:

Exception(int error_code);

int Get_error_code() const;
    int Get_error_class() const;
    const char *Get_error_string() const;
  ];
];
```

The PE MPI implementation follows:

```
public:

      Exception(int ec) : error_code(ec)
      [
        (void)MPI_Error_class(error_code, &error_class);
        int resultlen;
        (void)MPI_Error_string(error_code, error_string, &resultlen);
      ]

      virtual ~Exception(){ }


      virtual int Get_error_code() const
      [
        return error_code;
      ]

      virtual int Get_error_class() const
      [
        return error_class;
```

```
    ]

    virtual const char* Get_error_string() const
    [
      return error_string;
    ]

  protected:

    int  error_code;
    char error_string[MPI_MAX_ERROR_STRING];
    int  error_class;

};
```

Chapter 7. Predefined MPI data types

These are the predefined MPI data types that you can use with MPI:

- "Special purpose data types"
- "Data types for C language bindings"
- "Data types for FORTRAN language bindings"
- "Data types for reduction functions (C reduction types)" on page 50
- "Data types for reduction functions (FORTRAN reduction types)" on page 50

Special purpose data types

Data type	Description
MPI_BYTE	Untyped byte data
MPI_LB	Explicit lower bound marker
MPI_PACKED	Packed data (byte)
MPI_UB	Explicit upper bound marker

Data types for C language bindings

Data type	Description
MPI_CHAR	8-bit character
MPI_DOUBLE	64-bit floating point
MPI_FLOAT	32-bit floating point
MPI_INT	32-bit integer
MPI_LONG	32-bit integer
MPI_LONG_DOUBLE	64-bit floating point
MPI_LONG_LONG	64-bit integer
MPI_LONG_LONG_INT	64-bit integer
MPI_SHORT	16-bit integer
MPI_SIGNED_CHAR	8-bit signed character
MPI_UNSIGNED	32-bit unsigned integer
MPI_UNSIGNED_CHAR	8-bit unsigned character
MPI_UNSIGNED_LONG	32-bit unsigned integer
MPI_UNSIGNED_LONG_LONG	64-bit unsigned integer
MPI_UNSIGNED_SHORT	16-bit unsigned integer
MPI_WCHAR	Wide (16-bit) unsigned character

Data types for FORTRAN language bindings

Data type	Description
MPI_CHARACTER	8-bit character

MPI_COMPLEX	32-bit floating point real, 32-bit floating point imaginary
MPI_COMPLEX8	32-bit floating point real, 32-bit floating point imaginary
MPI_COMPLEX16	64-bit floating point real, 64-bit floating point imaginary
MPI_COMPLEX32	128-bit floating point real, 128-bit floating point imaginary
MPI_DOUBLE_COMPLEX	64-bit floating point real, 64-bit floating point imaginary
MPI_DOUBLE_PRECISION	64-bit floating point
MPI_INTEGER	32-bit integer
MPI_INTEGER1	8-bit integer
MPI_INTEGER2	16-bit integer
MPI_INTEGER4	32-bit integer
MPI_INTEGER8	64-bit integer
MPI_LOGICAL	32-bit logical
MPI_LOGICAL1	8-bit logical
MPI_LOGICAL2	16-bit logical
MPI_LOGICAL4	32-bit logical
MPI_LOGICAL8	64-bit logical
MPI_REAL	32-bit floating point
MPI_REAL4	32-bit floating point
MPI_REAL8	64-bit floating point
MPI_REAL16	128-bit floating point

Data types for reduction functions (C reduction types)

Data type	Description
MPI_DOUBLE_INT	{MPI_DOUBLE, MPI_INT}
MPI_FLOAT_INT	{MPI_FLOAT, MPI_INT}
MPI_LONG_DOUBLE_INT	{MPI_LONG_DOUBLE, MPI_INT}
MPI_LONG_INT	{MPI_LONG, MPI_INT}
MPI_SHORT_INT	{MPI_SHORT, MPI_INT}
MPI_2INT	{MPI_INT, MPI_INT}

Data types for reduction functions (FORTRAN reduction types)

Data type	Description
MPI_2COMPLEX	{MPI_COMPLEX, MPI_COMPLEX}
MPI_2DOUBLE_PRECISION	{MPI_DOUBLE_PRECISION, MPI_DOUBLE_PRECISION}

	MPI_2INTEGER	{MPI_INTEGER, MPI_INTEGER}
	MPI_2REAL	{MPI_REAL, MPI_REAL}

Chapter 8. MPI reduction operations

These are the **predefined reduction operations** for use with MPI_ACCUMULATE, MPI_ALLREDUCE, MPI_EXSCAN, MPI_REDUCE, MPI_REDUCE_SCATTER, and MPI_SCAN. To invoke a predefined operation, place any of the following reductions in variable *op*.

Operation	Description
MPI_BAND	bitwise AND
MPI_BOR	bitwise OR
MPI_BXOR	bitwise XOR
MPI_LAND	logical AND
MPI_LOR	logical OR
MPI_LXOR	logical XOR
MPI_MAX	maximum value
MPI_MAXLOC	maximum value and location
MPI_MIN	minimum value
MPI_MINLOC	minimum value and location
MPI_PROD	product
MPI_REPLACE	*f(a,b) = b* (the current value in the target memory is replaced by the value supplied by the origin)
MPI_SUM	sum

This is a list of the basic **data type arguments of the reduction operations**:

Type	Arguments
Byte	MPI_BYTE
C integer	MPI_INT MPI_LONG MPI_LONG_LONG_INT MPI_SHORT MPI_UNSIGNED MPI_UNSIGNED_LONG MPI_UNSIGNED_LONG_LONG MPI_UNSIGNED_SHORT
C pair	MPI_DOUBLE_INT MPI_FLOAT_INT MPI_LONG_INT MPI_LONG_DOUBLE_INT MPI_SHORT_INT MPI_2INT
Complex	MPI_COMPLEX
Floating point	MPI_DOUBLE MPI_DOUBLE_PRECISION MPI_FLOAT MPI_LONG_DOUBLE MPI_REAL

FORTRAN integer	MPI_INTEGER MPI_INTEGER8
FORTRAN pair	MPI_2DOUBLE_PRECISION MPI_2INTEGER MPI_2REAL
Logical	MPI_LOGICAL

This is a list of the **valid data types for each op option**:

Type	**Data types**
Byte	MPI_BAND MPI_BOR MPI_BXOR MPI_REPLACE
C integer	MPI_BAND MPI_BOR MPI_BXOR MPI_LAND MPI_LOR MPI_LXOR MPI_MAX MPI_MIN MPI_PROD MPI_REPLACE MPI_SUM
C pair	MPI_MAXLOC MPI_MINLOC MPI_REPLACE
Complex	MPI_PROD MPI_REPLACE MPI_SUM
Floating point	MPI_MAX MPI_MIN MPI_PROD MPI_REPLACE MPI_SUM
FORTRAN integer	MPI_BAND MPI_BOR MPI_BXOR MPI_MAX MPI_MIN MPI_PROD MPI_REPLACE MPI_SUM
FORTRAN pair	MPI_MAXLOC MPI_MINLOC MPI_REPLACE
Logical	MPI_LAND MPI_LOR MPI_LXOR MPI_REPLACE

Examples of MPI reduction operations

These are examples of user-defined reduction functions for integer vector addition.

C example

```
void int_sum (int *in, int *inout,
     int *len, MPI_Datatype *type);

{
   int i
   for (i=0; i<*len; i++)  {
      inout[i] + = in[i];
   }
}
```

FORTRAN example

```
      SUBROUTINE INT_SUM(IN,INOUT,LEN,TYPE)

      INTEGER IN(*),INOUT(*),LEN,TYPE,I

      DO I = 1,LEN
         INOUT(I) = IN(I) + INOUT(I)
      ENDDO
      END
```

User-supplied reduction operations have four arguments:

- The first argument, **in**, is an array or scalar variable. The length, in elements, is specified by the third argument, **len**.

  This argument is an input array to be reduced.
- The second argument, **inout**, is an array or scalar variable. The length, in elements, is specified by the third argument, **len**.

  This argument is an input array to be reduced and the result of the reduction will be placed here.
- The third argument, **len** is the number of elements in **in** and **inout** to be reduced.
- The fourth argument **type** is the data type of the elements to be reduced.

Users may code their own reduction operations, with the restriction that the operations must be associative. Also, C programmers should note that the values of **len** and **type** will be passed by reference. No communication calls are allowed in user-defined reduction operations. See “Limitations in setting the thread stack size” on page 36 for thread stack size considerations if you are using the deprecated MPE_I nonblocking reduction operations with your own reduction functions.

Chapter 9. C++ MPI constants

This chapter lists C++ MPI constants, including the following:

- "Error classes"
- "Maximum sizes" on page 58
- "Environment inquiry keys" on page 58
- "Predefined attribute keys" on page 58
- "Results of communicator and group comparisons" on page 59
- "Topologies" on page 59
- "File operation constants" on page 59
- "MPI-IO constants" on page 59
- "One-sided constants" on page 59
- "Combiner constants used for data type decoding functions" on page 59
- "Assorted constants" on page 60
- "Collective constants" on page 60
- "Error handling specifiers" on page 60
- "Special data types for construction of derived data types" on page 60
- "Elementary data types (C and C++)" on page 60
- "Elementary data types (FORTRAN)" on page 61
- "Data types for reduction functions (C and C++)" on page 61
- "Data types for reduction functions (FORTRAN)" on page 61
- "Optional data types" on page 61
- "Collective operations" on page 61
- "Null handles" on page 62
- "Empty group" on page 62
- "Threads constants" on page 62
- "FORTRAN 90 data type matching constants" on page 62

Error classes

MPI::SUCCESS
MPI::ERR_BUFFER
MPI::ERR_COUNT
MPI::ERR_TYPE
MPI::ERR_TAG
MPI::ERR_COMM
MPI::ERR_RANK
MPI::ERR_REQUEST
MPI::ERR_ROOT
MPI::ERR_GROUP
MPI::ERR_OP
MPI::ERR_TOPOLOGY
MPI::ERR_DIMS
MPI::ERR_ARG
MPI::ERR_UNKNOWN
MPI::ERR_TRUNCATE
MPI::ERR_OTHER
MPI::ERR_INTERN
MPI::ERR_IN_STATUS

MPI::ERR_PENDING
MPI::ERR_INFO_KEY
MPI::ERR_INFO_VALUE
MPI::ERR_INFO_NOKEY
MPI::ERR_INFO
MPI::ERR_FILE
MPI::ERR_NOT_SAME
MPI::ERR_AMODE
MPI::ERR_UNSUPPORTED_DATAREP
MPI::ERR_UNSUPPORTED_OPERATION
MPI::ERR_NO_SUCH_FILE
MPI::ERR_FILE_EXISTS
MPI::ERR_BAD_FILE
MPI::ERR_ACCESS
MPI::ERR_NO_SPACE
MPI::ERR_QUOTA
MPI::ERR_READ_ONLY
MPI::ERR_FILE_IN_USE
MPI::ERR_DUP_DATAREP
MPI::ERR_CONVERSION
MPI::ERR_IO
MPI::ERR_WIN
MPI::ERR_BASE
MPI::ERR_SIZE
MPI::ERR_DISP
MPI::ERR_LOCKTYPE
MPI::ERR_ASSERT
MPI::ERR_RMA_CONFLICT
MPI::ERR_RMA_SYNC
MPI::ERR_NO_MEM
MPI::ERR_LASTCODE

Maximum sizes

MPI::MAX_ERROR_STRING
MPI::MAX_PROCESSOR_NAME
MPI::MAX_FILE_NAME
MPI::MAX_DATAREP_STRING
MPI::MAX_INFO_KEY
MPI::MAX_INFO_VAL
MPI::MAX_OBJECT_NAME

Environment inquiry keys

MPI::TAG_UB
MPI::IO
MPI::HOST
MPI::WTIME_IS_GLOBAL

Predefined attribute keys

MPI::LASTUSEDCODE
MPI::WIN_BASE
MPI::WIN_SIZE
MPI::WIN_DISP_UNIT

Results of communicator and group comparisons

MPI::IDENT
MPI::CONGRUENT
MPI::SIMILAR
MPI::UNEQUAL

Topologies

MPI::GRAPH
MPI::CART

File operation constants

MPI::SEEK_SET
MPI::SEEK_CUR
MPI::SEEK_END
MPI::DISTRIBUTE_NONE
MPI::DISTRIBUTE_BLOCK
MPI::DISTRIBUTE_CYCLIC
MPI::DISTRIBUTE_DFLT_DARG
MPI::ORDER_C
MPI::ORDER_FORTRAN
MPI::DISPLACEMENT_CURRENT

MPI-IO constants

MPI::MODE_RDONLY
MPI::MODE_WRONLY
MPI::MODE_RDWR
MPI::MODE_CREATE
MPI::MODE_APPEND
MPI::MODE_EXCL
MPI::MODE_DELETE_ON_CLOSE
MPI::MODE_UNIQUE_OPEN
MPI::MODE_SEQUENTIAL
MPI::MODE_NOCHECK
MPI::MODE_NOSTORE
MPI::MODE_NOPUT
MPI::MODE_NOPRECEDE
MPI::MODE_NOSUCCEED

One-sided constants

MPI::LOCK_EXCLUSIVE
MPI::LOCK_SHARED

Combiner constants used for data type decoding functions

MPI::COMBINER_NAMED
MPI::COMBINER_DUP
MPI::COMBINER_CONTIGUOUS
MPI::COMBINER_VECTOR
MPI::COMBINER_HVECTOR_INTEGER
MPI::COMBINER_HVECTOR
MPI::COMBINER_INDEXED
MPI::COMBINER_HINDEXED_INTEGER
MPI::COMBINER_HINDEXED

MPI::COMBINER_INDEXED_BLOCK
MPI::COMBINER_STRUCT_INTEGER
MPI::COMBINER_STRUCT
MPI::COMBINER_SUBARRAY
MPI::COMBINER_DARRAY
MPI::COMBINER_F90_REAL
MPI::COMBINER_F90_COMPLEX
MPI::COMBINER_F90_INTEGER
MPI::COMBINER_RESIZED

Assorted constants

MPI::BSEND_OVERHEAD
MPI::PROC_NULL
MPI::ANY_SOURCE
MPI::ANY_TAG
MPI::UNDEFINED
MPI::KEYVAL_INVALID
MPI::BOTTOM

Collective constants

MPI::ROOT
MPI::IN_PLACE

Error handling specifiers

MPI::ERRORS_ARE_FATAL
MPI::ERRORS_RETURN
MPI::ERRORS_THROW_EXCEPTIONS

See Chapter 6, “Using error handlers - predefined error handler for C++,” on page 47.

Special data types for construction of derived data types

MPI::UB
MPI::LB
MPI::BYTE
MPI::PACKED

Elementary data types (C and C++)

MPI::CHAR
MPI::UNSIGNED_CHAR
MPI::SIGNED_CHAR
MPI::SHORT
MPI::INT
MPI::LONG
MPI::UNSIGNED_SHORT
MPI::UNSIGNED
MPI::UNSIGNED_LONG
MPI::FLOAT
MPI::DOUBLE
MPI::LONG_DOUBLE
MPI::LONG_LONG
MPI::UNSIGNED_LONG_LONG
MPI::WCHAR

Elementary data types (FORTRAN)

MPI::INTEGER
MPI::REAL
MPI::DOUBLE_PRECISION
MPI::F_COMPLEX
MPI::LOGICAL
MPI::CHARACTER

Data types for reduction functions (C and C++)

MPI::FLOAT_INT
MPI::DOUBLE_INT
MPI::LONG_INT
MPI::TWOINT
MPI::SHORT_INT
MPI::LONG_DOUBLE_INT

Data types for reduction functions (FORTRAN)

MPI::TWOREAL
MPI::TWODOUBLE_PRECISION
MPI::TWOINTEGER
MPI::TWOF_COMPLEX

Optional data types

MPI::INTEGER1
MPI::INTEGER2
MPI::INTEGER4
MPI::INTEGER8
MPI::REAL4
MPI::REAL8
MPI::REAL16
MPI::LOGICAL1
MPI::LOGICAL2
MPI::LOGICAL4
MPI::LOGICAL8
MPI::F_DOUBLE_COMPLEX
MPI::F_COMPLEX8
MPI::F_COMPLEX16
MPI::F_COMPLEX32

Collective operations

MPI::MAX
MPI::MIN
MPI::SUM
MPI::PROD
MPI::MAXLOC
MPI::MINLOC
MPI::BAND
MPI::BOR
MPI::BXOR
MPI::LAND
MPI::LOR
MPI::LXOR
MPI::REPLACE

Null handles

MPI::GROUP_NULL
MPI::COMM_NULL
MPI::DATATYPE_NULL
MPI::REQUEST_NULL
MPI::OP_NULL
MPI::ERRHANDLER_NULL
MPI::INFO_NULL
MPI::WIN_NULL

Empty group

MPI::GROUP_EMPTY

Threads constants

MPI::THREAD_SINGLE
MPI::THREAD_FUNNELED
MPI::THREAD_SERIALIZED
MPI::THREAD_MULTIPLE

FORTRAN 90 data type matching constants

MPI::TYPECLASS_REAL
MPI::TYPECLASS_INTEGER
MPI::TYPECLASS_COMPLEX

Chapter 10. MPI size limits

When using MPI, you should be aware of certain size limits. Specifically, there are:

- System limits on the size of various MPI elements.
- Limits on the total number of tasks in a parallel job, and the maximum number of tasks on a node. Note that usually the limits on useful tasks in a job is really about the resources available on the cluster. If your cluster has 128 processors, it is unlikely you would run more than 128 MPI tasks. If you have two processors per node, you will probably not want to run more than two tasks per node.

System limits

These are the system limits on the size of various MPI elements and the relevant environment variable or tunable parameter. The MPI standard identifies several values that have limits in any MPI implementation. For these values, the standard indicates a named constant to express the limit. See **mpi.h** for these constants and their values. The limits described below are specific to PE and are not part of standard MPI.

- Maximum buffer size for any MPI communication (for 32-bit applications only): 2 GB
- Default early arrival buffer size: (**MP_BUFFER_MEM**) 64MB (for both User Space and IP)
- Minimum pre-allocated early arrival buffer size: (50 * eager_limit) number of bytes
- Maximum pre_allocated early arrival buffer size: 256 MB
- Minimum message envelope buffer size: 1 MB
- Default eager limit (**MP_EAGER_LIMIT**): See Table 3 on page 64. Note that the default values shown in Table 3 on page 64 are initial estimates that are used by the MPI library. Depending on the value of **MP_BUFFER_MEM** and the job type, these values will be adjusted to guarantee a safe eager send protocol.
- Maximum eager limit: 256 KB
- MPI uses the **MP_BUFFER_MEM** and the **MP_EAGER_LIMIT** values that are selected for a job to determine how many complete messages, each with a size that is equal to or less than the eager_limit, can be sent eagerly from every task of the job to a single task, without causing the single target to run out of buffer space. This is done by allocating to each sending task a number of message credits for each target. The sending task will consume one message credit for each eager send to a particular target. It will get that credit back after the message has been matched at that target.

  The sending task can continue to send eager messages to a particular target as long as it still has message credits for that target. The following equation is used to calculate the number of credits to be allocated:

  ```
  MP_BUFFER_MEM / (MP_PROCS * MAX(MP_EAGER_LIMIT, 64))
  ```

  MPI uses this equation to ensure that there are at least two credits for each target. If needed, MPI reduces the initially selected value of **MP_EAGER_LIMIT**, or increases the initially selected value of **MP_BUFFER_MEM**, in order to achieve this minimum threshold of two credits for each target.

  If the user has specified an initial value for **MP_BUFFER_MEM** or **MP_EAGER_LIMIT**, and MPI has changed either one or both of these values, an informational message is issued. If the user has specified **MP_BUFFER_MEM** using the two values format, then the maximum value specified by the second

parameter will be used in the equation above. See *IBM Parallel Environment: Operation and Use, Volume 1* for more information about specifying values for **MP_BUFFER_MEM**.

If the user allows both **MP_BUFFER_MEM** and **MP_EAGER_LIMIT** to default, then the initial value that was selected for **MP_BUFFER_MEM** will be 64 MB (for both User Space and IP jobs). MPI estimates the initial value for **MP_EAGER_LIMIT** based on the job size, as shown in Table 3. MPI then does the calculation again to ensure that there will be at least two credits for each target.

Any time a message that is small enough to be eligible for eager send cannot be guaranteed destination buffer space, the message is handled by rendezvous protocol. Destination buffer space unavailability cannot cause a safe MPI program to fail, but could cause hangs in unsafe MPI programs. An *unsafe* program is one that assumes MPI can guarantee system buffering of sent data until the receive is posted. The MPI standard warns that unsafe programs, though they may work in some cases, are not valid MPI. We suggest every application be checked for safety by running it just once with **MP_EAGER_LIMIT** set to **0**, which will cause an unsafe application to hang. Because eager limit, along with task count, affects the minimum buffer memory requirement, it is possible to produce an unworkable combination when both **MP_EAGER_LIMIT** and **MP_BUFFER_MEM** are explicitly set. MPI will override unworkable combinations. If either the **MP_EAGER_LIMIT** or the **MP_BUFFER_MEM** value is changed by MPI, an informational message is issued.

Parallel Environment on some systems supports up to 8192 tasks. The eager limit defaults based on task count, and shown in Table 3, are the same for all systems.

Table 3. MPI eager limits

Number of tasks	Default limit (MP_EAGER_LIMIT)
1 to 256	32768
257 to 512	16384
513 to 1024	8192
1025 to 2048	4096
2049 to 4096	2048
4097 to 8192	1024

- Maximum aggregate unsent data, per task: no specific limit
- Maximum number of communicators, file handles, and windows: approximately 2000
- Maximum number of distinct tags: all nonnegative integers less than 2**32-1

Maximum number of tasks and tasks per node

Table 4 lists the limits on the total number of tasks in a parallel job, and the maximum number of tasks on a node (operating system image). If two limits are listed, the most restrictive limit applies.

Table 4. Task limits for parallel jobs

Protocol Library	Switch/Adapter	Total Task Limit	Task per Node Limit
IP	any	8192	large
User Space	pSeries HPS with one adapter	8192	64
User Space	pSeries HPS with two adapters per network	8192	128

For a system with a pSeries HPS switch and adapter, the *Task per Node Limit* is 64 tasks per adapter per network. For a system with two adapters per network, the task per node limit is 128, or 64 * 2. This enables the running of a 128 task per node MPI job over User Space. This may be useful on 64 CPU nodes with the Simultaneous Multi-Threading (SMT) technology available on IBM System p5™ servers and AIX 5.3 enabled. The LoadLeveler configuration also helps determine how may tasks can be run on a node. To run 128 tasks per node, LoadLeveler must be configured with 128 starters per node. In theory, you can configure more than two adapters per network and run more than 128 tasks per node. However, this means running more than one task per CPU, and results in reduced performance. Also, the lower layer of the protocol stack has a 128 tasks per node limit for enabling shared memory. The protocol stack does not use shared memory when there are more than 128 tasks per node.

For running an MPI job over IP, the task per node limit is not affected by the number of adapters; the task per node limit may be constrained by the number of LoadLeveler starters configured per node. There is a 128 task per node limit for enabling shared memory use by MPI and LAPI. There is seldom a reason to run more than one task per CPU, so the limit of 128 tasks per node will rarely be an issue. For IBM System p5 servers with SMT (Simultaneous Multi-Threading), there will be cases where running two tasks per physical CPU with SMT enabled gives better performance. This is permitted, but it does not always result in better performance.

Although the communication adapters support the stated limits for tasks per node, maximum aggregate bandwidth through the adapter is achieved with a smaller task per node count, if all tasks are simultaneously involved in message passing. Thus, if individual MPI tasks can do SMP parallel computations on multiple CPUs (using OpenMP or threads), performance may be better than if all MPI tasks compete for adapter resources.

Chapter 11. Parallel utility subroutines

These are the parallel utility subroutines that are available for parallel programming. These user-callable, threadsafe subroutines take advantage of the parallel operating environment (POE).

mpc_isatty
Determines whether a device is a terminal on the home node. See "mpc_isatty" on page 69.

MP_BANDWIDTH, mpc_bandwidth
Obtains user space switch bandwidth statistics. See "MP_BANDWIDTH, mpc_bandwidth" on page 71.

MP_DISABLEINTR, mpc_disableintr
Disables message arrival interrupts for the MPI task from which it was called. See "MP_DISABLEINTR, mpc_disableintr" on page 76.

MP_ENABLEINTR, mpc_enableintr
Enables message arrival interrupts for the MPI task from which it was called. See "MP_ENABLEINTR, mpc_enableintr" on page 79.

MP_FLUSH, mpc_flush
Flushes task output buffers. See "MP_FLUSH, mpc_flush" on page 82.

MP_INIT_CKPT, mpc_init_ckpt
Starts user-initiated checkpointing. See "MP_INIT_CKPT, mpc_init_ckpt" on page 84.

MP_QUERYINTR, mpc_queryintr
Returns the state of interrupts for the MPI task from which it was called. See "MP_QUERYINTR, mpc_queryintr" on page 86.

MP_SET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks
Registers subroutines to be invoked when the application is checkpointed, resumed, and restarted. See "MP_SET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks" on page 89.

MP_STATISTICS_WRITE, mpc_statistics_write
Prints both MPI and LAPI transmission statistics. See "MP_STATISTICS_WRITE, mpc_statistics_write" on page 92.

MP_STATISTICS_ZERO, mpc_statistics_zero
Resets (zeros) the **MPCI_stats_t** structure. It has no effect on LAPI. See "MP_STATISTICS_ZERO, mpc_statistics_zero" on page 95.

MP_STDOUT_MODE, mpc_stdout_mode
Sets the mode for STDOUT. See "MP_STDOUT_MODE, mpc_stdout_mode" on page 96.

MP_STDOUTMODE_QUERY, mpc_stdoutmode_query
Queries the current STDOUT mode setting. See "MP_STDOUTMODE_QUERY, mpc_stdoutmode_query" on page 99.

MP_UNSET_CKPT_CALLBACKS, mpc_unset_ckpt_callbacks
Unregisters checkpoint, resume, and restart application callbacks. See "MP_UNSET_CKPT_CALLBACKS, mpc_unset_ckpt_callbacks" on page 101.

pe_dbg_breakpoint
Provides a communication mechanism between Parallel Operating Environment (POE) and an attached third party debugger (TPD). See “pe_dbg_breakpoint” on page 103.

pe_dbg_checkpnt
Checkpoints a process that is under debugger control, or a group of processes. See “pe_dbg_checkpnt” on page 109.

pe_dbg_checkpnt_wait
Waits for a checkpoint, or pending checkpoint file I/O, to complete. See “pe_dbg_checkpnt_wait” on page 113.

pe_dbg_getcrid
Returns the checkpoint/restart ID. See “pe_dbg_getcrid” on page 115.

pe_dbg_getrtid
Returns real thread ID of a thread in a specified process given its virtual thread ID. See “pe_dbg_getrtid” on page 116.

pe_dbg_getvtid
Returns virtual thread ID of a thread in a specified process given its real thread ID. See “pe_dbg_getvtid” on page 117.

pe_dbg_read_cr_errfile
Opens and reads information from a checkpoint or restart error file. See “pe_dbg_read_cr_errfile” on page 118.

pe_dbg_restart
Restarts processes from a checkpoint file. See “pe_dbg_restart” on page 119.

mpc_isatty

Purpose

Determines whether a device is a terminal on the home node.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_isatty(int FileDescriptor);
```

Description

This parallel utility subroutine determines whether the file descriptor specified by the *FileDescriptor* parameter is associated with a terminal device on the home node. In a parallel operating environment partition, these three file descriptors are implemented as pipes to the partition manager daemon. Therefore, the **isatty()** subroutine will always return **false** for each of them. This subroutine is provided for use by remote tasks that may want to know whether one of these devices is actually a terminal on the home node, for example, to determine whether or not to output a prompt.

Parameters

FileDescriptor
is the file descriptor number of the device. Valid values are:

0 or STDIN
Specifies STDIN as the device to be checked.

1 or STDOUT
Specifies STDOUT as the device to be checked.

2 or STDERR
Specifies STDERR as the device to be checked.

Notes

This subroutine has a C version only. Also, it is threadsafe.

Return values

In C and C++ calls, the following applies:

0 Indicates that the device is *not* associated with a terminal on the home node.

1 Indicates that the device *is* associated with a terminal on the home node.

-1 Indicates an invalid *FileDescriptor* parameter.

Examples

C Example

```
/*
 * Running this program, after compiling with mpcc_r,
 * without redirecting STDIN, produces the following output:
 *
 *     isatty() reports STDIN as a non-terminal device
```

```
 *     mpc_isatty() reports STDIN as a terminal device
 */

#include "pm_util.h"

main()
{
 if (isatty(STDIN)) {
  printf("isatty() reports STDIN as a terminal device\n");
 } else {
  printf("isatty() reports STDIN as a non-terminal device\n");
  if (mpc_isatty(STDIN)) {
   printf("mpc_isatty() reports STDIN as a terminal device\n");
  } else {
   printf("mpc_isatty() reports STDIN as a non-terminal device\n");
  }
 }
}
```

MP_BANDWIDTH, mpc_bandwidth

Purpose

Obtains user space switch bandwidth statistics.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
#include <lapi.h>
int mpc_bandwidth(lapi_handle_t hndl, int flag, bw_stat_t *bw);
```

FORTRAN synopsis

```
MP_BANDWIDTH(INTEGER HNDL, INTEGER FLAG, INTEGER*8 BW_SENT, INTEGER*8 BW_RECV,
 INTEGER*8 BW_TIME_SEC, INTEGER*4 BW_TIME_USEC, INTEGER RC)
```

Description

This parallel utility subroutine is a wrapper API program that users can call to obtain the user space switch bandwidth statistics. LAPI's Query interface is used to obtain byte counts of the data sent and received. This routine returns the byte counts and time values to allow the bandwidth to be calculated.

For C and C++ language programs, this routine uses a structure that contains the data count fields, as well as time values in both seconds and microseconds. These are filled in at the time of the call, from the data obtained by the LAPI Query interface and a ″get time of day″ call.

This routine requires a valid LAPI handle for LAPI programs. For MPI programs, the handle is not required. A flag parameter is required to indicate whether the call has been made from an MPI or LAPI program.

If the program is a LAPI program, the flag MP_BW_LAPI must be set and the handle value must be specified. If the program is an MPI program, the flag MP_BW_MPI must be set, and any handle specified is ignored.

In the case where a program uses both MPI and LAPI in the same program, where **MP_MSG_API** is set to either **mpi,lapi** or **mpi_lapi**, separate sets of statistics are maintained for the MPI and LAPI portions of the program. To obtain the MPI bandwidth statistics, this routine must be called with the MP_BW_MPI flag, and any handle specified is ignored. To obtain the LAPI bandwidth statistics, this routine must be called with the MP_BW_LAPI flag and a valid LAPI handle value.

Parameters

In C, *bw* is a pointer to a **bw_stat_t** structure. This structure is defined as:

```
typedef struct{
     unsigned long long switch_sent;
     unsigned long long switch_recv;
     int64_t time_sec;
     int32_t time_usec;
} bw_stat_t;
```

where:

switch_sent is an unsigned long long value of the number of bytes sent.

switch_recv is an unsigned long long value of the number of bytes received.

time_sec is a 64-bit integer value of time in seconds.

time_usec is a 32-bit integer value of time in microseconds.

In FORTRAN:

BW_SENT is a 64-bit integer value of the number of bytes sent.

BW_RECV is a 64-bit integer value of the number of bytes received.

BW_TIME_SEC
is a 64-bit integer time value of time in seconds.

BW_TIME_USEC
is a 32-bit integer time value of time in microseconds.

Flag is either MP_BW_MPI or MP_BW_LAPI, indicating whether the program is using MPI or LAPI.

Bw_data is a pointer to the bandwidth data structure, that will include the timestamp and bandwidth data count of sends and receives as requested. The bandwidth data structure may be declared and passed locally by the calling program.

Hndl is a valid LAPI handle filled in by a LAPI_Init() call for LAPI programs. For MPI programs, this is ignored.

RC in FORTRAN, will contain an integer value returned by this function. This should always be the last parameter.

Notes

1. The send and receive data counts are for bandwidth data at the software level of current tasks running, and not what the adapter is capable of.
2. Intranode communication using shared memory will specifically *not* be measured with this API. Likewise, this API does not return values of the bandwidth of local data sent to itself.
3. In the case with striping over multiple adapters, the data counts are an aggregate of the data exchanged at the application level, and not on a per-adapter basis.

Return values

0 Indicates successful completion.

-1 Incorrect flag (not MP_BW_MPI or MP_BW_LAPI).

greater than 0
See the list of LAPI error codes in *IBM RSCT: LAPI Programming Guide*.

Examples

C Examples

1. To determine the bandwidth in an MPI program:

```
#include <mpi.h>
#include <time.h>
#include <lapi.h>
#include <pm_util.h>
```

```
int rc;
main(int argc, char *argv[])
{
         bw_stat_t bw_in;
         MPI_Init(&argc, &argv);
           .
           .
           .
   /* start collecting bandwidth .. */
        rc = mpc_bandwidth(NULL, MP_BW_MPI, &bw_in);
          .
          .
          .
        printf("Return from  mpc_bandwidth ...rc = %d.\n",rc);
        printf("Bandwidth of data sent: %lld.\n",
           bw_in.switch_sent);
        printf("Bandwidth of data recv: %lld.\n",
          bw_in.switch_recv);
        printf("time(seconds): %lld.\n",bw_in.time_sec);
        printf("time(mseconds): %d.\n",bw_in->time_usec);
          .
          .
          .
        MPI_Finalize();
        exit(rc);
}
```

2. To determine the bandwidth in a LAPI program:

```
#include <lapi.h>
#include <time.h>
#include <pm_util.h>
int rc;
main(int argc, char *argv[])
{
        lapi_handle_t hndl;
        lapi_info_t info;
        bw_stat_t work;
        bw_stat_t bw_in;
        bzero(&info, sizeof(lapi_info_t));
        rc = LAPI_Init(&hndl, &info);
          .
          .
          .
        rc = mpc_bandwidth(hndl, MP_BW_LAPI, &bw_in);
          .
          .
          .
        printf("Return from  mpc_bandwidth ...rc = %d.\n",rc);
        printf("Bandwidth of data sent: %lld.\n",
           bw_in.switch_sent);
        printf("Bandwidth of data recv: %lld.\n",
           bw_in.switch_recv);
        printf("time(seconds): %lld.\n", bw_in.time_sec);
        printf("time(mseconds): %d.\n",bw_in.time_usec);
          .
          .
          .
        LAPI_Term(hndl);
        exit(rc);
}
```

FORTRAN Examples

1. To determine the bandwidth in an MPI program:

```
      program  bw_mpi
      include "mpif.h"
      include "lapif.h"
```

```
integer retcode
integer taskid
integer numtask
integer hndl
integer*8 bw_secs
integer*4 bw_usecs
integer*8 bw_sent_data
integer*8 bw_recv_data
.
.
.
call mpi_init(retcode)
call mpi_comm_rank(mpi_comm_world, taskid, retcode)
write  (6,*) 'Taskid is ',taskid
.
.
.
call mp_bandwidth(hndl,MP_BW_MPI, bw_sent_data, bw_recv_data, bw_secs,
      bw_usecs,retcode)
write  (6,*) 'MPI_BANDWIDTH returned. Time (sec) is ',bw_secs
write  (6,*) ' Time (usec) is ',bw_usecs
write  (6,*) ' Data sent (bytes): ',bw_sent_data
write  (6,*) ' Data received (bytes): ',bw_sent_recv
write  (6,*) ' Return code: ',retcode
.
.
.
call mpi_barrier(mpi_comm_world,retcode)
call mpi_finalize(retcode)
```

2. To determine the bandwidth in a LAPI program:

```
program  bw_lapi
include "mpif.h"
include "lapif.h"
TYPE (LAPI_INFO_T) :: lapi_info
integer retcode
integer taskid
integer numtask
integer hndl
integer*8 bw_secs
integer*4 bw_usecs
integer*8 bw_sent_data
integer*8 bw_recv_data
.
.
.
call lapi_init(hndl, lapi_info, retcode)
.
.
.
call mp_bandwidth(hndl,MP_BW_LAPI, bw_sent_data, bw_recv_data, bw_secs,
      bw_usecs,retcode)
write  (6,*) 'MPI_BANDWIDTH returned. Time (sec) is ',bw_secs
write  (6,*) ' Time (usec) is ',bw_usecs
write  (6,*) ' Data sent (bytes): ',bw_sent_data
write  (6,*) ' Data received (bytes): ',bw_sent_recv
write  (6,*) ' Return code: ',retcode
.
.
.
call lapi_term(hndl,retcode)
```

Related information

Commands:

- mpcc_r

- mpCC_r
- mpxlf_r
- mpxlf90_r
- mpxlf95_r

Subroutines:

- MP_STATISTICS_WRITE, mpc_statistics_write
- MP_STATISTICS_ZERO, mpc_statistics_zero

MP_DISABLEINTR, mpc_disableintr

Purpose

Disables message arrival interrupts on a node.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_disableintr();
```

FORTRAN synopsis

```
MP_DISABLEINTR(INTEGER RC)
```

Description

This parallel utility subroutine disables message arrival interrupts for the MPI task from which it was called. Use this subroutine to dynamically control masking interrupts on a node.

Parameters

In FORTRAN, *RC* will contain one of the values listed under **Return Values**.

Notes

- This subroutine is only effective when the communication subsystem is active. This is from MPI_INIT to MPI_FINALIZE. If this subroutine is called when the subsystem is inactive, the call will have no effect and the return code will be -1.
- This subroutine overrides the setting of the environment variable MP_CSS_INTERRUPT.
- Inappropriate use of the interrupt control subroutines may reduce performance.
- This subroutine can be used for IP and User Space protocols.
- This subroutine is threadsafe.
- Using this subroutine will suppress the MPI-directed switching of interrupt mode, leaving the user in control for the rest of the run. See MPI_FILE_OPEN and MPI_WIN_CREATE in *IBM Parallel Environment: MPI Subroutine Reference*.

Return values

0 Indicates successful completion.

-1 Indicates that the MPI library was not active. The call was either made before MPI_INIT or after MPI_FINALIZE.

Examples

C Example

```
/*
 * Running this program, after compiling with mpcc_r,
 * without setting the MP_CSS_INTERRUPT environment variable,
 * and without using the "-css_interrupt" command-line option,
 * produces the following output:
 *
 *    Interrupts are DISABLED
```

```
 *    About to enable interrupts..
 *    Interrupts are ENABLED
 *    About to disable interrupts...
 *    Interrupts are DISABLED
 */

#include "pm_util.h"

#define QUERY if (intr = mpc_queryintr()) {\
   printf("Interrupts are ENABLED\n");\
  } else {\
   printf("Interrupts are DISABLED\n");\
  }

main()
{
 int intr;

 QUERY

 printf("About to enable interrupts...\n");
 mpc_enableintr();

 QUERY

 printf("About to disable interrupts...\n");
 mpc_disableintr();

 QUERY
}
```

FORTRAN Example

Running the following program, after compiling with **mpxlf_r**, without setting the MP_CSS_INTERRUPT environment variable, and without using the **-css_interrupt** command-line option, produces the following output:

```
      Interrupts are DISABLED
      About to enable interrupts..
      Interrupts are ENABLED
      About to disable interrupts...
      Interrupts are DISABLED



      PROGRAM INTR_EXAMPLE

      INTEGER RC

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      WRITE(6,*)'About to enable interrupts...'
      CALL MP_ENABLEINTR(RC)

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      WRITE(6,*)'About to disable interrupts...'
```

```
CALL MP_DISABLEINTR(RC)

CALL MP_QUERYINTR(RC)
IF (RC .EQ. 0) THEN
   WRITE(6,*)'Interrupts are DISABLED'
ELSE
   WRITE(6,*)'Interrupts are ENABLED'
ENDIF

STOP
END
```

Related information

Subroutines:

- MP_ENABLEINTR, mpc_enableintr
- MP_QUERYINTR, mpc_queryintr

MP_ENABLEINTR, mpc_enableintr

Purpose

Enables message arrival interrupts on a node.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_enableintr();
```

FORTRAN synopsis

```
MP_ENABLEINTR(INTEGER RC)
```

Description

This parallel utility subroutine enables message arrival interrupts for the MPI task from which it was called. Use this subroutine to dynamically control masking interrupts on a node.

Parameters

In FORTRAN, *RC* will contain one of the values listed under **Return Values**.

Notes

- This subroutine is only effective when the communication subsystem is active. This is from MPI_INIT to MPI_FINALIZE. If this subroutine is called when the subsystem is inactive, the call will have no effect and the return code will be -1.
- This subroutine overrides the setting of the environment variable MP_CSS_INTERRUPT.
- Inappropriate use of the interrupt control subroutines may reduce performance.
- This subroutine can be used for IP and User Space protocols.
- This subroutine is threadsafe.
- Using this subroutine will suppress the MPI-directed switching of interrupt mode, leaving the user in control for the rest of the run. See MPI_FILE_OPEN and MPI_WIN_CREATE in *IBM Parallel Environment: MPI Subroutine Reference*.

Return values

0 Indicates successful completion.

-1 Indicates that the MPI library was not active. The call was either made before MPI_INIT or after MPI_FINALIZE.

Examples

C Example

```
/*
 * Running this program, after compiling with mpcc_r,
 * without setting the MP_CSS_INTERRUPT environment variable,
 * and without using the "-css_interrupt" command-line option,
 * produces the following output:
 *
 *    Interrupts are DISABLED
```

```
 *    About to enable interrupts..
 *    Interrupts are ENABLED
 *    About to disable interrupts...
 *    Interrupts are DISABLED
 */

#include "pm_util.h"

#define QUERY if (intr = mpc_queryintr()) {\
   printf("Interrupts are ENABLED\n");\
  } else {\
   printf("Interrupts are DISABLED\n");\
  }

main()
{
 int intr;

 QUERY

 printf("About to enable interrupts...\n");
 mpc_enableintr();

 QUERY

 printf("About to disable interrupts...\n");
 mpc_disableintr();

 QUERY
}
```

FORTRAN Example

Running this program, after compiling with **mpxlf_r**, without setting the MP_CSS_INTERRUPT environment variable, and without using the **-css_interrupt** command-line option, produces the following output:

```
      Interrupts are DISABLED
      About to enable interrupts..
      Interrupts are ENABLED
      About to disable interrupts...
      Interrupts are DISABLED



      PROGRAM INTR_EXAMPLE

      INTEGER RC

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      WRITE(6,*)'About to enable interrupts...'
      CALL MP_ENABLEINTR(RC)

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      WRITE(6,*)'About to disable interrupts...'
```

```
CALL MP_DISABLEINTR(RC)

CALL MP_QUERYINTR(RC)
IF (RC .EQ. 0) THEN
   WRITE(6,*)'Interrupts are DISABLED'
ELSE
   WRITE(6,*)'Interrupts are ENABLED'
ENDIF

STOP
END
```

Related information

Subroutines:

- MP_DISABLEINTR, mpc_disableintr
- MP_QUERYINTR, mpc_queryintr

MP_FLUSH, mpc_flush

Purpose

Flushes task output buffers.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_flush(int option);
```

FORTRAN synopsis

```
MP_FLUSH(INTEGER OPTION)
```

Description

This parallel utility subroutine flushes output buffers from all of the parallel tasks to STDOUT at the home node. This is a synchronizing call across all parallel tasks.

If the current STDOUT mode is ordered, then when all tasks have issued this call or when any of the output buffers are full:

1. All STDOUT buffers are flushed and put out to the user screen (or redirected) in task order.
2. An acknowledgement is sent to all tasks and control is returned to the user.

If current STDOUT mode is unordered and all tasks have issued this call, all output buffers are flushed and put out to the user screen (or redirected).

If the current STDOUT mode is single and all tasks have issued this call, the output buffer for the current single task is flushed and put out to the user screen (or redirected).

Parameters

option
is a file descriptor. The only valid value is:

1 Indicates to flush STDOUT buffers.

Notes

- This is a synchronizing call regardless of the current STDOUT mode.
- All STDOUT buffers are flushed at the end of the parallel job.
- If mpc_flush is not used, standard output streams not terminated with a newline character are buffered, even if a subsequent read to standard input is made. This may cause prompt message to appear only after input has been read.
- This subroutine is threadsafe.

Return values

In C and C++ calls, the following applies:

0 Indicates successful completion

-1 Indicates that an error occurred. A message describing the error will be issued.

Examples

C Example

The following program uses **poe** with the **-labelio yes** option and three tasks:

```
    #include <pm_util.h>

main()
{
 mpc_stdout_mode(STDIO_ORDERED);
 printf("These lines will appear in task order\n");
 /*
  * Call mpc_flush here to make sure that one task
  * doesn't change the mode before all tasks have
  * sent the previous printf string to the home node.
  */
 mpc_flush(1);
 mpc_stdout_mode(STDIO_UNORDERED);
 printf("These lines will appear in the order received by the home node\n");
 /*
  * Since synchronization is not used here, one task could actually
  * execute the next statement before one of the other tasks has
  * executed the previous statement, causing one of the unordered
  * lines not to print.
  */
 mpc_stdout_mode(1);
 printf("Only 1 copy of this line will appear from task 1\n");
}
```

Running this C program produces the following output (the task order of lines 4 through 6 may differ):

- **0** : These lines will appear in task order.
- **1** : These lines will appear in task order.
- **2** : These lines will appear in task order.
- **1** : These lines will appear in the order received by the home node.
- **2** : These lines will appear in the order received by the home node.
- **0** : These lines will appear in the order received by the home node.
- **1** : Only 1 copy of this line will appear from task 1.

FORTRAN Example

```
CALL MP_STDOUT_MODE(-2)
WRITE(6, *) 'These lines will appear in task order'
CALL MP_FLUSH(1)
CALL MP_STDOUT_MODE(-3)
WRITE(6, *) 'These lines will appear in the order received by the home node'
CALL MP_STDOUT_MODE(1)
WRITE(6, *) 'Only 1 copy of this line will appear from task 1'
END
```

Related information

Subroutines:

- MP_STDOUT_MODE, mpc_stdout_mode
- MP_STDOUTMODE_QUERY, mpc_stdoutmode_query

MP_INIT_CKPT, mpc_init_ckpt

Purpose

Starts user-initiated checkpointing.

Library

libmpi_r.a

C synopsis

```
#include <pm_ckpt.h>
int mpc_init_ckpt(int flags);
```

FORTRAN synopsis

```
i = MP_INIT_CKPT(%val(j))
```

Description

MP_INIT_CKPT starts complete or partial user-initiated checkpointing. The checkpoint file name consists of the base name provided by the MP_CKPTFILE and MP_CKPTDIR environment variables, with a suffix of the task ID and a numeric checkpoint tag to differentiate it from an earlier checkpoint file.

If the MP_CKPTFILE environment variable is not specified, a default base name is constructed: **poe.ckpt.***tag*, where *tag* is an integer that allows multiple versions of checkpoint files to exist. The file name specified by MP_CKPTFILE may include the full path of where the checkpoint files will reside, in which case the MP_CKPTDIR variable is to be ignored. If MP_CKPTDIR is not defined and MP_CKPTFILE does not specify a full path name, MP_CKPTFILE is used as a relative path name from the original working directory of the task.

Parameters

In C, *flags* can be set to MP_CUSER, which indicates complete user-initiated checkpointing, or MP_PUSER, which indicates partial user-initiated checkpointing.

In FORTRAN, *j* should be set to **0** (the value of MP_CUSER) or **1** (the value of MP_PUSER).

Notes

Complete user-initiated checkpointing is a synchronous operation. All tasks of the parallel program must call MP_INIT_CKPT. MP_INIT_CKPT suspends the calling thread until all other tasks have called it (MP_INIT_CKPT). Other threads in the task are not suspended. After all tasks of the application have issued MP_INIT_CKPT, a local checkpoint is taken of each task.

In partial user-initiated checkpointing, one task of the parallel program calls MP_INIT_CKPT, thus invoking a checkpoint on the entire application. A checkpoint is performed asynchronously on all other tasks. The thread that called MP_INIT_CKPT is suspended until the checkpoint is taken. Other threads in the task are not suspended.

Upon returning from the MP_INIT_CKPT call, the application continues to run. It may, however, be a restarted application that is now running, rather than the original, if the program was restarted from a checkpoint file.

In a case where several threads in a task call MP_INIT_CKPT using the same flag, the calls are serialized.

The task that calls MP_INIT_CKPT does not need to be an MPI program.

There are certain limitations associated with checkpointing an application. See “Checkpoint and restart limitations” on page 38 for more information.

For general information on checkpointing and restarting programs, see *IBM Parallel Environment: Operation and Use, Volume 1*.

For more information on the use of LoadLeveler and checkpointing, see *Tivoli Workload Scheduler LoadLeveler: Using and Administering*.

Return values

0 Indicates successful completion.

1 Indicates that a restart operation occurred.

-1 Indicates that an error occurred. A message describing the error will be issued.

Examples

C Example

```
#include <pm_ckpt.h>
int mpc_init_ckpt(int flags);
```

FORTRAN Example

```
i = MP_INIT_CKPT(%val(j))
```

Related information

Commands:

- poeckpt
- poerestart

Subroutines:

- MP_SET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks
- MP_UNSET_CKPT_CALLBACKS, mpc_unset_ckpt_callbacks

MP_QUERYINTR, mpc_queryintr

Purpose

Returns the state of interrupts on a node.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_queryintr();
```

FORTRAN synopsis

```
MP_QUERYINTR(INTEGER RC)
```

Description

This parallel utility subroutine returns the state of interrupts for the MPI task from which it was called.

Parameters

In FORTRAN, *RC* will contain one of the values listed under **Return Values**.

Notes

This subroutine is threadsafe.

Return values

0 Indicates that interrupts are disabled for the MPI task from which this subroutine is called.

1 Indicates that interrupts are enabled for the MPI task from which this subroutine is called.

Examples

C Example

```
/*
 * Running this program, after compiling with mpcc_r,
 * without setting the MP_CSS_INTERRUPT environment variable,
 * and without using the "-css_interrupt" command-line option,
 * produces the following output:
 *
 *    Interrupts are DISABLED
 *    About to enable interrupts..
 *    Interrupts are ENABLED
 *    About to disable interrupts...
 *    Interrupts are DISABLED
 */

#include "pm_util.h"

#define QUERY if (intr = mpc_queryintr()) {\
   printf("Interrupts are ENABLED\n");\
  } else {\
   printf("Interrupts are DISABLED\n");\
  }
```

```
main()
{
 int intr;

 QUERY

 printf("About to enable interrupts...\n");
 mpc_enableintr();

 QUERY

 printf("About to disable interrupts...\n");
 mpc_disableintr();

 QUERY
}
```

FORTRAN Example

Running this program, after compiling with **mpxlf_r**, without setting the MP_CSS_INTERRUPT environment variable, and without using the **-css_interrupt** command-line option, produces the following output:

```
Interrupts are DISABLED
About to enable interrupts..
Interrupts are ENABLED
About to disable interrupts...
Interrupts are DISABLED
```

```
      PROGRAM INTR_EXAMPLE

      INTEGER RC

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      WRITE(6,*)'About to enable interrupts...'
      CALL MP_ENABLEINTR(RC)

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      WRITE(6,*)'About to disable interrupts...'
      CALL MP_DISABLEINTR(RC)

      CALL MP_QUERYINTR(RC)
      IF (RC .EQ. 0) THEN
         WRITE(6,*)'Interrupts are DISABLED'
      ELSE
         WRITE(6,*)'Interrupts are ENABLED'
      ENDIF

      STOP
      END
```

Related information

Subroutines:

- MP_DISABLEINTR, mpc_disableintr
- MP_ENABLEINTR, mpc_enableintr

MP_SET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks

Purpose

Registers subroutines to be invoked when the application is checkpointed, resumed, and restarted.

Library

libmpi_r.a

C synopsis

```
#include <pm_ckpt.h>
int mpc_set_ckpt_callbacks(callbacks_t *cbs);
```

FORTRAN synopsis

```
MP_SET_CKPT_CALLBACKS(EXTERNAL CHECKPOINT_CALLBACK_FUNC,
        EXTERNAL RESUME_CALLBACK_FUNC,
        EXTERNAL RESTART_CALLBACK_FUNC,
        INTEGER RC)
```

Description

The MP_SET_CKPT_CALLBACKS subroutine is called to register subroutines to be invoked when the application is checkpointed, resumed, and restarted.

Parameters

In C, *cbs* is a pointer to a **callbacks_t** structure. The structure is defined as:

```
typedef struct {
void (*checkpoint_callback)(void);
void (*restart_callback)(void);
void (*resume_callback)(void);
} callbacks_t;
```

where:

checkpoint_callback Points to the subroutine to be called at checkpoint time.

restart_callback Points to the subroutine to be called at restart time.

resume_callback Points to the subroutine to be called when an application is resumed after taking a checkpoint.

In FORTRAN:

CHECKPOINT_CALLBACK_FUNC Specifies the subroutine to be called at checkpoint time.

RESUME_CALLBACK_FUNC Specifies the subroutine to be called when an application is resumed after taking a checkpoint.

RESTART_CALLBACK_FUNC Specifies the subroutine to be called at restart time.

RC Contains one of the values listed under **Return Values** .

Notes

In order to ensure their completion, the callback subroutines cannot be dependent on the action of any other thread in the current process, or any process created by the task being checkpointed, because these threads or processes or both may or may not be running while the callback subroutines are executing.

The callback subroutines cannot contain calls to:

1. MP_SET_CKPT_CALLBACKS, MP_UNSET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks, or mpc_unset_ckpt_callbacks.
2. Any MPI or LAPI subroutines

If a call to MP_SET_CKPT_CALLBACKS is issued while a checkpoint is in progress, it is possible that the newly-registered callback may or may not run during this checkpoint.

There are certain limitations associated with checkpointing an application. See “Checkpoint and restart limitations” on page 38 for more information.

For general information on checkpointing and restarting programs, see *IBM Parallel Environment: Operation and Use, Volume 1*.

For more information on the use of LoadLeveler and checkpointing, see *Tivoli Workload Scheduler LoadLeveler: Using and Administering*.

Return values

-1 Indicates that an error occurred. A message describing the error will be issued.

non-negative integer
Indicates the handle that is to be used in MP_UNSET_CKPT_CALLBACKS to unregister the subroutines.

Examples

C Example

```
#include <pm_ckpt.h>
int ihndl;
callbacks_t cbs;
void foo(void);
void bar(void);
cbs.checkpoint_callback=foo;
cbs.resume_callback=bar;
cbs.restart_callback=bar;
ihndl = mpc_set_ckpt_callbacks(callbacks_t *cbs);
```

FORTRAN Example

```
SUBROUTINE FOO
:
RETURN
END
SUBROUTINE BAR
:
RETURN
END
PROGRAM MAIN
EXTERNAL FOO, BAR
INTEGER HANDLE, RC
```

```
      .
      .
CALL MP_SET_CKPT_CALLBACKS(FOO,BAR,BAR,HANDLE)
IF (HANDLE .NE. 0) STOP 666
      .
      .
CALL MP_UNSET_CKPT_CALLBACKS(HANDLE,RC)
      .
      .
END
```

Related information

Commands:

- poeckpt
- poerestart

Subroutines:

- MP_INIT_CKPT, mpc_init_ckpt
- MP_UNSET_CKPT_CALLBACKS, mpc_unset_ckpt_callbacks

MP_STATISTICS_WRITE, mpc_statistics_write

Purpose

Prints both MPI and LAPI transmission statistics.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_statistics_write(FILE *fp);
```

FORTRAN synopsis

```
MP_STATISTICS_WRITE(INTEGER FILE_DESCRIPTOR, INTEGER RC)
```

Description

If the **MP_STATISTICS** environment variable is set to **yes**, MPI will keep a running total on a set of statistical data. If an application calls this function after **MPI_INIT** is completed, but before **MPI_FINALIZE** is called, it will print out the current total of all available MPI and LAPI data. If this function is called after **MPI_FINALIZE** is completed, it will print out **only** the final MPI data.

Note: LAPI will always keep its own statistical total with or without having **MP_STATISTICS** set.

This function can be added to an MPI program to check communication progress. However, keeping statistical data costs computing cycles, and may impair latency or bandwidth.

In the output, each piece of MPI statistical data is preceded by **MPI**, and each piece of LAPI statistical data is preceded by **LAPI**.

The **MPCI_stats_t** structure contains this statistical information, which is printed out:

sends	Count of sends initiated.
sendsComplete	Count of sends completed (message sent).
sendWaitsComplete	Count of send waits completed (blocking and nonblocking).
recvs	Count of receives initiated.
recvWaitsComplete	Count of receive waits complete.
earlyArrivals	Count of messages received for which no receive was posted.
earlyArrivalsMatched	Count of early arrivals for which a posted receive has been found.
lateArrivals	Count of messages received for which a receive was posted.
shoves	Count of calls to lapi_send_msg.
pulls	Count of calls to lapi_recv and lapi_recv_vec.

threadedLockYields Count of lock releases due to waiting threads.

unorderedMsgs Count of the total number of out of order messages.

buffer_mem_hwmark The peak of the memory usage of **buffer_memory** for the early arrivals.

If the peak memory usage is greater than the amount preallocated with environment variable **MP_BUFFER_MEM**, you may wish to increase the preallocation. If the peak memory usage is significantly less than the amount preallocated, you may wish to decrease the preallocation, but set an upper bound that equals the previous preallocation value. Decreasing the preallocation without using the prior preallocation as an upper bound may hurt performance by forcing a deeper, unwarranted conservatism in the use of eager protocol.

tokenStarveds Number of times a message with the length less than or equal to eager limit were forced to use rendezvous protocol.

If there are more than a few times a message was forced to use rendezvous protocol, you may wish to increase the upper bound given by the second argument of environment variable **MP_BUFFER_MEM**. If raising the upper bound for **MP_BUFFER_MEM** causes the buffer_mem_hwmark to go up, and there are still messages forced back to rendezvous protocol, there may be a progress or workload imbalance among the tasks in your application. Adjustments that allow even more eager messages may aggravate the imbalance and harm overall performance.

envelope_mem_used Number of bytes the memory buffer used for storing the envelopes.

The **lapi_stats_t** structure contains this statistical information:

Tot_retrans_pkt_cnt Retransmit packet count.

Tot_gho_pkt_cnt Ghost packets count.

Tot_pkt_sent_ Total packets sent.

Tot_pkt_recv_cnt Total packets received.

Tot_data_sent Count of total data sent.

Tot_data_recv Count of total data received.

Parameters

fp In C, *fp* is either STDOUT, STDERR or a FILE pointer returned by the fopen function.

In FORTRAN, FILE_DESCRIPTOR is the file descriptor of the file that this function will write to, having these values:

1 Indicates that the output is to be written to STDOUT.

2 Indicates that the output is to be written to STDERR.

Other Indicates the integer returned by the XL FORTRAN utility **getfd**, if the output is to be written to an application-defined file.

The **getfd** utility converts a FORTRAN LUNIT number to a file descriptor. See **Examples** for more detail.

RC In FORTRAN, *RC* will contain the integer value returned by this function. See **Return Values** for more detail.

Return values

-1 Neither MPI nor LAPI statistics are available.

0 Both MPI and LAPI statistics are available.

1 Only MPI statistics are available.

2 Only LAPI statistics are available.

Examples

C Example

```
#include "pm_util.h"

     ......

     MPI_Init( ... );

     MPI_Send( ... );

     MPI_Recv( ... );

     /* Write statistics to standard out */
     mpc_statistics_write(stdout);

     MPI_Finalize();
```

FORTRAN Example

```
integer(4) LUNIT, stat_ofile, stat_rc, getfd

      call MPI_INIT (ierror)
      .....

c     stat_ofile = 1 if output is to go to stdout
c     stat_ofile = 2 if output is to go to stderr
c     If output is to go a file do the following
      LUNIT = 4
      OPEN (LUNIT, FILE="/tmp/mpi_stat.out")
      CALL FLUSH_(LUNIT)
      stat_ofile = getfd(LUNIT)
      call MP_STATISTICS_WRITE(stat_ofile, stat_rc)
      call MPI_FINALIZE(ierror)

      .....
```

MP_STATISTICS_ZERO, mpc_statistics_zero

Purpose

Resets (zeros) the **MPCI_stats_t** structure. It has no effect on LAPI.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
mpc_statistics_zero();
```

FORTRAN synopsis

```
MP_STATISTICS_ZERO()
```

Description

If the **MP_STATISTICS** environment variable is set to **yes**, MPI will keep a running total on a set of statistical data, after **MPI_INIT** is completed. At any time during execution, the application can call this function to reset the current total to zero.

Parameters

None.

Return values

None.

MP_STDOUT_MODE, mpc_stdout_mode

Purpose

Sets the mode for STDOUT.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_stdout_mode(int mode);
```

FORTRAN synopsis

```
MP_STDOUT_MODE(INTEGER MODE)
```

Description

This parallel utility subroutine requests that STDOUT be set to single, ordered, or unordered mode. In single mode, only one task output is displayed. In unordered mode, output is displayed in the order received at the home node. In ordered mode, each parallel task writes output data to its own buffer. When a flush request is made all the task buffers are flushed, in order of task ID, to STDOUT home node.

Parameters

mode
is the mode to which STDOUT is to be set. The valid values are:

taskid Specifies single mode for STDOUT, where *taskid* is the task identifier of the new single task. This value must be between 0 and *n*-1, where *n* is the total of tasks in the current partition. The *taskid* requested does not have to be the issuing task.

-2 Specifies ordered mode for STDOUT. The macro STDIO_ORDERED is supplied for use in C programs.

-3 Specifies unordered mode for STDOUT. The macro STDIO_UNORDERED is supplied for use in C programs.

Notes

- All current STDOUT buffers are flushed before the new STDOUT mode is established.
- The initial mode for STDOUT is set by using the environment variable **MP_STDOUTMODE**, or by using the command-line option **-stdoutmode**, with the latter overriding the former. The default STDOUT mode is unordered.
- This subroutine is implemented with a half second sleep interval to ensure that the mode change request is processed before subsequent writes to STDOUT.
- This subroutine is threadsafe.

Return values

In C and C++ calls, the following applies:

0 Indicates successful completion.

-1 Indicates that an error occurred. A message describing the error will be issued.

Examples

C Example

The following program uses **poe** with the **-labelio yes** option and three tasks:

```
    #include <pm_util.h>

main()
{
 mpc_stdout_mode(STDIO_ORDERED);
 printf("These lines will appear in task order\n");
 /*
  * Call mpc_flush here to make sure that one task
  * doesn't change the mode before all tasks have
  * sent the previous printf string to the home node.
  */
 mpc_flush(1);
 mpc_stdout_mode(STDIO_UNORDERED);
 printf("These lines will appear in the order received by the home node\n");
 /*
  * Since synchronization is not used here, one task could actually
  * execute the next statement before one of the other tasks has
  * executed the previous statement, causing one of the unordered
  * lines not to print.
  */
 mpc_stdout_mode(1);
 printf("Only 1 copy of this line will appear from task 1\n");
}
```

Running the above C program produces the following output (task order of lines 4-6 may differ):

- **0** : These lines will appear in task order.
- **1** : These lines will appear in task order.
- **2** : These lines will appear in task order.
- **1** : These lines will appear in the order received by the home node.
- **2** : These lines will appear in the order received by the home node.
- **0** : These lines will appear in the order received by the home node.
- **1** : Only 1 copy of this line will appear from task 1.

FORTRAN Example

```
CALL MP_STDOUT_MODE(-2)
WRITE(6, *) 'These lines will appear in task order'
CALL MP_FLUSH(1)
CALL MP_STDOUT_MODE(-3)
WRITE(6, *) 'These lines will appear in the order received by the home node'
CALL MP_STDOUT_MODE(1)
WRITE(6, *) 'Only 1 copy of this line will appear from task 1'
END
```

Running the above program produces the following output (the task order of lines 4 through 6 may differ):

- **0** : These lines will appear in task order.
- **1** : These lines will appear in task order.
- **2** : These lines will appear in task order.
- **1** : These lines will appear in the order received by the home node.
- **2** : These lines will appear in the order received by the home node.
- **0** : These lines will appear in the order received by the home node.

- **1 :** Only 1 copy of this line will appear from task 1.

Related information

Commands:

- mpcc_r
- mpCC_r
- mpxlf_r

Subroutines:

- MP_FLUSH, mpc_flush
- MP_STDOUTMODE_QUERY, mpc_stdoutmode_query
- MP_SYNCH, mpc_synch

MP_STDOUTMODE_QUERY, mpc_stdoutmode_query

Purpose

Queries the current STDOUT mode setting.

Library

libmpi_r.a

C synopsis

```
#include <pm_util.h>
int mpc_stdoutmode_query(int *mode);
```

FORTRAN synopsis

```
MP_STDOUTMODE_QUERY(INTEGER MODE)
```

Description

This parallel utility subroutine returns the mode to which STDOUT is currently set.

Parameters

mode
is the address of an integer in which the current STDOUT mode setting will be returned. Possible return values are:

taskid Indicates that the current STDOUT mode is single, i.e. output for only task taskid is displayed.

-2 Indicates that the current STDOUT mode is ordered. The macro STDIO_ORDERED is supplied for use in C programs.

-3 Indicates that the current STDOUT mode is unordered. The macro STDIO_UNORDERED is supplied for use in C programs.

Notes

- Between the time one task issues a mode query request and receives a response, it is possible that another task can change the STDOUT mode setting to another value unless proper synchronization is used.
- This subroutine is threadsafe.

Return values

In C and C++ calls, the following applies:

0 Indicates successful completion.

-1 Indicates that an error occurred. A message describing the error will be issued.

Examples

C Example

The following program uses **poe** with one task:

```
#include <pm_util.h>

main()
```

```
{
 int mode;

 mpc_stdoutmode_query(&mode);
 printf("Initial (default) STDOUT mode is %d\n", mode);
 mpc_stdout_mode(STDIO_ORDERED);
 mpc_stdoutmode_query(&mode);
 printf("New STDOUT mode is %d\n", mode);
}
```

Running the above program produces the following output:

- Initial (default) STDOUT mode is -3
- New STDOUT mode is -2

FORTRAN Example

The following program uses **poe** with one task:

```
INTEGER MODE

CALL MP_STDOUTMODE_QUERY(mode)
WRITE(6, *) 'Initial (default) STDOUT mode is', mode
CALL MP_STDOUT_MODE(-2)
CALL MP_STDOUTMODE_QUERY(mode)
WRITE(6, *) 'New STDOUT mode is', mode
END
```

Running the above program produces the following output:

- Initial (default) STDOUT mode is -3
- New STDOUT mode is -2

Related information

Commands:

- mpcc_r
- mpCC_r
- mpxlf_r

Subroutines:

- MP_FLUSH, mpc_flush
- MP_STDOUT_MODE, mpc_stdout_mode
- MP_SYNCH, mpc_synch

MP_UNSET_CKPT_CALLBACKS, mpc_unset_ckpt_callbacks

Purpose

Unregisters checkpoint, resume, and restart application callbacks.

Library

libmpi_r.a

C synopsis

```
#include <pm_ckpt.h>
int mpc_unset_ckpt_callbacks(int handle);
```

FORTRAN synopsis

```
MP_UNSET_CKPT_CALLBACKS(INTEGER HANDLE, INTEGER RC)
```

Description

The MP_UNSET_CKPT_CALLBACKS subroutine is called to unregister checkpoint, resume, and restart application callbacks that were registered with the MP_SET_CKPT_CALLBACKS subroutine.

Parameters

handle is an integer indicating the set of callback subroutines to be unregistered. This integer is the value returned by the subroutine used to register the callback subroutine.

In FORTRAN, *RC* contains one of the values listed under **Return Values**.

Notes

If a call to MP_UNSET_CKPT_CALLBACKS is issued while a checkpoint is in progress, it is possible that the previously-registered callback will still be run during this checkpoint.

There are certain limitations associated with checkpointing an application. See “Checkpoint and restart limitations” on page 38 for more information.

For general information on checkpointing and restarting programs, see *IBM Parallel Environment: Operation and Use, Volume 1*.

For more information on the use of LoadLeveler and checkpointing, see *Tivoli Workload Scheduler LoadLeveler: Using and Administering*.

Return values

0 Indicates that MP_UNSET_CKPT_CALLBACKS successfully removed the callback subroutines from the list of registered callback subroutines

-1 Indicates that an error occurred. A message describing the error will be issued.

Examples

C Example

```
#include <pm_ckpt.h>
int ihndl;
callbacks_t cbs;
void foo(void);
void bar(void);
cbs.checkpoint_callback=foo;
cbs.resume_callback=bar;
cbs.restart_callback=bar;
ihndl = mpc_set_ckpt_callbacks(callbacks_t *cbs);
:
mpc_unset_ckpt_callbacks(ihndl);
:
```

FORTRAN Example

```
SUBROUTINE FOO
:
RETURN
END
SUBROUTINE BAR
:
RETURN
END
PROGRAM MAIN
EXTERNAL FOO, BAR
INTEGER HANDLE, RC
:
CALL MP_SET_CKPT_CALLBACKS(FOO,BAR,BAR,HANDLE)
IF (HANDLE .NE. 0) STOP 666
:
CALL MP_UNSET_CKPT_CALLBACKS(HANDLE,RC)
:
END
```

Related information

Commands:

- poeckpt
- poerestart

Subroutines:

- MP_INIT_CKPT, mpc_init_ckpt
- MP_SET_CKPT_CALLBACKS, mpc_set_ckpt_callbacks

pe_dbg_breakpoint

Purpose

Provides a communication mechanism between Parallel Operating Environment (POE) and an attached third party debugger (TPD).

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>
void pe_dbg_breakpoint(void);
```

Description

The **pe_dbg_breakpoint** subroutine is used to exchange information between POE and an attached TPD for the purposes of starting, checkpointing, or restarting a parallel application. The call to the subroutine is made by the POE application within the context of various debug events and related POE global variables, which may be examined or filled in by POE and the TPD. All task-specific arrays are allocated by POE and should be indexed by task number (starting with 0) to retrieve or set information specific to that task.

The TPD should maintain a breakpoint within this function, check the value of **pe_dbg_debugevent** when the function is entered, take the appropriate actions for each event as described below, and allow the POE executable to continue.

PE_DBG_INIT_ENTRY
Used by POE to determine if a TPD is present. The TPD should set the following:

int pe_dbg_stoptask
Should be set to 1 if a TPD is present. POE will then cause the remote applications to be stopped using **ptrace**, allowing the TPD to attach to and continue the tasks as appropriate.

In addition, POE will interpret the SIGSOUND and SIGRETRACT signals as checkpoint requests from the TPD. SIGSOUND should be sent when the parallel job should continue after a successful checkpoint, and SIGRETRACT should be sent when the parallel job should terminate after a successful checkpoint.

Note: Unpredictable results may occur if these signals are sent while a parallel checkpoint from a **PE_DBG_CKPT_REQUEST** is still in progress.

PE_DBG_CREATE_EXIT
Indicates that all remote tasks have been created and are stopped. The TPD may retrieve the following information about the remote tasks:

int pe_dbg_count
The number of remote tasks that were created. Also the number of elements in task-specific arrays in the originally started process, which remains constant across restarts.

For a restarted POE process, this number may not be the same as the number of tasks that existed when POE was originally started. To

determine which tasks may have exited prior to the checkpoint from which the restart is performed, the **poe_task_info** routine should be used.

long *pe_dbg_hosts
Address of the array of remote task host IP addresses.

long *pe_dbg_pids
Address of the array of remote task process IDs. Each of these will also be used as the chk_pid field of the cstate structure for that task's checkpoint.

char **pe_dbg_executables
Address of the array of remote task executable names, excluding path.

PE_DBG_CKPT_REQUEST
Indicates that POE has received a user-initiated checkpoint request from one or all of the remote tasks, has received a request from LoadLeveler to checkpoint an interactive job, or has detected a pending checkpoint while being run as a LoadLeveler batch job. The TPD should set the following:

int pe_dbg_do_ckpt
Should be set to 1 if the TPD wishes to proceed with the checkpoint.

PE_DBG_CKPT_START
Used by POE to inform the TPD whether or not to issue a checkpoint of the POE process. The TPD may retrieve or set the following information for this event:

int pe_dbg_ckpt_start
Indicates that the checkpoint may proceed if set to 1, and the TPD may issue a **pe_dbg_checkpnt** of the POE process and some or all of the remote tasks.

The TPD should obtain (or derive) the checkpoint file names, checkpoint flags, cstate, and checkpoint error file names from the variables below.

char *pe_dbg_poe_ckptfile
Indicates the full pathname to the POE checkpoint file to be used when checkpointing the POE process. The name of the checkpoint error file can be derived from this name by concatenating the **.err** suffix. The checkpoint error file name should also be used for **PE_DBG_CKPT_START** events to know the file name from which to read the error data.

char **pe_dbg_task_ckptfiles
Address of the array of full pathnames to be used for each of the task checkpoints. The name of the checkpoint error file can be derived from this name by concatenating the **.err** suffix.

int pe_dbg_poe_ckptflags
Indicates the checkpoint flags to be used when checkpointing the POE process. Other supported flag values for terminating or stopping the POE process may be ORed in by the TPD, if the TPD user issued the checkpoint request.

int pe_dbg_task_ckptflags
Indicates the checkpoint flags to be used when checkpointing the remote tasks. Other supported flag values for stopping the remote tasks must be ORed in by the TPD.

The **id** argument for calls to the **pe_dbg_checkpnt** routine may be derived from the checkpoint flags. If **CHKPNT_CRID** is set in the checkpoint flags, the **pe_dbg_getcrid** routine should be used to determine the CRID of the checkpoint/restart group. Otherwise, the PID of the target process should be used. Note that the **CHKPNT_CRID** flag will always be set for the remote task checkpoints, and may or may not be set for POE checkpoints.

int pe_dbg_task_pipecnt
Indicates the number of pipefds that will appear for each task in the pe_dbg_task_pipefds array. This value must also be used for chk_nfd in the cstate structure of the remote task checkpoints.

int **pe_dbg_task_pipefds
Pointer to the arrays containing the file descriptor numbers for each of the remote tasks. These numbers must be used for chk_fdp in the cstate structure of the remote task checkpoints.

The following variable should be examined by the TPD, but contains no information directly related to making the **pe_dbg_checkpnt** calls.

int pe_dbg_ckpt_aware
Indicates whether or not the remote tasks that make up the parallel application are checkpoint aware.

The following variables should be filled in by the TPD prior to continuing POE from this event:

int *pe_dbg_ckpt_pmd
Address of an array used by the TPD to indicate which tasks will have the checkpoints performed by the TPD (value=0) and which tasks the Partition Manager Daemon (PMD) should issue checkpoints for (value=1). POE requires that the TPD must perform all checkpoints for a particular parallel job on any node where at least one checkpoint will be performed by the TPD.

int pe_dbg_brkpt_len
Used to inform POE of how much data to allocate for pe_dbg_brkpt_data for later use by the TPD when saving or restoring breakpoint data. A value of 0 may be used when there is no breakpoint data.

PE_DBG_CKPT_START_BATCH
Same as **PE_DBG_CKPT_START**, but the following variables should be ignored:

- **int pe_dbg_ckpt_start**
- **int pe_dbg_poe_ckptflags**

For this event, the TPD should not issue a checkpoint of the POE process.

PE_DBG_CKPT_VERIFY
Indicates that POE has detected a pending checkpoint. POE must verify that the checkpoint was issued by the TPD before proceeding. The TPD should set the following:

int pe_dbg_is_tpd
Should be set to 1 if the TPD issued the checkpoint request.

PE_DBG_CKPT_STATUS
Indicates the status of the remote checkpoints that were performed by the TPDs. The TPD should set the following:

int *pe_dbg_task_ckpterrnos
Address of the array of errnos from the remote task checkpoints (0 for successful checkpoint). These values can be obtained from the Py_error field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

void *pe_dbg_brkpt_data
The breakpoint data to be included as part of POE's checkpoint file. The format of the data is defined by the TPD, and may be retrieved from POE's address space at restart time.

int *pe_dbg_Sy_errors
The secondary errors obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the Sy_error field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

int *pe_dbg_Xtnd_errors
The extended errors obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the Xtnd_error field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

int *pe_dbg_error_lens
The user error data lengths obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the error_len field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

PE_DBG_CKPT_ERRDATA
Indicates that the TPD has reported one or more task checkpoint failures, and that POE has allocated space in the following array for the TPD to use to fill in the error data.

char **pe_dbg_error_data
The user error data obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the error data field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

PE_DBG_CKPT_DETACH
Used by POE to indicate to the TPD that it should detach from the POE process. After being continued from **pe_dbg_breakpoint** for this event (just prior to the TPD actually detaching), POE will wait until its trace bit is no longer set before instructing the kernel to write its checkpoint file. POE will indicate to the TPD that it is safe to reattach to the POE process by creating the file **/tmp/.poe.***PID***.reattach**, where *PID* is the process ID of the POE process.

PE_DBG_CKPT_RESULTS
Indicates the checkpoint results to either POE or the TPD, depending on who issued the checkpoint of POE.

int pe_dbg_ckpt_rc
If the TPD issued the checkpoint, this variable should be filled in by the TPD and should contain the return code from the call to **pe_dbg_checkpnt**. Otherwise, POE will fill in this value to indicate to the TPD whether the checkpoint succeeded (value=1) or failed (value=0). For failed checkpoints, the TPD may obtain the error information from the POE checkpoint error file.

int pe_dbg_ckpt_errno
If the TPD issued the checkpoint and the checkpoint failed, this variable should be filled in by the TPD and should contain the errno set by AIX upon return from **pe_dbg_checkpnt**.

PE_DBG_CKPT_RESUME
When this event occurs, the TPD may continue or terminate the remote tasks (or keep them stopped) after a successful checkpoint. The TPD must not perform the post-checkpoint actions until this event is received, to ensure that POE and LoadLeveler have performed their post-checkpoint synchronization. If the TPD did not issue the checkpoint, the following variable should be examined:

int pe_dbg_ckpt_action
POE will fill in this value to indicate to the TPD if the remote tasks should be continued (value=0) or terminated (value=1) after a successful checkpoint.

PE_DBG_CKPT_CANCEL
Indicates that POE has received a request to cancel an in-progress checkpoint. The TPD should cause a SIGINT to be sent to the thread that issued the **pe_dbg_checkpnt** calls in the remote tasks. If the TPD is non-threaded and performs nonblocking checkpoints, the task checkpoints cannot be cancelled.

Note: If the TPD user issues a request to cancel a checkpoint being performed by the TPD, the TPD should send a SIGGRANT to the POE process so that the remote checkpoints being performed by the PMDs can be interrupted. Otherwise, the checkpoint call in the TPD can return while some remote checkpoints are still in progress.

PE_DBG_RESTART_READY
Indicates that processes for the remote task restarts have been created and that **pe_dbg_restart** calls for the remote tasks may be issued by the TPD. The TPD must perform the restarts of all remote tasks.

The TPD should first retrieve the remote task information specified in the variables described above under **PE_DBG_CREATE_EXIT**. The TPD should then obtain (or derive) the restart file names, the restart flags, rstate, and restart error file names from the variables below. The **id** argument for the **pe_dbg_restart** call must be derived from the remote task PID using **pe_dbg_getcrid** routine.

char **pe_dbg_task_rstfiles
Address of the array of full pathnames to be used for each of the task restarts. The name of the restart error file can be derived from this name by concatenating the **.err** suffix.

int pe_dbg_task_rstflags
Indicates the restart flags to be used when restarting the remote tasks. Other supported flag values for stopping the remote tasks may be ORed in by the TPD.

char **pe_dbg_task_rstate
Address of the array of strings containing the restart data required for each of the remote tasks. This value may be used as is for the rst_buffer member of the rstate structure used in the remote task restarts, or additional data may be appended by the TPD, as described below:

```
DEBUGGER_STOP=yes
```

If this string appears in the task restart data, followed by a newline (**\n**) character and a **\0**, the remote task will send a SIGSTOP signal to itself once all restart actions have been completed in the restart handler. This

will likely be used by the TPD when tasks are checkpoint-aware, and the TPD wants immediate control of the task after it completes restart initialization.

The rst_len member of the rstate structures should include a **\0**, whether the TPD appends to the rst_buffer or not.

The following variables should be re-examined by the TPD during this event:

int pe_dbg_ckpt_aware
Indicates whether or not the remote tasks that make up the parallel application are checkpoint aware.

void *pe_dbg_brkpt_data
The breakpoint data that was included as part of POE's checkpoint file. The format of the data is defined by the TPD.

The following variables should be filled in by the TPD prior to continuing POE from this event. This also implies that all remote restarts must have been performed before continuing POE:

int *pe_dbg_task_rsterrnos
Address of the array of errnos from the remote task restarts (0 for successful restart). These values can be obtained from the Py_error field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

int *pe_dbg_Sy_errors
The secondary errors obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the Sy_error field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

int *pe_dbg_Xtnd_errors
The extended errors obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the Xtnd_error field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

int *pe_dbg_error_lens
The user error data lengths obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the error_len field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

PE_DBG_RESTART_ERRDATA
Indicates that the TPD has reported one or more task restart failures, and that POE has allocated space in the following array for the TPD to use to fill in the error data.

char **pe_dbg_error_data
The user error data obtained from **pe_dbg_read_cr_errfile**. These values can be obtained from the error data field of the cr_error_t struct, returned from the **pe_dbg_read_cr_errfile** calls.

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file. This flag is an uppercase letter **i**.

Any references to process ID or PID above represent the real process ID, and not the virtual process ID associated with checkpointed/restarted processes.

pe_dbg_checkpnt

Purpose

Checkpoints a process that h is under debugger control, or a group of processes.

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>
int pe_dbg_checkpnt(path, id, flags, cstate, epath)
char *path;
id_t id;
unsigned int flags;
chk_state_t *cstate;
char *epath;
```

Description

The **pe_dbg_checkpnt** subroutine allows a process to checkpoint a process that is under debugger control, or a set of processes that have the same checkpoint/restart group ID (CRID). The state information of the checkpointed processes is saved in a single file. All information required to restart the processes (other than the executable files, any shared libraries, any explicitly loaded modules and data, if any, passed through the restart system calls) is contained in the checkpoint file.

Processes to be checkpointed will be stopped before the process information is written to the checkpoint file to maintain data integrity. If a process has not registered a checkpoint handler, it will be stopped when a checkpoint request is issued. However, if a process has registered a checkpoint handler, the debugger must allow the checkpoint handler to reach its call to **checkpnt_commit** for the process to be put into the stopped state.

After all processes have been stopped, the checkpoint file is written with process information one process at a time. After the write has completed successfully, the **pe_dbg_checkpnt** subroutine will do one of the following depending on the value of the flags passed:

- Continue the processes.
- Terminate all the checkpointed processes.
- Leave the processes in the stopped state.

If any one of the processes to be checkpointed is a **setuid** or **setgid** program, the **pe_dbg_checkpnt** subroutine will fail, unless the caller has superuser privilege. If shared memory is being used within the set of processes being checkpointed, all processes that use the shared memory must belong to the checkpoint/restart group being checkpointed, or the **pe_dbg_checkpnt** subroutine will fail, unless the **CHKPNT_IGNORE_SHMEM** flag is set.

The **pe_dbg_checkpnt** subroutine may be interrupted, in which case, all processes being checkpointed will continue to run and neither a checkpoint file nor an error file will be created.

Parameters

path
The path of the checkpoint file to be created. This file will be created read-only with the ownership set to the user ID of the process invoking the **pe_dbg_checkpnt** call.

id Indicates the process ID of the process to be checkpointed or the checkpoint/restart group ID or CRID of the set of processes to be checkpointed as specified by a value of the **flags** parameter.

flags
Determines the behavior of the **pe_dbg_checkpnt** subroutine and defines the interpretation of the **id** parameter. The **flags** parameter is constructed by logically ORing the following values, which are defined in the **sys/checkpnt.h** file:

CHKPNT_AND_STOP
Setting this bit causes the checkpointed processes to be put in a stopped state after a successful checkpoint operation. The processes can be continued by sending them SIGCONT. The default is to checkpoint and continue running the processes.

CHKPNT_AND_STOPTRC
Setting this bit causes any process that is traced to be put in a stopped state after a successful checkpoint operation. The processes can be continued by sending them SIGCONT. The default is to checkpoint and continue running the processes.

CHKPNT_AND_TERMINATE
Setting this bit causes the checkpointed processes to be terminated on a successful checkpoint operation. The default is to checkpoint and continue running the processes.

CHKPNT_CRID
Specifies that the **id** parameter is the checkpoint/restart group ID or CRID of the set of processes to be checkpointed.

CHKPNT_IGNORE_SHMEM
Specifies that shared memory should not be checkpointed.

CHKPNT_NODELAY
Specifies that **pe_dbg_checkpnt** will not wait for the completion of the checkpoint call. As soon as all the processes to be checkpointed have been identified, and the checkpoint operation started for each of them, the call will return. The kernel will not provide any status on whether the call was successful. The application must examine the checkpoint file to determine if the checkpoint operation succeeded or not. By default, the **pe_dbg_checkpnt** subroutine will wait for all the checkpoint data to be completely written to the checkpoint file before returning.

The **CHKPNT_AND_TERMINATE** and **CHKPNT_AND_STOP** flags are mutually exclusive. Do not specify them at the same time.

cstate
Pointer to a structure of type chk_state_t. This parameter is ignored unless the process is the primary checkpoint process for the pending checkpoint operation. The list of file descriptors that need to be inherited at restart time should be specified in the structure.

epath
An error file name to log error and debugging data if the checkpoint fails. This field is mandatory and must be provided.

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file. This flag is an uppercase letter **i**.

Any references to process ID or PID above represent the real process ID, and not the virtual process ID associated with checkpointed or restarted processes.

Return values

Upon successful completion, a value of **CHECKPOINT_OK** is returned.

If the invoking process is included in the set of processes being checkpointed, and the **CHKPNT_AND_TERMINATE** flag is set, this call will not return if the checkpoint is successful because the process will be terminated.

If the **pe_dbg_checkpnt** call is unsuccessful, **CHECKPOINT_FAILED** is returned and the errno global variable is set to indicate the error.

If a process that successfully checkpointed itself is restarted, it will return from the **pe_dbg_checkpnt** call with a value of **RESTART_OK**.

Errors

The **pe_dbg_checkpnt** subroutine is unsuccessful when the global variable errno contains one of the following values:

EACCES
One of the following is true:

- The file exists, but could not be opened successfully in exclusive mode, or write permission is denied on the file, or the file is not a regular file.
- Search permission is denied on a component of the path prefix specified by the path parameter. Access could be denied due to a secure mount.
- The file does not exist, and write permission is denied for the parent directory of the file to be created.

EAGAIN
Either the calling process or one or more of the processes to be checkpointed is already involved in another checkpoint or restart operation.

EINTR Indicates that the checkpoint operation was terminated due to receipt of a signal. No checkpoint file will be created. A call to the **pe_dbg_checkpnt_wait** subroutine should be made when this occurs, to ensure that the processes reach a state where subsequent checkpoint operations will not fail unpredictably.

EINVAL
Indicates that a NULL **path** or **epath** parameter was passed in, or an invalid set of flags was set, or an invalid id parameter was passed.

ENOMEM
Insufficient memory exists to initialize the checkpoint structures.

ENOSYS
One of the following is true:

- The caller of the function is not a debugger.
- The process could not be checkpointed because it violated a restriction.

ENOTSUP
One of the processes to be checkpointed is a kernel process or has a kernel-only thread.

EPERM
Indicates that the process does not have appropriate privileges to checkpoint one or more of the processes.

ESRCH
One of the following is true:

- The process whose process ID was passed, or the checkpoint/restart group whose CRID was passed, does not exist.
- The process whose process ID was passed, or the checkpoint/restart group whose CRID was passed, is not checkpointable because there in no process that had the environment variable **CHECKPOINT** set to **yes** at execution time.
- The indicated checkpoint/restart group does not have a primary checkpoint process.

pe_dbg_checkpnt_wait

Purpose

Waits for a checkpoint, or pending checkpoint file I/O, to complete.

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>
int pe_dbg_checkpnt_wait(id, flags, options)
id_t id;
unsigned int flags;
int *options;
```

Description

The **pe_dbg_checkpnt_wait** subroutine can be used to:

- Wait for a pending checkpoint issued by the calling thread's process to complete.
- Determine whether a pending checkpoint issued by the calling thread's process has completed, when the CHKPNT_NODELAY flag is specified.
- Wait for any checkpoint file I/O that may be in progress during an interrupted checkpoint to complete.

The **pe_dbg_checkpnt_wait** subroutine will return to the caller once any checkpoint file I/O that may be in progress during an interrupted checkpoint has completed. The **pe_dbg_checkpnt** routine does not wait for this file I/O to complete when the checkpoint operation is interrupted. Failure to perform this call after an interrupted checkpoint can cause a process or set of processes to be in a state where subsequent checkpoint operations could fail unpredictably.

Parameters

id Indicates the process ID or the checkpoint/restart group ID (CRID) of the processes for which a checkpoint operation was initiated or interrupted, as specified by a value of the flag parameter.

flags
Defines the interpretation of the **id** parameter. The **flags** parameter may contain the following value, which is defined in the **sys/checkpnt.h** file:

CHKPNT_CRID
Specifies that the **id** parameter is the checkpoint/restart group ID or CRID of the set of processes for which a checkpoint operation was initiated or interrupted.

CHKPNT_NODELAY
Specifies that **pe_dbg_checkpnt_wait** will not wait for the completion of the checkpoint call. This flag should not be used when waiting for pending checkpoint file I/O to complete.

options
This field is reserved for future use and should be set to NULL.

Future implementations of this function may return the checkpoint error code in this field. Until then, the size of the checkpoint error file can be used in most cases to determine whether the checkpoint succeeded or failed. If the size of

the file is 0, the checkpoint succeeded, otherwise the checkpoint failed and checkpoint error file will contain the error codes. If the file does not exist, the checkpoint most likely failed due to an **EPERM** or **ENOENT** on the checkpoint error file pathname.

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file. This flag is an uppercase letter **i**.

Any references to process ID or PID above represent the real process ID, and not the virtual process ID associated with checkpointed/restarted processes.

Return values

Upon successful completion, a value of 0 is returned, indicating that one of the following is true:

- The pending checkpoint completed.
- There was no pending checkpoint.
- The pending file I/O completed.
- There was no pending file I/O.

If the **pe_dbg_checkpnt_wait** call is unsuccessful, -1 is returned and the errno global variable is set to indicate the error.

Errors

The **pe_dbg_checkpnt_wait** subroutine is unsuccessful when the global variable errno contains one of the following values:

EINPROGRESS
Indicates that the pending checkpoint operation has not completed when the **CHKPNT_NODELAY** flag is specified.

EINTR Indicates that the operation was terminated due to receipt of a signal.

EINVAL
Indicates that an invalid flag was set.

ENOSYS
The caller of the function is not a debugger.

ESRCH
The process whose process ID was passed or the checkpoint/restart group whose CRID was passed does not exist.

pe_dbg_getcrid

Purpose

Returns the checkpoint/restart ID.

Library

POE API library (libpoeapi.a)

C synopsis

```
crid_t pe_dbg_getcrid(pid)
pid_t pid;
```

Description

The **pe_dbg_getcrid** subroutine returns the checkpoint/restart group ID (CRID) of the process whose process ID was specified in the **pid** parameter, or the CRID of the calling process if a value of -1 was passed.

Parameters

pid Either the process ID of a process to obtain its CRID, or -1 to request the CRID of the calling process.

Notes

Any references to process ID or PID above represent the real process ID, and not the virtual process ID associated with checkpointed/restarted processes.

Return values

If the process belongs to a checkpoint/restart group, a valid CRID is returned. If the process does not belong to any checkpoint/restart group, a value of zero is returned. For any error, a value of -1 is returned and the errno global variable is set to indicate the error.

Errors

The **pe_dbg_getcrid** subroutine is unsuccessful when the global variable errno contains one of the following values:

ENOSYS The caller of the function is not a debugger.

ESRCH There is no process with a process id equal to **pid**.

pe_dbg_getrtid

Purpose

Returns real thread ID of a thread in a specified process given its virtual thread ID.

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>

tid_t pe_dbg_getrtid(pid, vtid)
pid_t pid;
tid_t vtid;
```

Description

The **pe_dbg_getrtid** subroutine returns the real thread ID of the specified virtual thread in the specified process.

Parameters

pid The real process ID of the process containing the thread for which the real thread ID is needed

vtid The virtual thread ID of the thread for which the real thread ID is needed.

Return values

If the calling process is not a debugger, a value of -1 is returned. Otherwise, the **pe_dbg_getrtid** call is always successful. If the process does not exist or has exited or is not a restarted process, or if the provided virtual thread ID does not exist in the specified process, the value passed in the **vtid** parameter is returned. Otherwise, the real thread ID of the thread whose virtual thread ID matches the value passed in the **vtid** parameter is returned

Errors

The **pe_dbg_getrtid** subroutine is unsuccessful if the following is true:

ENOSYS The caller of the function is not a debugger.

pe_dbg_getvtid

Purpose

Returns virtual thread ID of a thread in a specified process given its real thread ID.

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>

tid_t pe_dbg_getvtid(pid, rtid)
pid_t pid;
tid_t rtid
```

Description

The **pe_dbg_getvtid** subroutine returns the virtual thread ID of the specified real thread in the specified process.

Parameters

pid The real process ID of the process containing the thread for which the real thread ID is needed

rtid The real thread ID of the thread for which the virtual thread ID is needed.

Return values

If the calling process is not a debugger, a value of -1 is returned.

Otherwise, the **pe_dbg_getvtid** call is always successful.

If the process does not exist, the process has exited, the process is not a restarted process, or the provided real thread ID does not exist in the specified process, the value passed in the **rtid** parameter is returned.

Otherwise, the virtual thread ID of the thread whose real thread ID matches the value passed in the **rtid** parameter is returned.

Errors

The **pe_dbg_getvtid** subroutine is unsuccessful if the following is true:

ENOSYS The caller of the function is not a debugger.

pe_dbg_read_cr_errfile

Purpose

Opens and reads information from a checkpoint or restart error file.

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>
void pe_dbg_read_cr_errfile(char *path, cr_error_t *err_data, int cr_errno)
```

Description

The **pe_dbg_read_cr_errfile** subroutine is used to obtain the error information from a failed checkpoint or restart. The information is returned in the cr_error_t structure, as defined in **/usr/include/sys/checkpnt.h**.

Parameters

path
The full pathname to the error file to be read.

err_data
Pointer to a cr_error_t structure in which the error information will be returned.

cr_errno
The errno from the **pe_dbg_checkpnt** or **pe_dbg_restart** call that failed. This value is used for the Py_error field of the returned structure if the file specified by the **path** parameter does not exist, has a size of 0, or cannot be opened.

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file. This flag is an uppercase letter **i**.

pe_dbg_restart

Purpose

Restarts processes from a checkpoint file.

Library

POE API library (libpoeapi.a)

C synopsis

```
#include <pe_dbg_checkpnt.h>
int pe_dbg_restart(path, id, flags, rstate, epath)
char *path;
id_t id;
unsigned int flags;
rst_state_t *rstate;
char *epath;
```

Description

The **pe_dbg_restart** subroutine allows a process to restart all the processes whose state information has been saved in the checkpoint file.

All information required to restart these processes (other than the executable files, any shared libraries and explicitly loaded modules) is recreated from the information from the checkpoint file. Then, a new process is created for each process whose state was saved in the checkpoint file. The only exception is the primary checkpoint process, which overlays an existing process specified by the **id** parameter.

When restarting a single process that was checkpointed, the **id** parameter specifies the process ID of the process to be overlaid. When restarting a set of processes, the **id** parameter specifies the checkpoint/restart group ID of the process to be overlaid, and the **flags** parameter must set **RESTART_OVER_CRID**. This process must also be the primary checkpoint process of the checkpoint/restart group. The user ID and group IDs of the primary checkpoint process saved in the checkpoint file should match the user ID and group IDs of the process it will overlay.

After all processes have been re-created successfully, the **pe_dbg_restart** subroutine will do one of the following, depending on the value of the **flags** passed:

- Continue the processes from the point where each thread was checkpointed.
- Leave the processes in the stopped state.

A primary checkpoint process inherits attributes from the attributes saved in the file, and also from the process it overlays. Other processes in the checkpoint file obtain their attributes only from the checkpoint file, unless they share some attributes with the primary checkpoint process. In this case, the shared attributes are inherited. Although the resource usage of each checkpointed process is saved in the checkpoint file, the resource usage attributes will be zeroed out when it is restarted and the **getrusage** subroutine will return only resource usage after the last restart operation.

Some new state data can be provided to processes, primary or non-primary, at restart time if they have a checkpoint handler. The handler should have passed in a valid **rst** parameter when it called **checkpnt_commit** at checkpoint time. At restart time, a pointer to an interface buffer can be passed through the **rstate** parameter in the **pe_dbg_restart** subroutine. The data in the buffer will be copied to the address

previously specified in the **rst** parameter by the checkpoint handler before the process is restarted. The format of the interface buffer is entirely application dependent.

If any one of the processes to be restarted is a **setuid** or a **setgid** program, the **pe_dbg_restart** subroutine will fail, unless the caller has root privilege.

Parameters

path
The path of the checkpoint file to use for the restart. Must be a valid checkpoint file created by a **pe_dbg_checkpnt** call.

id Indicates the process ID or the checkpoint/restart group ID or CRID of the process that is to be overlaid by the primary checkpoint process as identified by the flags parameter.

flags
Determines the behavior of the **pe_dbg_restart** subroutine and defines the interpretation of the **id** parameter. The **flags** parameter is constructed by logically OR'ing one or more of the following values, which are defined in the **sys/checkpnt.h** file:

RESTART_AND_STOP
Setting this bit will cause the restarted processes to be put in a stopped state after a successful restart operation. They can be continued by sending them SIGCONT. The default is to restart and resume running the processes at the point where each thread in the process was checkpointed.

RESTART_AND_STOPTRC
Setting this bit will cause any process that was traced at checkpoint time to be put in a stopped state after a successful restart operation. The processes can be continued by sending them SIGCONT. The default is to restart and resume execution of the processes at the point where each thread in the process was checkpointed.

RESTART_IGNORE_BADSC
Causes the restart operation not to fail if a kernel extension that was present at checkpoint time is not present at restart time. However, if the restarted program uses any system calls in the missing kernel extension, the program will fail when those calls are used.

RESTART_OVER_CRID
Specifies that the **id** parameter is the checkpoint/restart group ID or CRID of the process over which the primary checkpoint process will be restarted. There are multiple processes to be restarted.

RESTART_PAG_ALL
Same as **RESTART_WAITER_PAG**.

RESTART_WAITER_PAG
Ensures that credentials are restored in the restarted process.

rstate
Pointer to a structure of type rst_state_t.

epath
Path to error file to log error and debugging data, if restart fails.

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file. This flag is an uppercase letter **i**.

Any references to process ID or PID above represent the real process ID, and not the virtual process ID associated with checkpointed/restarted processes.

Return values

Upon successful completion, a value of 0 is returned. Otherwise, a value of -1 is returned and the errno global variable is set to indicate the error.

Errors

The **pe_dbg_restart** subroutine is unsuccessful when the global variable errno contains one of the following values:

EACCES
One of the following is true:

- The file exists, but could not be opened successfully in exclusive mode, or write permission is denied on the file, or the file is not a regular file.
- Search permission is denied on a component of the path prefix specified by the path parameter. Access could be denied due to a secure mount.
- The file does not exist, and write permission is denied for the parent directory of the file to be created.

EAGAIN
One of the following is true:

- The user ID has reached the maximum limit of processes that it can have simultaneously, and the invoking process is not privileged.
- Either the calling process or the target process is involved in another checkpoint or restart operation.

EFAULT
Copying from the interface buffer failed. The **rstate** parameter points to a location that is outside the address space of the process.

EINVAL
One of the following is true:

- A NULL path was passed in.
- The checkpoint file contains invalid or inconsistent data.
- The target process is a kernel process.
- The restart data length in the rstate structure is greater than **MAX_RESTART_DATA**.

ENOMEM
One of the following is true:

- There is insufficient memory to create all the processes in the checkpoint file.
- There is insufficient memory to allocate the restart structures inside the kernel.

ENOSYS
One of the following is true:

- The caller of the function is not a debugger.

- One or more processes could not be restarted because a restriction was violated.
- File descriptors or user ID or group IDs are mismatched between the primary checkpoint process and overlaid process.
- The calling process is also the target of the **pe_dbg_restart** subroutine.

EPERM

One of the following is true:

- The calling process does not have appropriate privileges to target for overlay by a restarted process, one or more of the processes identified by the **id** parameter.
- The calling process does not have appropriate privileges to restart one or more of the processes in the checkpoint file.

ESRCH

Indicates that there is no process with the process ID specified by the **id** parameter, or there is no checkpoint restart group with the specified CRID.

Chapter 12. Parallel task identification API subroutines

PE includes an API that allows an application to retrieve the process IDs of all POE *master processes*, or *home node processes* that are running on the same node. The information that is retrieved can be used for accounting, or to get more detailed information about the tasks that are spawned by these POE processes.

The subroutine:

poe_master_task
Retrieves the list of process IDs of POE master processes currently running on the system

poe_task_info
Returns a NULL-terminated array of pointers to structures of type **POE_TASKINFO**.

poe_master_tasks

Purpose

Retrieves the list of process IDs of POE master processes currently running on this system.

C synopsis

```
#include "poeapi.h"
int poe_master_tasks(pid_t **poe_master_pids);
```

Description

An application invoking this subroutine while running on a given node can retrieve the list of process IDs of all POE master processes that are currently running on the same node. This information can be used for accounting purposes or can be passed to the **poe_task_info** subroutine to obtain more detailed information about tasks spawned by these POE master processes.

Parameters

On return, (**poe_master_pids*) points to the first element of an array of *pid_t* elements that contains the process IDs of POE master processes. It is the responsibility of the calling program to free this array. This pointer is NULL if no POE master process is running on this system or if there is an error condition.

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file.

If you are using the **-bl:libpoeapi.exp** binder option, **-L/usr/lpp/ppe.poe/lib** is required; otherwise, you will need to use: **-llibpoeapi**.

Return values

greater than 0
Indicates the size of the array that (**poe_master_pids*) points to

0 Indicates that no POE master process is running.

-1 Indicates that a system error has occurred.

-2 Indicates that POE is unable to allocate memory.

-3 Indicates a non-valid *poe_master_pids* argument.

Related information

- poe_task_info

poe_task_info

Purpose

Returns a NULL-terminated array of pointers to structures of type POE_TASKINFO.

C synopsis

```
#include "poeapi.h"
int poe_task_info(pid_t poe_master_pid, POE_TASKINFO ***poe_taskinfo);
```

Description

Given the process ID of a POE master process, this subroutine returns to the calling program through the *poe_taskinfo* argument a NULL-terminated array of pointers to structures of type POE_TASKINFO. There is one POE_TASKINFO structure for each POE task spawned by this POE master process on a local or remote node.

Each POE_TASKINFO structure contains:
- node name
- IP address
- task ID
- session ID
- child process name
- child process ID

Parameters

poe_master_pid
Specifies the process ID of a POE master process.

poe_taskinfo
On return, points to the first element of a NULL-terminated array of pointers to structures of type POE_TASKINFO.

This pointer is NULL if there is an error condition. It is the responsibility of the calling program to free the array of pointers to POE_TASKINFO structures, as well as the relevant POE_TASKINFO structures and the subcomponents **h_name**, **h_addr**, and **p_name**.

The structure POE_TASKINFO is defined in **poeapi.h**:

```
typedef struct POE_TASKINFO {
   char *h_name; /* host name */
   char *ip_addr; /* IP address */
   int task_id; /* task ID */
   int session_id; /* session ID */
   pid_t pid; /* child process ID */
   char *p_name; /* child process name */
} POE_TASKINFO:
```

Notes

Use **-I/usr/lpp/ppe.poe/include** to pick up the header file.

If you are using the **-bI:libpoeapi.exp** binder option, **-L/usr/lpp/ppe.poe/lib** is required; otherwise, you will need to use: **-llibpoeapi**.

Return values

greater than 0
Indicates the size of the array that (**poe_taskinfo*) points to

0 Indicates that no POE master process is running or that task information is not available yet

-1 Indicates that a system error has occurred.

-2 Indicates that POE is unable to allocate memory.

-3 Indicates a non-valid *poe_master_pids* argument.

Related information

- poe_master_tasks

Appendix A. MPE subroutine summary

This is a list of the nonblocking collective communication subroutines that are available for parallel programming. These subroutines, which have a prefix of **MPE_I**, are extensions of the MPI standard. They are part of IBM's implementation of the MPI standard for PE. For descriptions of these subroutines, see *IBM Parallel Environment: MPI Subroutine Reference*.

With PE Version 4, these nonstandard extensions remain available, but their use is deprecated. The implementation of these routines depends on hidden message passing threads. These routines may **not** be used with environment variable **MP_SINGLE_THREAD** set to **yes**.

Earlier versions of PE/MPI allowed matching of blocking (MPI) with nonblocking (MPE_I) collectives. With PE Version 4, it is advised that you do not match blocking and nonblocking collectives in the same collective operation. If you do, a hang situation can occur. It is possible that some existing applications may hang, when run using PE Version 4. In the case of an unexpected hang, turn on DEVELOP mode by setting the environment variable **MP_EUIDEVELOP** to **yes**, and rerun your application. DEVELOP mode will detect and report any mismatch. If DEVELOP mode identifies a mismatch, you may continue to use the application as is, by setting **MP_SHARED_MEMORY** to **no**. If possible, alter the application to remove the matching of nonblocking with blocking collectives.

Name: C and FORTRAN	Description
MPE_Iallgather MPE_IALLGATHER	nonblocking allgather operation.
MPE_Iallgatherv MPE_IALLGATHERV	nonblocking allgatherv operation.
MPE_Iallreduce MPE_IALLREDUCE	nonblocking allreduce operation.
MPE_Ialltoall MPE_IALLTOALL	nonblocking alltoall operation.
MPE_Ialltoallv MPE_IALLTOALLV	nonblocking alltoallv operation.
MPE_Ibarrier MPE_IBARRIER	nonblocking barrier operation.
MPE_Ibcast MPE_IBCAST	nonblocking broadcast operation.
MPE_Igather MPE_IGATHER	nonblocking gather operation.
MPE_Igatherv MPE_IGATHERV	nonblocking gatherv operation.
MPE_Ireduce MPE_IREDUCE	nonblocking reduce operation
MPE_Ireduce_scatter MPE_IREDUCE_SCATTER	nonblocking reduce_scatter operation
MPE_Iscan MPE_ISCAN	nonblocking scan operation.
MPE_Iscatter MPE_ISCATTER	nonblocking scatter operation.

| **MPE_Iscatterv MPE_ISCATTERV**
| nonblocking scatterv operation.

Appendix B. MPE subroutine bindings

The list in “Bindings for nonblocking collective communication” summarizes the binding information for all of the MPE subroutines listed in *IBM Parallel Environment: MPI Subroutine Reference*. With PE Version 4, these nonstandard extensions remain available, but their use is deprecated. The implementation of these routines depends on hidden message passing threads. These routines may **not** be used with environment variable **MP_SINGLE_THREAD** set to **yes**.

Earlier versions of PE/MPI allowed matching of blocking (MPI) with nonblocking (MPE_I) collectives. With PE Version 4, it is advised that you do not match blocking and nonblocking collectives in the same collective operation. If you do, a hang situation can occur. It is possible that some existing applications may hang, when run using PE Version 4. In the case of an unexpected hang, turn on DEVELOP mode by setting the environment variable **MP_EUIDEVELOP** to **yes**, and rerun your application. DEVELOP mode will detect and report any mismatch. If DEVELOP mode identifies a mismatch, you may continue to use the application as is, by setting **MP_SHARED_MEMORY** to **no**. If possible, alter the application to remove the matching of nonblocking with blocking collectives.

Note: FORTRAN refers to FORTRAN 77 bindings that are officially supported for MPI. However, FORTRAN 77 bindings can be used by FORTRAN 90. FORTRAN 90 offers array section and assumed shape arrays as parameters on calls. These are not safe with MPI.

Bindings for nonblocking collective communication

This is a list of the C and FORTRAN bindings for nonblocking collective communication subroutines. These subroutines, which have a prefix of **MPE_I**, are extensions of the MPI standard. They are part of IBM’s implementation of the MPI standard for PE.

Name: C and FORTRAN	Binding: C and FORTRAN
MPE_Iallgather	int MPE_Iallgather(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype, MPI_Comm comm,MPI_Request *request*);
MPE_IALLGATHER	MPE_IALLGATHER(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE, CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Iallgatherv	int MPE_Iallgatherv(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int *recvcounts,int *displs,MPI_Datatype recvtype,MPI_Comm comm,MPI_Request *request*);
MPE_IALLGATHERV	MPE_IALLGATHERV(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE, CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER DISPLS(*),INTEGER RECVTYPE,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Iallreduce	int MPE_Iallreduce(*void* sendbuf,void* recvbuf,int*

	*count,MPI_Datatype datatype,MPI_Op op,MPI_Comm comm,MPI_Request *request*);
MPE_IALLREDUCE	MPE_IALLREDUCE(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER OP,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Ialltoall	int MPE_Ialltoall(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype,MPI_Comm comm,MPI_Request *request*);
MPE_IALLTOALL	MPE_IALLTOALL(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Ialltoallv	int MPE_Ialltoallv(*void* sendbuf,int *sendcounts,int *sdispls,MPI_Datatype sendtype,void* recvbuf,int *recvcounts,int *rdispls,MPI_Datatype recvtype,MPI_Comm comm,MPI_Request *request*);
MPE_IALLTOALLV	MPE_IALLTOALV(*CHOICE SENDBUF,INTEGER SENDCOUNTS(*),INTEGER SDISPLS(*),INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER RDISPLS(*),INTEGER RECVTYPE,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Ibarrier	int MPE_Ibarrier(*MPI_Comm comm, MPI_Request *request*);
MPE_IBARRIER	MPE_IBARRIER(*INTEGER COMM, INTEGER REQUEST, INTEGER IERROR*)
MPE_Ibcast	int MPE_Ibcast(*void* buffer, int count, MPI_Datatype datatype, int root, MPI_Comm comm, MPI_Request *request*);
MPE_IBCAST	MPE_IBCAST(*CHOICE BUFFER, INTEGER COUNT, INTEGER DATATYPE, INTEGER ROOT, INTEGER COMM, INTEGER REQUEST, INTEGER IERROR*)
MPE_Igather	int MPE_Igather(*void* sendbuf, int sendcount, MPI_Datatype sendtype, void* recvbuf, int recvcount, MPI_Datatype recvtype, int root, MPI_Comm comm, MPI_Request *request*);
MPE_IGATHER	MPE_IGATHER(*CHOICE SENDBUF, INTEGER SENDCOUNT, INTEGER SENDTYPE, CHOICE RECVBUF, INTEGER RECVCOUNT, INTEGER RECVTYPE, INTEGER ROOT, INTEGER COMM, INTEGER REQUEST, INTEGER IERROR*)
MPE_Igatherv	int MPE_Igatherv(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int *recvcounts,int *displs,MPI_Datatype recvtype,int root,MPI_Comm comm,MPI_Request *request*);

MPE_IGATHERV	MPE_IGATHERV(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE, CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER DISPLS(*),INTEGER RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Ireduce	int MPE_Ireduce(*void* sendbuf,void* recvbuf,int count,MPI_Datatype datatype,MPI_Op op,int root,MPI_Comm comm,MPI_Request *request*);
MPE_IREDUCE	MPE_IREDUCE(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER OP,INTEGER ROOT,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Ireduce_scatter	int MPE_Ireduce_scatter(*void* sendbuf,void* recvbuf,int *recvcounts,MPI_Datatype datatype,MPI_Op op,MPI_Comm comm,MPI_Request *request*);
MPE_IREDUCE_SCATTER	MPE_IREDUCE_SCATTER(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER DATATYPE,INTEGER OP,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Iscan	int MPE_Iscan(*void* sendbuf,void* recvbuf,int count,MPI_Datatype datatype,MPI_Op op,MPI_Comm comm,MPI_Request *request*);
MPE_ISCAN	MPE_ISCAN(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER OP,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Iscatter	int MPE_Iscatter(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype,int root,MPI_Comm comm,MPI_Request *request*);
MPE_ISCATTER	MPE_ISCATTER(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPE_Iscatterv	int MPE_Iscatterv(*void* sendbuf,int *sendcounts,int *displs,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype,int root,MPI_Comm comm,MPI_Request *request*);
MPE_ISCATTERV	MPE_ISCATTERV(*CHOICE SENDBUF,INTEGER SENDCOUNTS(*),INTEGER DISPLS(*),INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)

Appendix C. MPI subroutine and function summary

PE MPI provides subroutines and functions for parallel programming. For descriptions of these subroutines and functions, see *IBM Parallel Environment: MPI Subroutine Reference*.

Subroutines for collective communication

These are the MPI subroutines and functions for collective communications:

Name: C C++ FORTRAN **Description**

MPI_Allgather MPI::Comm::Allgather MPI_ALLGATHER
Collects messages from each task and distributes the resulting message to each.

MPI_Allgatherv MPI::Comm::Allgatherv MPI_ALLGATHERV
Collects messages from each task and distributes the resulting message to all tasks. Messages can have variable sizes and displacements.

MPI_Allreduce MPI::Comm::Allreduce MPI_ALLREDUCE
Applies a reduction operation.

MPI_Alltoall MPI::Comm::Alltoall MPI_ALLTOALL
Sends a distinct message from each task to every task.

MPI_Alltoallv MPI::Comm::Alltoallv MPI_ALLTOALLV
Sends a distinct message from each task to every task. Messages can have different sizes and displacements.

MPI_Alltoallw MPI::Comm::Alltoallw MPI_ALLTOALLW
Sends a distinct message from each task to every task. Messages can have different data types, sizes, and displacements.

MPI_Barrier MPI::Comm::Barrier MPI_BARRIER
Blocks each task until all tasks have called it.

MPI_Bcast MPI::Comm::Bcast MPI_BCAST
Broadcasts a message from *root* to all tasks in the group.

MPI_Exscan MPI::Intracomm::Exscan MPI_EXSCAN
Performs a prefix reduction on data distributed across the group.

MPI_Gather MPI::Comm::Gather MPI_GATHER
Collects individual messages from each task in a group at the *root* task.

MPI_Gatherv MPI::Comm::Gatherv MPI_GATHERV
Collects individual messages from each task in *comm* at the *root* task. Messages can have different sizes and displacements.

MPI_Op_create MPI::Op::Init MPI_OP_CREATE
Binds a user-defined reduction operation to an *op* handle.

MPI_Op_free MPI::Op::Free MPI_OP_FREE
Marks a user-defined reduction operation for deallocation.

MPI_Reduce MPI::Comm::Reduce MPI_REDUCE
Applies a reduction operation to the vector *sendbuf* over the set of tasks specified by *comm* and places the result in *recvbuf* on *root*.

MPI_Reduce_scatter MPI::Comm::Reduce_scatter MPI_REDUCE_SCATTER
Applies a reduction operation to the vector *sendbuf* over the set of tasks specified by *comm* and scatters the result according to the values in *recvcounts*.

MPI_Scan MPI::Intracomm::Scan MPI_SCAN
Performs a parallel prefix reduction on data distributed across a group.

MPI_Scatter MPI::Comm::Scatter MPI_SCATTER
Distributes individual messages from *root* to each task in *comm*.

MPI_Scatterv MPI::Comm::Scatterv MPI_SCATTERV
Distributes individual messages from *root* to each task in *comm*. Messages can have different sizes and displacements.

Subroutines for communicators

Name: C C++ FORTRAN **Description**

MPI_Attr_delete (none) MPI_ATTR_DELETE
Removes an attribute value from a communicator.

MPI_Attr_get (none) MPI_ATTR_GET
Retrieves an attribute value from a communicator.

MPI_Attr_put (none) MPI_ATTR_PUT
Associates an attribute value with a communicator.

(none) MPI::Comm::Clone (MPI::Cartcomm::Clone, MPI::Graphcomm::Clone, MPI::Intercomm::Clone, MPI::Intracomm::Clone) (none)
Creates a new communicator that is a duplicate of an existing communicator.

MPI_Comm_compare MPI::Comm::Compare MPI_COMM_COMPARE
Compares the groups and contexts of two communicators.

MPI_Comm_create MPI::Intercomm::Create, MPI::Intracomm::Create MPI_COMM_CREATE Creates a new communicator with a given group.

MPI_Comm_create_errhandler MPI::Comm::Create_errhandler MPI_COMM_CREATE_ERRHANDLER
Creates an error handler that can be attached to communicators.

MPI_Comm_create_keyval MPI::Comm::Create_keyval MPI_COMM_CREATE_KEYVAL
Generates a new communicator attribute key.

MPI_Comm_delete_attr MPI::Comm::Delete_attr MPI_COMM_DELETE_ATTR
Removes an attribute value from a communicator.

MPI_Comm_dup MPI::Cartcomm::Dup, MPI::Graphcomm::Dup, MPI::Intercomm::Dup, MPI::Intracomm::Dup MPI_COMM_DUP
Creates a new communicator that is a duplicate of an existing communicator.

MPI_Comm_free MPI::Comm::Free MPI_COMM_FREE
Marks a communicator for deallocation.

MPI_Comm_free_keyval MPI::Comm::Free_keyval MPI_COMM_FREE_KEYVAL
Marks a communicator attribute key for deallocation.

MPI_Comm_get_attr MPI::Comm::Get_attr MPI_COMM_GET_ATTR
Retrieves the communicator attribute value identified by the key.

MPI_Comm_get_errhandler MPI::Comm::Get_errhandler MPI_COMM_GET_ERRHANDLER
Retrieves the error handler currently associated with a communicator.

MPI_Comm_rank MPI::Comm::Get_rank MPI_COMM_RANK
Returns the rank of the local task in the group associated with a communicator.

MPI_Comm_remote_group MPI::Intercomm::Get_remote_group MPI_COMM_REMOTE_GROUP
Returns the handle of the remote group of an inter-communicator.

MPI_Comm_remote_size MPI::Intercomm::Get_remote_size MPI_COMM_REMOTE_SIZE
Returns the size of the remote group of an inter-communicator.

MPI_Comm_set_attr MPI::Comm::Set_attr MPI_COMM_SET_ATTR
Attaches the communicator attribute value to the communicator and associates it with the key.

MPI_Comm_set_errhandler MPI::Comm::Set_errhandler MPI_COMM_SET_ERRHANDLER
Attaches a new error handler to a communicator.

MPI_Comm_size MPI::Comm::Get_size MPI_COMM_SIZE
Returns the size of the group associated with a communicator.

MPI_Comm_split MPI::Intercomm::Split, MPI::Intracomm::Split MPI_COMM_SPLIT
Splits a communicator into multiple communicators based on *color* and *key*.

MPI_Comm_test_inter MPI::Comm::Is_inter MPI_COMM_TEST_INTER
Returns the type of a communicator (intra-communicator or inter-communicator).

MPI_Intercomm_create MPI::Intracomm::Create_intercomm MPI_INTERCOMM_CREATE
Creates an inter-communicator from two intra-communicators.

MPI_Intercomm_merge MPI::Intercomm::Merge MPI_INTERCOMM_MERGE
Creates an intra-communicator by merging the local and remote groups of an inter-communicator.

MPI_Keyval_create (none) MPI_KEYVAL_CREATE
Generates a new communicator attribute key.

MPI_Keyval_free (none) MPI_KEYVAL_FREE
Marks a communicator attribute key for deallocation.

Subroutines for conversion functions

Name: C C++ FORTRAN	Description
MPI_Comm_c2f (none) (none)	Translates a C communicator handle into a FORTRAN handle to the same communicator.
MPI_Comm_f2c (none) (none)	Returns a C handle to a communicator.
MPI_Errhandler_c2f (none) (none)	Translates a C error handler into a FORTRAN handle to the same error handler.
MPI_Errhandler_f2c (none) (none)	Returns a C handle to an error handler.
MPI_File_c2f (none) (none)	Translates a C file handle into a FORTRAN handle to the same file.
MPI_File_f2c (none) (none)	Returns a C handle to a file.
MPI_Group_c2f (none) (none)	Translates a C group handle into a FORTRAN handle to the same group.
MPI_Group_f2c (none) (none)	Returns a C handle to a group.
MPI_Info_c2f (none) (none)	Translates a C Info object handle into a FORTRAN handle to the same Info object.
MPI_Info_f2c (none) (none)	Returns a C handle to an Info object.
MPI_Op_c2f (none) (none)	Translates a C reduction operation handle into a FORTRAN handle to the same operation.
MPI_Op_f2c (none) (none)	Returns a C reduction operation handle to an operation.
MPI_Request_c2f (none) (none)	Translates a C request handle into a FORTRAN handle to the same request.
MPI_Request_f2c (none) (none)	Returns a C handle to a request.
MPI_Status_c2f (none) (none)	Translates a C status object into a FORTRAN status object.

MPI_Status_f2c (none) (none)
Converts a FORTRAN status object into a C status object.

MPI_Type_c2f (none) (none) Translates a C data type handle into a FORTRAN handle to the same data type.

MPI_Type_f2c (none) (none) Returns a C handle to a data type.

MPI_Win_c2f (none) (none) Translates a C window handle into a FORTRAN handle to the same window.

MPI_Win_f2c (none) (none) Returns a C handle to a window.

Subroutines for derived data types

Name: C C++ FORTRAN **Description**

MPI_Address (none) MPI_ADDRESS
Returns the address of a location in memory.

MPI_Get_address MPI::Get_address MPI_GET_ADDRESS
Returns the address of a location in memory.

MPI_Get_elements MPI::Status::Get_elements MPI_GET_ELEMENTS
Returns the number of basic elements in a message.

MPI_Pack MPI::Datatype::Pack MPI_PACK
Packs the message in the specified send buffer into the specified buffer space.

MPI_Pack_external MPI::Datatype::Pack_external MPI_PACK_EXTERNAL
Packs the message in the specified send buffer into the specified buffer space, using the external32 data format.

MPI_Pack_external_size MPI::Datatype::Pack_external_size MPI_PACK_EXTERNAL_SIZE Returns the number of bytes required to hold the data, using the external32 data format.

MPI_Pack_size MPI::Datatype::Pack_size MPI_PACK_SIZE
Returns the number of bytes required to hold the data.

(none) (none) MPI_SIZEOF Returns the size in bytes of the machine representation of the given variable.

MPI_Type_commit MPI::Datatype::Commit MPI_TYPE_COMMIT
Makes a data type ready for use in communication.

MPI_Type_contiguous MPI::Datatype::Create_contiguous MPI_TYPE_CONTIGUOUS Returns a new data type that represents the concatenation of *count* instances of *oldtype*.

MPI_Type_create_darray MPI::Datatype::Create_darray MPI_TYPE_CREATE_DARRAY
Generates the data types corresponding to an HPF-like distribution of an *ndims*-dimensional array of *oldtype* elements onto an *ndims*-dimensional grid of logical tasks.

MPI_Type_create_f90_complex MPI::Datatype::Create_f90_complex MPI_TYPE_CREATE_F90_COMPLEX
Returns a predefined MPI data type that matches a COMPLEX variable of KIND selected_real_kind(*p, r*).

MPI_Type_create_f90_integer MPI::Datatype::Create_f90_integer MPI_TYPE_CREATE_F90_INTEGER
Returns a predefined MPI data type that matches an INTEGER variable of KIND selected_integer_kind(*r*).

MPI_Type_create_f90_real MPI::Datatype::Create_f90_real MPI_TYPE_CREATE_F90_REAL
Returns a predefined MPI data type that matches a REAL variable of KIND selected_real_kind(*p, r*).

MPI_Type_create_hindexed MPI::Datatype::Create_hindexed MPI_TYPE_CREATE_HINDEXED
Returns a new data type that represents *count* blocks. Each block is defined by an entry in *array_of_blocklengths* and *array_of_displacements*. Displacements are expressed in bytes.

MPI_Type_create_hvector MPI::Datatype::Create_hvector MPI_TYPE_CREATE_HVECTOR
Returns a new data type that represents equally-spaced blocks. The spacing between the start of each block is given in bytes.

MPI_Type_create_indexed_block MPI::Datatype::Create_indexed_block MPI_TYPE_CREATE_INDEXED_BLOCK
Returns a new data type that represents *count* blocks.

MPI_Type_create_keyval MPI::Datatype::Create_keyval MPI_TYPE_CREATE_KEYVAL
Generates a new attribute key for a data type.

MPI_Type_create_resized MPI::Datatype::Create_resized MPI_TYPE_CREATE_RESIZED
Duplicates a data type and changes the upper bound, lower bound, and extent.

MPI_Type_create_struct MPI::Datatype::Create_struct MPI_TYPE_CREATE_STRUCT
Returns a new data type that represents *count* blocks. Each block is defined by an entry in *array_of_blocklengths*, *array_of_displacements*, and *array_of_types*. Displacements are expressed in bytes.

MPI_Type_create_subarray MPI::Datatype::Create_subarray MPI_TYPE_CREATE_SUBARRAY
Returns a new data type that represents an *ndims*-dimensional subarray of an *ndims*-dimensional array.

MPI_Type_delete_attr MPI::Datatype::Delete_attr MPI_TYPE_DELETE_ATTR
Deletes an attribute from a data type.

MPI_Type_dup MPI::Datatype::Dup MPI_TYPE_DUP
Duplicates the existing type with associated key values.

MPI_Type_extent (none) MPI_TYPE_EXTENT
Returns the extent of any defined data type.

MPI_Type_free MPI::Datatype::Free MPI_TYPE_FREE
Marks a derived data type for deallocation and sets its handle to MPI_DATATYPE_NULL.

MPI_Type_free_keyval MPI::Datatype::Free_keyval MPI_TYPE_FREE_KEYVAL
Frees a data type key value.

MPI_Type_get_attr MPI::Datatype::Get_attr MPI_TYPE_GET_ATTR
Attaches an attribute to a data type.

MPI_Type_get_contents MPI::Datatype::Get_contents MPI_TYPE_GET_CONTENTS Obtains the arguments used in the creation of the data type.

MPI_Type_get_envelope MPI::Datatype::Get_envelope MPI_TYPE_GET_ENVELOPE Determines the constructor that was used to create the data type.

MPI_Type_get_extent MPI::Datatype::Get_extent MPI_TYPE_GET_EXTENT
Returns the lower bound and the extent of any defined data type.

MPI_Type_get_true_extent MPI::Datatype::Get_true_extent MPI_TYPE_GET_TRUE_EXTENT
Returns the true extent of any defined data type.

MPI_Type_hindexed (none) MPI_TYPE_HINDEXED
Returns a new data type that represents *count* distinct blocks with offsets expressed in bytes.

MPI_Type_hvector (none) MPI_TYPE_HVECTOR
Returns a new data type of *count* blocks with *stride* expressed in bytes.

MPI_Type_indexed MPI::Datatype::Create_indexed MPI_TYPE_INDEXED
Returns a new data type that represents *count* blocks with stride in terms of defining type.

MPI_Type_lb (none) MPI_TYPE_LB
Returns the lower bound of a data type.

MPI_Type_match_size MPI::Datatype::Match_size MPI_TYPE_CREATE_MATCH_SIZE
Returns a reference (handle) to one of the predefined named data types, not a duplicate.

MPI_Type_set_attr MPI::Datatype::Set_attr MPI_TYPE_SET_ATTR
Attaches the data type attribute value to the data type and associates it with the key.

MPI_Type_size MPI::Datatype::Get_size MPI_TYPE_SIZE
Returns the number of bytes represented by any defined data type.

MPI_Type_struct (none) MPI_TYPE_STRUCT
Returns a new data type that represents *count* blocks, each with a distinct format and offset.

MPI_Type_ub (none) MPI_TYPE_UB
Returns the upper bound of a data type.

MPI_Type_vector MPI::Datatype::Create_vector MPI_TYPE_VECTOR
Returns a new data type that represents equally-spaced blocks of replicated data.

MPI_Unpack MPI::Datatype::Unpack MPI_UNPACK
Unpacks the message into the specified receive buffer from the specified packed buffer.

MPI_Unpack_external MPI::Datatype::Unpack_external MPI_UNPACK_EXTERNAL
Unpacks the message into the specified receive buffer from the specified packed buffer, using the external32 data format.

Subroutines for environment management

Name: C C++ FORTRAN **Description**

MPI_Abort MPI::Comm::Abort MPI_ABORT
When called by one or more tasks, forces all tasks of an MPI job to terminate.

MPI_Errhandler_create (none) MPI_ERRHANDLER_CREATE
Registers a user-defined error handler.

MPI_Errhandler_free MPI::Errhandler::Free MPI_ERRHANDLER_FREE
Marks an error handler for deallocation.

MPI_Errhandler_get (none) MPI_ERRHANDLER_GET
Gets an error handler associated with a communicator.

MPI_Errhandler_set (none) MPI_ERRHANDLER_SET
Associates a new error handler with a communicator.

MPI_Error_class MPI::Get_error_class MPI_ERROR_CLASS
Returns the error class for the corresponding error code.

MPI_Error_string MPI::Get_error_string MPI_ERROR_STRING
Returns the error string for a given error code.

MPI_File_create_errhandler MPI::File::Create_errhandler MPI_FILE_CREATE_ERRHANDLER
Registers a user-defined error handler that you can associate with an open file.

MPI_File_get_errhandler MPI::File::Get_errhandler MPI_FILE_GET_ERRHANDLER
Retrieves the error handler currently associated with a file handle.

MPI_File_set_errhandler MPI::File::Set_errhandler MPI_FILE_SET_ERRHANDLER
Associates a new error handler with a file.

MPI_Finalize MPI::Finalize MPI_FINALIZE
Terminates all MPI processing.

MPI_Finalized MPI::Is_finalized MPI_FINALIZED
Returns **true** if MPI_FINALIZE has completed.

MPI_Get_processor_name MPI::Get_processor_name MPI_GET_PROCESSOR_NAME
Returns the name of the local processor.

MPI_Get_version MPI::Get_version MPI_GET_VERSION
Returns the version of the MPI standard supported.

MPI_Init MPI::Init MPI_INIT Initializes MPI.

MPI_Init_thread MPI::Init_thread MPI_INIT_THREAD
Initializes MPI and the MPI threads environment.

MPI_Initialized MPI::Is_initialized MPI_INITIALIZED
Determines if MPI is initialized.

MPI_Is_thread_main MPI::Is_thread_main MPI_IS_THREAD_MAIN
Determines whether the calling thread is the thread that called MPI_INIT or MPI_INIT_THREAD.

MPI_Query_thread MPI::Query_thread MPI_QUERY_THREAD
Returns the current level of threads support.

MPI_Wtick MPI::Wtick MPI_WTICK
Returns the resolution of MPI_WTIME in seconds.

MPI_Wtime MPI::Wtime MPI_WTIME
Returns the current value of *time* as a floating-point value.

Subroutines for external interfaces

Name: C C++ FORTRAN **Description**

MPI_Add_error_class MPI::Add_error_class MPI_ADD_ERROR_CLASS
Creates a new error class and returns the value for it.

MPI_Add_error_code MPI::Add_error_code MPI_ADD_ERROR_CODE
Creates a new error code and returns the value for it.

MPI_Add_error_string MPI::Add_error_string MPI_ADD_ERROR_STRING
Associates an error string with a user-defined error code or class.

MPI_Comm_call_errhandler MPI::Comm::Call_errhandler MPI_COMM_CALL_ERRHANDLER
Calls the error handler assigned to the communicator with the error code supplied.

MPI_Comm_get_name MPI::Comm::Get_name MPI_COMM_GET_NAME
Returns the name that was last associated with a communicator.

MPI_Comm_set_name MPI::Comm::Set_name MPI_COMM_SET_NAME
Associates a name string with a communicator.

MPI_File_call_errhandler MPI::File::Call_errhandler MPI_FILE_CALL_ERRHANDLER
Calls the error handler assigned to the file with the error code supplied.

MPI_Grequest_complete MPI::Grequest::Complete MPI_GREQUEST_COMPLETE
Marks the generalized request complete.

MPI_Grequest_start MPI::Grequest::Start MPI_GREQUEST_START
Initializes a generalized request.

MPI_Status_set_cancelled MPI::Status::Set_cancelled MPI_STATUS_SET_CANCELLED
Defines cancellation information for a request.

MPI_Status_set_elements MPI::Status::Set_elements MPI_STATUS_SET_ELEMENTS
Defines element information for a request.

MPI_Type_get_name MPI::Datatype::Get_name MPI_TYPE_GET_NAME
Returns the name that was last associated with a data type.

MPI_Type_set_name MPI::Datatype::Set_name MPI_TYPE_SET_NAME
Associates a name string with a data type.

MPI_Win_call_errhandler MPI::Win::Call_errhandler MPI_WIN_CALL_ERRHANDLER
Calls the error handler assigned to the window with the error code supplied.

MPI_Win_get_name MPI::Win::Get_name MPI_WIN_GET_NAME
Returns the name that was last associated with a window.

MPI_Win_set_name MPI::Win::Set_name MPI_WIN_SET_NAME
Associates a name string with a window.

Subroutines for group management

Name: C C++ FORTRAN **Description**

MPI_Comm_group MPI::Comm::Get_group MPI_COMM_GROUP
Returns the group handle associated with a communicator.

MPI_Group_compare MPI::Group::Compare MPI_GROUP_COMPARE
Compares the contents of two task groups.

MPI_Group_difference MPI::Group::Difference MPI_GROUP_DIFFERENCE
Creates a new group that is the difference of two existing groups.

MPI_Group_excl MPI::Group::Excl MPI_GROUP_EXCL
Removes selected tasks from an existing group to create a new group.

MPI_Group_free MPI::Group::Free MPI_GROUP_FREE
Marks a group for deallocation.

MPI_Group_incl MPI::Group::Incl MPI_GROUP_INCL
Creates a new group consisting of selected tasks from an existing group.

MPI_Group_intersection MPI::Group::Intersect MPI_GROUP_INTERSECTION
Creates a new group that is the intersection of two existing groups.

MPI_Group_range_excl MPI::Group::Range_excl MPI_GROUP_RANGE_EXCL
Creates a new group by excluding selected tasks of an existing group.

MPI_Group_range_incl MPI::Group::Range_incl MPI_GROUP_RANGE_INCL
Creates a new group consisting of selected ranges of tasks from an existing group.

MPI_Group_rank MPI::Group::Get_rank MPI_GROUP_RANK
Returns the rank of the local task with respect to group.

MPI_Group_size MPI::Group::Get_size MPI_GROUP_SIZE
Returns the number of tasks in a group.

MPI_Group_translate_ranks MPI::Group::Translate_ranks MPI_GROUP_TRANSLATE_RANKS
Converts task ranks of one group into ranks of another group.

MPI_Group_union MPI::Group::Union MPI_GROUP_UNION
Creates a new group that is the union of two existing groups.

Subroutines for Info objects

Name: C C++ FORTRAN Description

MPI_Info_create MPI::Info::Create MPI_INFO_CREATE
Creates a new, empty Info object.

MPI_Info_delete MPI::Info::Delete MPI_INFO_DELETE
Deletes a (*key, value*) pair from an Info object.

MPI_Info_dup MPI::Info::Dup MPI_INFO_DUP
Duplicates an Info object.

MPI_Info_free MPI::Info::Free MPI_INFO_FREE
Frees an Info object and sets its handle to MPI_INFO_NULL.

MPI_Info_get MPI::Info::Get MPI_INFO_GET
Retrieves the value associated with *key* in an Info object.

MPI_Info_get_nkeys MPI::Info::Get_nkeys MPI_INFO_GET_NKEYS
Returns the number of keys defined in an Info object.

MPI_Info_get_nthkey MPI::Info::Get_nthkey MPI_INFO_GET_NTHKEY
Retrieves the *n*th key defined in an Info object.

MPI_Info_get_valuelen MPI::Info::Get_valuelen MPI_INFO_GET_VALUELEN
Retrieves the length of the value associated with a key of an Info object.

MPI_Info_set MPI::Info::Set MPI_INFO_SET
Adds a (*key, value*) pair to an Info object.

Subroutines for memory allocation

Name: C C++ FORTRAN Description

MPI_Alloc_mem MPI::Alloc_mem MPI_ALLOC_MEM
Allocates storage and returns a pointer to it.

MPI_Free_mem MPI::Free_mem MPI_FREE_MEM
Frees a block of storage.

Subroutines for MPI-IO

Name: C C++ FORTRAN Description

MPI_File_close MPI::File::Close MPI_FILE_CLOSE
Closes a file.

MPI_File_delete MPI::File::Delete MPI_FILE_DELETE
Deletes a file after pending operations to the file complete.

MPI_File_get_amode MPI::File::Get_amode MPI_FILE_GET_AMODE
Retrieves the access mode specified when the file was opened.

MPI_File_get_atomicity MPI::File::Get_atomicity MPI_FILE_GET_ATOMICITY
Retrieves the current atomicity mode in which the file is accessed.

MPI_File_get_byte_offset MPI::File::Get_byte_offset MPI_FILE_GET_BYTE_OFFSET
Allows conversion of an offset.

MPI_File_get_group MPI::File::Get_group MPI_FILE_GET_GROUP
Retrieves the group of tasks that opened the file.

MPI_File_get_info MPI::File::Get_info MPI_FILE_GET_INFO
Returns a new Info object identifying the hints associated with a file.

MPI_File_get_position MPI::File::Get_position MPI_FILE_GET_POSITION
Returns the current position of the individual file pointer relative to the current file view.

MPI_File_get_position_shared MPI::File::Get_position_shared MPI_FILE_GET_POSITION_SHARED
Returns the current position of the shared file pointer relative to the current file view.

MPI_File_get_size MPI::File::Get_size MPI_FILE_GET_SIZE
Retrieves the current file size.

MPI_File_get_type_extent MPI::File::Get_type_extent MPI_FILE_GET_TYPE_EXTENT
Retrieves the extent of a data type.

MPI_File_get_view MPI::File::Get_view MPI_FILE_GET_VIEW
Retrieves the current file view.

MPI_File_iread MPI::File::Iread MPI_FILE_IREAD
Performs a nonblocking read operation.

MPI_File_iread_at MPI::File::Iread_at MPI_FILE_IREAD_AT
Performs a nonblocking read operation using an explicit offset.

MPI_File_iread_shared MPI::File::Iread_shared MPI_FILE_IREAD_SHARED
Performs a nonblocking read operation using the shared file pointer.

MPI_File_iwrite MPI::File::Iwrite MPI_FILE_IWRITE
Performs a nonblocking write operation.

MPI_File_iwrite_at MPI::File::Iwrite_at MPI_FILE_IWRITE_AT
Performs a nonblocking write operation using an explicit offset.

MPI_File_iwrite_shared MPI::File::Iwrite_shared MPI_FILE_IWRITE_SHARED
Performs a nonblocking write operation using the shared file pointer.

MPI_File_open MPI::File::Open MPI_FILE_OPEN
Opens a file.

MPI_File_preallocate MPI::File::Preallocate MPI_FILE_PREALLOCATE
Ensures that storage space is allocated for the first *size* bytes of the file associated with *fh*.

MPI_File_read MPI::File::Read MPI_FILE_READ
Reads from a file.

MPI_File_read_all MPI::File::Read_all MPI_FILE_READ_ALL
Reads from a file collectively.

MPI_File_read_all_begin MPI::File::Read_all_begin MPI_FILE_READ_ALL_BEGIN
Initiates a split collective read operation from a file.

MPI_File_read_all_end MPI::File::Read_all_end MPI_FILE_READ_ALL_END
Completes a split collective read operation from a file.

MPI_File_read_at MPI::File::Read_at MPI_FILE_READ_AT
Reads from a file using an explicit offset.

MPI_File_read_at_all MPI::File::Read_at_all MPI_FILE_READ_AT_ALL
Reads from a file collectively using an explicit offset.

MPI_File_read_at_all_begin MPI::File::Read_at_all_begin MPI_FILE_READ_AT_ALL_BEGIN
Initiates a split collective read operation from a file using an explicit offset.

MPI_File_read_at_all_end MPI::File::Read_at_all_end MPI_FILE_READ_AT_ALL_END
Completes a split collective read operation from a file using an explicit offset.

MPI_File_read_ordered MPI::File::Read_ordered MPI_FILE_READ_ORDERED
Reads from a file collectively using the shared file pointer.

MPI_File_read_ordered_begin MPI::File::Read_ordered_begin MPI_FILE_READ_ORDERED_BEGIN
Initiates a split collective read operation from a file using the shared file pointer.

MPI_File_read_ordered_end MPI::File::Read_ordered_end MPI_FILE_READ_ORDERED_END
Completes a split collective read operation from a file using the shared file pointer.

MPI_File_read_shared MPI::File::Read_shared MPI_FILE_READ_SHARED
Reads from a file using the shared file pointer.

MPI_File_seek MPI::File::Seek MPI_FILE_SEEK
Sets a file pointer.

MPI_File_seek_shared MPI::File::Seek_shared MPI_FILE_SEEK_SHARED
Sets a shared file pointer.

MPI_File_set_atomicity MPI::File::Set_atomicity MPI_FILE_SET_ATOMICITY
Modifies the current atomicity mode for an opened file.

MPI_File_set_info MPI::File::Set_info MPI_FILE_SET_INFO
Specifies new hints for an open file.

MPI_File_set_size MPI::File::Set_size MPI_FILE_SET_SIZE
Expands or truncates an open file.

MPI_File_set_view MPI::File::Set_view MPI_FILE_SET_VIEW
Associates a new view with an open file.

MPI_File_sync MPI::File::Sync MPI_FILE_SYNC
Commits file updates of an open file to storage devices.

MPI_File_write MPI::File::Write MPI_FILE_WRITE
Writes to a file.

MPI_File_write_all MPI::File::Write_all MPI_FILE_WRITE_ALL
Writes to a file collectively.

MPI_File_write_all_begin MPI::File::Write_all_begin MPI_FILE_WRITE_ALL_BEGIN
Initiates a split collective write operation to a file.

MPI_File_write_all_end MPI::File::Write_all_end MPI_FILE_WRITE_ALL_END
Completes a split collective write operation to a file.

MPI_File_write_at MPI::File::Write_at MPI_FILE_WRITE_AT
Performs a blocking write operation using an explicit offset.

MPI_File_write_at_all MPI::File::Write_at_all MPI_FILE_WRITE_AT_ALL
Performs a blocking write operation collectively using an explicit offset.

MPI_File_write_at_all_begin MPI::File::Write_at_all_begin MPI_FILE_WRITE_AT_ALL_BEGIN
Initiates a split collective write operation to a file using an explicit offset.

MPI_File_write_at_all_end MPI::File::Write_at_all_end MPI_FILE_WRITE_AT_ALL_END
Completes a split collective write operation to a file using an explicit offset.

MPI_File_write_ordered MPI::File::Write_ordered MPI_FILE_WRITE_ORDERED
Writes to a file collectively using the shared file pointer.

MPI_File_write_ordered_begin MPI::File::Write_ordered_begin MPI_FILE_WRITE_ORDERED_BEGIN
Initiates a split collective write operation to a file using the shared file pointer.

MPI_File_write_ordered_end MPI::File::Write_ordered_end MPI_FILE_WRITE_ORDERED_END
Completes a split collective write operation to a file using the shared file pointer.

MPI_File_write_shared MPI::File::Write_shared MPI_FILE_WRITE_SHARED
Writes to a file using the shared file pointer.

MPI_Register_datarep MPI::Register_datarep MPI_REGISTER_DATAREP
Registers a data representation.

Subroutines for MPI_Status objects

Name: C C++ FORTRAN Description

MPI_Request_get_status MPI::Request::Get_status MPI_REQUEST_GET_STATUS
Accesses the information associated with a request, without freeing the request.

Subroutines for one-sided communication

Name: C C++ FORTRAN Description

MPI_Accumulate MPI::Win::Accumulate MPI_ACCUMULATE
Accumulates, according to the specified reduction operation, the contents of the origin buffer to the specified target buffer.

MPI_Get MPI::Win::Get MPI_GET
Transfers data from a window at the target task to the origin task.

MPI_Put MPI::Win::Put MPI_PUT
Transfers data from the origin task to a window at the target task.

MPI_Win_complete MPI::Win::Complete MPI_WIN_COMPLETE
Completes an RMA access epoch on a window object

MPI_Win_create MPI::Win::Create MPI_WIN_CREATE
Allows each task in an intra-communicator group to specify a “window” in its memory that is made accessible to accesses by remote tasks.

MPI_Win_create_errhandler MPI::Win::Create_errhandler MPI_WIN_CREATE_ERRHANDLER
Creates an error handler that can be attached to windows.

MPI_Win_create_keyval MPI::Win::Create_keyval MPI_WIN_CREATE_KEYVAL
Generates a new window attribute key.

MPI_Win_delete_attr MPI::Win::Delete_attr MPI_WIN_DELETE_ATTR
Deletes an attribute from a window.

MPI_Win_fence MPI::Win::Fence MPI_WIN_FENCE
Synchronizes RMA calls on a window.

MPI_Win_free MPI::Win::Free MPI_WIN_FREE
Frees the window object and returns a null handle (equal to MPI_WIN_NULL).

MPI_Win_free_keyval MPI::Win::Free_keyval MPI_WIN_FREE_KEYVAL
Marks a window attribute key for deallocation.

MPI_Win_get_attr MPI::Win::Get_attr MPI_WIN_GET_ATTR
Retrieves the window attribute value identified by the key.

MPI_Win_get_errhandler MPI::Win::Get_errhandler MPI_WIN_GET_ERRHANDLER
Retrieves the error handler currently associated with a window.

MPI_Win_get_group MPI::Win::Get_group MPI_WIN_GET_GROUP
Returns a duplicate of the group of the communicator used to create a window.

MPI_Win_lock MPI::Win::Lock MPI_WIN_LOCK
Starts an RMA access epoch at the target task.

MPI_Win_post MPI::Win::Post MPI_WIN_POST
Starts an RMA exposure epoch for a local window.

MPI_Win_set_attr MPI::Win::Set_attr MPI_WIN_SET_ATTR
Attaches the window attribute value to the window and associates it with the key.

MPI_Win_set_errhandler MPI::Win::Set_errhandler MPI_WIN_SET_ERRHANDLER
Attaches a new error handler to a window.

MPI_Win_start MPI::Win::Start MPI_WIN_START
Starts an RMA access epoch for a window object.

MPI_Win_test MPI::Win::Test MPI_WIN_TEST
Tries to complete an RMA exposure epoch.

MPI_Win_unlock MPI::Win::Unlock MPI_WIN_UNLOCK
Completes an RMA access epoch at the target task.

MPI_Win_wait MPI::Win::Wait MPI_WIN_WAIT
Completes an RMA exposure epoch.

Subroutines for point-to-point communication

Name: C C++ FORTRAN **Description**

MPI_Bsend MPI::Comm::Bsend MPI_BSEND
Performs a blocking buffered mode send operation.

MPI_Bsend_init MPI::Comm::Bsend_init MPI_BSEND_INIT
Creates a persistent buffered mode send request.

MPI_Buffer_attach MPI::Attach_buffer MPI_BUFFER_ATTACH
Provides MPI with a message buffer for sending.

MPI_Buffer_detach MPI::Detach_buffer MPI_BUFFER_DETACH
Detaches the current buffer.

MPI_Cancel MPI::Request::Cancel MPI_CANCEL
Marks a nonblocking operation for cancellation.

MPI_Get_count MPI::Status::Get_count MPI_GET_COUNT
Returns the number of elements in a message.

MPI_Ibsend MPI::Comm::Ibsend MPI_IBSEND
Performs a nonblocking buffered send.

MPI_Iprobe MPI::Comm::Iprobe MPI_IPROBE
Checks to see if a message matching *source*, *tag*, and *comm* has arrived.

MPI_Irecv MPI::Comm::Irecv MPI_IRECV
Performs a nonblocking receive operation.

MPI_Irsend MPI::Comm::Irsend MPI_IRSEND
Performs a nonblocking ready send operation.

MPI_Isend MPI::Comm::Isend MPI_ISEND
Performs a nonblocking standard mode send operation.

MPI_Issend MPI::Comm::Issend MPI_ISSEND
Performs a nonblocking synchronous mode send operation.

MPI_Probe MPI::Comm::Probe MPI_PROBE
Waits until a message matching *source*, *tag*, and *comm* arrives.

MPI_Recv MPI::Comm::Recv MPI_RECV
Performs a blocking receive operation.

MPI_Recv_init MPI::Comm::Recv_init MPI_RECV_INIT
Creates a persistent receive request.

MPI_Request_free MPI::Request::Free MPI_REQUEST_FREE
Marks a request for deallocation.

MPI_Rsend MPI::Comm::Rsend MPI_RSEND
Performs a blocking ready mode send operation.

MPI_Rsend_init MPI::Comm::Rsend_init MPI_RSEND_INIT
Creates a persistent ready mode send request.

MPI_Send MPI::Comm::Send MPI_SEND
Blocking standard mode send.

MPI_Send_init MPI::Comm::Send_init MPI_SEND_INIT
Creates a persistent standard mode send request.

MPI_Sendrecv MPI::Comm::Sendrecv MPI_SENDRECV
Performs a blocking send and receive operation.

MPI_Sendrecv_replace MPI::Comm::Sendrecv_replace MPI_SENDRECV_REPLACE
Performs a blocking send and receive operation using a common buffer.

MPI_Ssend MPI::Comm::Ssend MPI_SSEND
Performs a blocking synchronous mode send operation.

MPI_Ssend_init MPI::Comm::Ssend_init MPI_SSEND_INIT
Creates a persistent synchronous mode send request.

MPI_Start MPI::Prequest::Start MPI_START
Activates a persistent request operation.

MPI_Startall MPI::Prequest::Startall MPI_STARTALL
Activates a collection of persistent request operations.

MPI_Test MPI::Request::Test MPI_TEST
Checks to see if a nonblocking operation has completed.

MPI_Test_cancelled MPI::Status::Is_cancelled MPI_TEST_CANCELLED
Tests whether a nonblocking operation was cancelled.

MPI_Testall MPI::Request::Testall MPI_TESTALL
Tests a collection of nonblocking operations for completion.

MPI_Testany MPI::Request::Testany MPI_TESTANY
Tests for the completion of any specified nonblocking operation.

MPI_Testsome MPI::Request::Testsome MPI_TESTSOME
Tests a collection of nonblocking operations for completion.

MPI_Wait MPI::Request::Wait MPI_WAIT
Waits for a nonblocking operation to complete.

MPI_Waitall MPI::Request::Waitall MPI_WAITALL
Waits for a collection of nonblocking operations to complete.

MPI_Waitany MPI::Request::Waitany MPI_WAITANY
Waits for any specified nonblocking operation to complete.

MPI_Waitsome MPI::Request::Waitsome MPI_WAITSOME
Waits for at least one of a list of nonblocking operations to complete.

Subroutines for profiling control

Name: C C++ FORTRAN **Description**

MPI_Pcontrol MPI::Pcontrol MPI_PCONTROL
Provides profile control.

Subroutines for Topologies

Name: C C++ FORTRAN **Description**

MPI_Cart_coords MPI::Cartcomm::Get_coords MPI_CART_COORDS
Translates task rank in a communicator into Cartesian task coordinates.

MPI_Cart_create MPI::Intracomm::Create_cart MPI_CART_CREATE
Creates a communicator containing topology information.

MPI_Cart_get MPI::Cartcomm::Get_topo MPI_CART_GET
Retrieves Cartesian topology information from a communicator.

MPI_Cart_map MPI::Cartcomm::Map MPI_CART_MAP
Computes placement of tasks on the physical processor.

MPI_Cart_rank MPI::Cartcomm::Get_cart_rank MPI_CART_RANK
Translates task coordinates into a task rank.

MPI_Cart_shift MPI::Cartcomm::Shift MPI_CART_SHIFT
Returns shifted source and destination ranks for a task.

MPI_Cart_sub MPI::Cartcomm::Sub MPI_CART_SUB
Partitions a Cartesian communicator into lower-dimensional subgroups.

MPI_Cartdim_get MPI::Cartcomm::Get_dim MPI_CARTDIM_GET
Retrieves the number of Cartesian dimensions from a communicator.

MPI_Dims_create MPI::Compute_dims MPI_DIMS_CREATE
Defines a Cartesian grid to balance tasks.

MPI_Graph_create MPI::Intracomm::Create_graph MPI_GRAPH_CREATE
Creates a new communicator containing graph topology information.

MPI_Graph_get MPI::Graphcomm::Get_topo MPI_GRAPH_GET
Retrieves graph topology information from a communicator.

MPI_Graph_map MPI::Graphcomm::Map MPI_GRAPH_MAP
Computes placement of tasks on the physical processor.

MPI_Graph_neighbors MPI::Graphcomm::Get_neighbors MPI_GRAPH_NEIGHBORS Returns the neighbors of the given task.

MPI_Graph_neighbors_count MPI::Graphcomm::Get_neighbors_count MPI_GRAPH_NEIGHBORS_COUNT
Returns the number of neighbors of the given task.

MPI_Graphdims_get MPI::Graphcomm::Get_dims MPI_GRAPHDIMS_GET
Retrieves graph topology information from a communicator.

MPI_Topo_test MPI::Comm::Get_topology MPI_TOPO_TEST
Returns the type of virtual topology associated with a communicator.

Appendix D. MPI subroutine bindings

The FORTRAN, C, and C++ bindings for MPI are contained in the same library and can be freely intermixed. The library is named **libmpi_r.a.** Because it contains both 32-bit and 64-bit objects, and the compiler and linker select between them, **libmpi_r.a** can be used for both 32-bit and 64-bit applications.

FORTRAN refers to FORTRAN 77 bindings that are officially supported for MPI. However, FORTRAN 77 bindings can be used by FORTRAN 90. FORTRAN 90 and High Performance FORTRAN (HPF) offer array section and assumed shape arrays as parameters on calls. **These are not safe with MPI**.

This is a summary of the binding information for all of the MPI subroutines listed in *IBM Parallel Environment: MPI Subroutine Reference*.

Bindings for collective communication

This is a list of the bindings for collective communication subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	Binding: C C++ FORTRAN
MPI_Allgather	int MPI_Allgather(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype, MPI_Comm comm*);
MPI::Comm::Allgather	void MPI::Comm::Allgather(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, void* recvbuf, int recvcount, const MPI::Datatype& recvtype*) *const*;
MPI_ALLGATHER	MPI_ALLGATHER(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER COMM,INTEGER IERROR*)
MPI_Allgatherv	int MPI_Allgatherv(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int *recvcounts,int *displs, MPI_Datatype recvtype,MPI_Comm comm*);
MPI::Comm::Allgatherv	void MPI::Comm::Allgatherv(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, void* recvbuf, const int recvcounts[], const int displs[], const MPI::Datatype& recvtype*)*const*;
MPI_ALLGATHERV	MPI_ALLGATHERV(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER DISPLS(*),INTEGER RECVTYPE,INTEGER COMM,INTEGER IERROR*)
MPI_Allreduce	int MPI_Allreduce(*void* sendbuf,void* recvbuf,int count,MPI_Datatype datatype,MPI_Op op,MPI_Comm comm*);

MPI::Comm::Allreduce	void MPI::Comm::Allreduce(*const void* sendbuf, void* recvbuf, int count, const MPI::Datatype& datatype, const MPI::Op& op*) *const*;
MPI_ALLREDUCE	MPI_ALLREDUCE(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER OP,INTEGER COMM,INTEGER IERROR*)
MPI_Alltoall	int MPI_Alltoall(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype, MPI_Comm comm*);
MPI::Comm::Alltoall	void MPI::Comm::Alltoall(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, void* recvbuf, int recvcount, const MPI::Datatype& recvtype*) *const*;
MPI_ALLTOALL	MPI_ALLTOALL(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER COMM,INTEGER IERROR*)
MPI_Alltoallv	int MPI_Alltoallv(*void* sendbuf,int *sendcounts,int *sdispls,MPI_Datatype sendtype,void* recvbuf,int *recvcounts,int *rdispls,MPI_Datatype recvtype,MPI_Comm comm*);
MPI::Comm::Alltoallv	void MPI::Comm::Alltoallv(*const void* sendbuf, const int sendcounts[], const int sdispls[], const MPI::Datatype& sendtype, void* recvbuf, const int recvcounts[], const int rdispls[], const MPI::Datatype& recvtype*) *const*;
MPI_ALLTOALLV	MPI_ALLTOALLV(*CHOICE SENDBUF,INTEGER SENDCOUNTS(*),INTEGER SDISPLS(*),INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER RDISPLS(*),INTEGER RECVTYPE,INTEGER COMM,INTEGER IERROR*)
MPI_Alltoallw	int MPI_Alltoallw(*void* sendbuf, int sendcounts[], int sdispls[], MPI_Datatype sendtypes[], void *recvbuf, int recvcounts[], int rdispls[], MPI_Datatype recvtypes[], MPI_Comm comm*);
MPI::Comm::Alltoallw	void MPI::Comm::Alltoallw(*const void *sendbuf, const int sendcounts[], const int sdispls[], const MPI::Datatype sendtypes[], void *recvbuf, const int recvcounts[], const int rdispls[], const MPI::Datatype recvtypes[]*) *const*;
MPI_ALLTOALLW	MPI_ALLTOALLW(*CHOICE SENDBUF(*), INTEGER SENDCOUNTS(*), INTEGER SDISPLS(*), INTEGER SENDTYPES(*), CHOICE RECVBUF, INTEGER RECVCOUNTS(*), INTEGER RDISPLS(*), INTEGER RECVTYPES(*), INTEGER COMM, INTEGER IERROR*)
MPI_Barrier	int MPI_Barrier(*MPI_Comm comm*);
MPI::Comm::Barrier()	void MPI::Comm::Barrier() *const*;

MPI_BARRIER	MPI_BARRIER(*INTEGER COMM,INTEGER IERROR*)
MPI_Bcast	int MPI_Bcast(*void* buffer,int count,MPI_Datatype datatype,int root,MPI_Comm comm*);
MPI::Comm::Bcast	void MPI::Comm::Bcast(*void* buffer, int count, const MPI::Datatype& datatype, int root*) *const*;
MPI_BCAST	MPI_BCAST(*CHOICE BUFFER,INTEGER COUNT,INTEGER DATATYPE,INTEGER ROOT,INTEGER COMM,INTEGER IERROR*)
MPI_Exscan	int MPI_Exscan(*void *sendbuf, void *recvbuf, int count, MPI_Datatype datatype, MPI_Op op, MPI_Comm comm*);
MPI::Intracomm::Exscan	void MPI::Intracomm::Exscan(*const void* sendbuf, void* recvbuf, int count, const MPI::Datatype& datatype, const MPI::Op& op*) *const*;
MPI_EXSCAN	MPI_EXSCAN(*CHOICE SENDBUF, CHOICE RECVBUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER OP, INTEGER COMM, INTEGER IERROR*)
MPI_Gather	int MPI_Gather(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype,int root,MPI_Comm comm*);
MPI::Comm::Gather	void MPI::Comm::Gather(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, void* recvbuf, int recvcount, const MPI::Datatype& recvtype, int root*) *const*;
MPI_GATHER	MPI_GATHER(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER IERROR*)
MPI_Gatherv	int MPI_Gatherv(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int *recvcounts,int *displs,MPI_Datatype recvtype,int root,MPI_Comm comm*);
MPI::Comm::Gatherv	void MPI::Comm::Gatherv(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, void* recvbuf, const int recvcounts[], const int displs[], const MPI::Datatype& recvtype, int root*) *const*;
MPI_GATHERV	MPI_GATHERV(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER DISPLS(*),INTEGER RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER IERROR*)
MPI_Op_create	int MPI_Op_create(*MPI_User_function *function, int commute, MPI_Op *op*);
MPI::Op::Init	void MPI::Op::Init(*MPI::User_function *func, bool commute*);

MPI_OP_CREATE	MPI_OP_CREATE(*EXTERNAL FUNCTION,INTEGER COMMUTE,INTEGER OP,INTEGER IERROR*)
MPI_Op_free	int MPI_Op_free(*MPI_Op *op*);
MPI::Op::Free	void MPI::Op::Free();
MPI_OP_FREE	MPI_OP_FREE(*INTEGER OP,INTEGER IERROR*)
MPI_Reduce	int MPI_Reduce(*void* sendbuf,void* recvbuf,int count,MPI_Datatype datatype,MPI_Op op,int root,MPI_Comm comm*);
MPI::Comm::Reduce	void MPI::Comm::Reduce(*const void* sendbuf, void* recvbuf, int count, const MPI::Datatype& datatype, const MPI::Op& op, int root*) *const*;
MPI_REDUCE	MPI_REDUCE(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER OP,INTEGER ROOT,INTEGER COMM,INTEGER IERROR*)
MPI_Reduce_scatter	int MPI_Reduce_scatter(*void* sendbuf,void* recvbuf,int *recvcounts,MPI_Datatype datatype,MPI_Op op,MPI_Comm comm*);
MPI::Comm::Reduce_scatter	void MPI::Comm::Reduce_scatter(*const void* sendbuf, void* recvbuf, int recvcounts[], const MPI::Datatype& datatype, const MPI::Op& op*) *const*;
MPI_REDUCE_SCATTER	MPI_REDUCE_SCATTER(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER RECVCOUNTS(*),INTEGER DATATYPE,INTEGER OP,INTEGER COMM,INTEGER IERROR*)
MPI_Scan	int MPI_Scan(*void* sendbuf,void* recvbuf,int count,MPI_Datatype datatype,MPI_Op op,MPI_Comm comm*);
MPI::Intracomm::Scan	void MPI::Intracomm::Scan(*const void *sendbuf, void *recvbuf, int count, const MPI::Datatype& datatype, const MPI::Op& op*) *const*;
MPI_SCAN	MPI_SCAN(*CHOICE SENDBUF,CHOICE RECVBUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER OP,INTEGER COMM,INTEGER IERROR*)
MPI_Scatter	int MPI_Scatter(*void* sendbuf,int sendcount,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype,int root MPI_Comm comm*);
MPI::Comm::Scatter	void MPI::Comm::Scatter(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, void* recvbuf, int recvcount, const MPI::Datatype& recvtype, int root*) *const*;
MPI_SCATTER	MPI_SCATTER(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER*

	RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER IERROR)
MPI_Scatterv	int MPI_Scatterv(*void* sendbuf,int *sendcounts,int *displs,MPI_Datatype sendtype,void* recvbuf,int recvcount,MPI_Datatype recvtype,int root,MPI_Comm comm*);
MPI::Comm::Scatterv	void MPI::Comm::Scatterv(*const void* sendbuf, const int sendcounts[], const int displs[], const MPI::Datatype& sendtype, void* recvbuf, int recvcount, const MPI::Datatype& recvtype, int root*) *const*;
MPI_SCATTERV	MPI_SCATTERV(*CHOICE SENDBUF,INTEGER SENDCOUNTS(*),INTEGER DISPLS(*),INTEGER SENDTYPE,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER ROOT,INTEGER COMM,INTEGER IERROR*)

Bindings for communicators

This is a list of the bindings for communicator subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Attr_delete	int MPI_Attr_delete(*MPI_Comm comm,int keyval*);
(none)	(none)
MPI_ATTR_DELETE	MPI_ATTR_DELETE(*INTEGER COMM,INTEGER KEYVAL,INTEGER IERROR*)
MPI_Attr_get	int MPI_Attr_get(*MPI_Comm comm,int keyval,void *attribute_val, int *flag*);
(none)	(none)
MPI_ATTR_GET	MPI_ATTR_GET(*INTEGER COMM,INTEGER KEYVAL,INTEGER ATTRIBUTE_VAL, LOGICAL FLAG,INTEGER IERROR*)
MPI_Attr_put	int MPI_Attr_put(*MPI_Comm comm,int keyval,void* attribute_val*);
(none)	(none)
MPI_ATTR_PUT	MPI_ATTR_PUT(*INTEGER COMM,INTEGER KEYVAL,INTEGER ATTRIBUTE_VAL, INTEGER IERROR*)
(none)	(none)
MPI::Comm::Clone	MPI::Cartcomm& MPI::Cartcomm::Clone() *const*;
	MPI::Graphcomm& MPI::Graphcomm::Clone() *const*;
	MPI::Intercomm& MPI::Intercomm::Clone() *const*;
	MPI::Intracomm& MPI::Intracomm::Clone() *const*;

(none)	(none)
MPI_Comm_compare	int MPI_Comm_compare(*MPI_Comm comm1,MPI_Comm comm2,int *result*);
MPI::Comm::Compare	int MPI::Comm::Compare(*const MPI::Comm& comm1, const MPI::Comm& comm2*);
MPI_COMM_COMPARE	MPI_COMM_COMPARE(*INTEGER COMM1,INTEGER COMM2,INTEGER RESULT,INTEGER IERROR*)
MPI_Comm_create	int MPI_Comm_create(*MPI_Comm comm_in, MPI_Group group, MPI_Comm *comm_out*);
MPI::Intercomm::Create MPI::Intracomm::Create	MPI::Intercomm MPI::Intercomm::Create(*const MPI::Group& group*) *const*; MPI::Intracomm MPI::Intracomm::Create(*const MPI::Group& group*) *const*;
MPI_COMM_CREATE	MPI_COMM_CREATE(*INTEGER COMM_IN, INTEGER GROUP, INTEGER COMM_OUT,INTEGER IERROR*)
MPI_Comm_create_errhandler	int MPI_Comm_create_errhandler (*MPI_Comm_errhandler_fn *function, MPI_Errhandler *errhandler*);
MPI::Comm::Create_errhandler	static MPI::Errhandler MPI::Comm::Create_errhandler (*MPI::Comm::Errhandler_fn* function*);
MPI_COMM_CREATE_ERRHANDLER	MPI_COMM_CREATE_ERRHANDLER(*EXTERNAL FUNCTION, INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_Comm_create_keyval	int MPI_Comm_create_keyval (*MPI_Comm_copy_attr_function *comm_copy_attr_fn, MPI_Comm_delete_attr_function *comm_delete_attr_fn, int *comm_keyval, void *extra_state*);
MPI::Comm::Create_keyval	int MPI::Comm::Create_keyval (*MPI::Comm::Copy_attr_function* comm_copy_attr_fn, MPI::Comm::Delete_attr_function* comm_delete_attr_fn, void* extra_state*);
MPI_COMM_CREATE_KEYVAL	MPI_COMM_CREATE_KEYVAL(*EXTERNAL COMM_COPY_ATTR_FN, EXTERNAL COMM_DELETE_ATTR_FN, INTEGER COMM_KEYVAL, INTEGER EXTRA_STATE, INTEGER IERROR*)
MPI_Comm_delete_attr	int MPI_Comm_delete_attr (*MPI_Comm comm, int comm_keyval*);

MPI::Comm::Delete_attr	void MPI::Comm::Delete_attr(*int comm_keyval*);
MPI_COMM_DELETE_ATTR	MPI_COMM_DELETE_ATTR(*INTEGER COMM, INTEGER COMM_KEYVAL, INTEGER IERROR*)
MPI_Comm_dup	int MPI_Comm_dup(*MPI_Comm comm,MPI_Comm *newcomm*);
MPI::Cartcomm::Dup MPI::Graphcomm::Dup MPI::Intercomm::Dup MPI::Intracomm::Dup	MPI::Cartcomm MPI::Cartcomm::Dup() *const*;
	MPI::Graphcomm MPI::Graphcomm::Dup() *const*;
	MPI::Intercomm MPI::Intercomm::Dup() *const*;
	MPI::Intracomm MPI::Intracomm::Dup() *const*;
MPI_COMM_DUP	MPI_COMM_DUP(*INTEGER COMM,INTEGER NEWCOMM,INTEGER IERROR*)
MPI_Comm_free	int MPI_Comm_free(*MPI_Comm *comm*);
MPI::Comm::Free	void MPI::Comm::Free(*void*);
MPI_COMM_FREE	MPI_COMM_FREE(*INTEGER COMM,INTEGER IERROR*)
MPI_Comm_free_keyval	int MPI_Comm_free_keyval (*int *comm_keyval*);
MPI::Comm::Free_keyval	void MPI::Comm::Free_keyval(*int& comm_keyval*);
MPI_COMM_FREE_KEYVAL	MPI_COMM_FREE_KEYVAL(*INTEGER COMM_KEYVAL, INTEGER IERROR*)
MPI_Comm_get_attr	int MPI_Comm_get_attr (*MPI_Comm comm, int comm_keyval, void *attribute_val, int *flag*);
MPI::Comm::Get_attr	bool MPI::Comm::Get_attr(*int comm_keyval, void* attribute_val*) *const*;
MPI_COMM_GET_ATTR	MPI_COMM_GET_ATTR(*INTEGER COMM, INTEGER COMM_KEYVAL, INTEGER ATTRIBUTE_VAL, LOGICAL FLAG, INTEGER IERROR*)
MPI_Comm_get_errhandler	int MPI_Comm_get_errhandler (*MPI_Comm comm, MPI_Errhandler *errhandler*);
MPI::Comm::Get_errhandler	MPI::Errhandler MPI::Comm::Get_errhandler() *const*;
MPI_COMM_GET_ERRHANDLER	MPI_COMM_GET_ERRHANDLER(*INTEGER COMM, INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_Comm_rank	MPI_Comm_rank
MPI::Comm::Get_rank	int MPI::Comm::Get_rank() *const*;
MPI_COMM_RANK	MPI_COMM_RANK(*INTEGER COMM,INTEGER RANK,INTEGER IERROR*)
MPI_Comm_remote_group	int MPI_Comm_remote_group(*MPI_Comm comm,MPI_group *group*);

MPI::Intercomm::Get_remote_group
MPI::Group MPI::Intercomm::Get_remote_group() *const*;

MPI_COMM_REMOTE_GROUP
MPI_COMM_REMOTE_GROUP(*INTEGER COMM,MPI_GROUP GROUP,INTEGER IERROR*)

MPI_Comm_remote_size int MPI_Comm_remote_size(*MPI_Comm comm,int *size*);

MPI::Intercomm::Get_remote_size
int MPI_Comm_remote_size(*MPI_Comm comm,int *size*);

MPI_COMM_REMOTE_SIZE MPI_COMM_REMOTE_SIZE(*INTEGER COMM,INTEGER SIZE,INTEGER IERROR*)

MPI_Comm_set_attr int MPI_Comm_set_attr (*MPI_Comm comm, int comm_keyval, void *attribute_val*);

MPI::Comm::Set_attr void MPI::Comm::Set_attr(*int comm_keyval, const void* attribute_val*) *const*;

MPI_COMM_SET_ATTR MPI_COMM_SET_ATTR(*INTEGER COMM, INTEGER COMM_KEYVAL, INTEGER ATTRIBUTE_VAL, INTEGER IERROR*)

MPI_Comm_set_errhandler int MPI_Comm_set_errhandler (*MPI_Comm comm, MPI_Errhandler *errhandler*);

MPI::Comm::Set_errhandler void MPI::Comm::Set_errhandler(*const MPI::Errhandler& errhandler*);

MPI_COMM_SET_ERRHANDLER
MPI_COMM_SET_ERRHANDLER(*INTEGER COMM, INTEGER ERRHANDLER, INTEGER IERROR*)

MPI_Comm_size int MPI_Comm_size(*MPI_Comm comm,int *size*);

MPI::Comm::Get_size int MPI::Comm::Get_size() *const*;

MPI_COMM_SIZE MPI_COMM_SIZE(*INTEGER COMM,INTEGER SIZE,INTEGER IERROR*)

MPI_Comm_split int MPI_Comm_split(*MPI_Comm comm_in, int color, int key, MPI_Comm *comm_out*);

MPI::Intercomm::Split MPI::Intracomm::Split
MPI::Intercomm MPI::Intercomm::Split(*int color, int key*) *const*;

MPI::Intracomm MPI::Intracomm::Split(*int color, int key*) *const*;

MPI_COMM_SPLIT MPI_COMM_SPLIT(*INTEGER COMM_IN, INTEGER COLOR, INTEGER KEY, INTEGER COMM_OUT, INTEGER IERROR*)

MPI_Comm_test_inter int MPI_Comm_test_inter(*MPI_Comm comm,int *flag*);

MPI::Comm::Is_inter bool MPI::Comm::Is_inter() *const*;

MPI_COMM_TEST_INTER	MPI_COMM_TEST_INTER(*INTEGER COMM,LOGICAL FLAG,INTEGER IERROR*)
MPI_Intercomm_create	int MPI_Intercomm_create(*MPI_Comm local_comm,int local_leader, MPI_Comm peer_comm,int remote_leader,int tag,MPI_Comm *newintercom*);
MPI::Intracomm::Create_intercomm	MPI::Intercomm MPI::Intracomm::Create_intercomm(*int local_leader, const MPI::Comm& peer_comm, int remote_leader, int tag*) *const*;
MPI_INTERCOMM_CREATE	MPI_INTERCOMM_CREATE(*INTEGER LOCAL_COMM,INTEGER LOCAL_LEADER, INTEGER PEER_COMM,INTEGER REMOTE_LEADER,INTEGER TAG, INTEGER NEWINTERCOM,INTEGER IERROR*)
MPI_Intercomm_merge	int MPI_Intercomm_merge(*MPI_Comm intercomm,int high, MPI_Comm *newintracomm*);
MPI::Intercomm::Merge	MPI::Intracomm MPI::Intercomm::Merge(*bool high*);
MPI_INTERCOMM_MERGE	MPI_INTERCOMM_MERGE(*INTEGER INTERCOMM,INTEGER HIGH, INTEGER NEWINTRACOMM,INTEGER IERROR*)
MPI_Keyval_create	int MPI_Keyval_create(*MPI_Copy_function *copy_fn, MPI_Delete_function *delete_fn,int *keyval, void* extra_state*);
(none)	(none)
MPI_KEYVAL_CREATE	MPI_KEYVAL_CREATE(*EXTERNAL COPY_FN,EXTERNAL DELETE_FN, INTEGER KEYVAL,INTEGER EXTRA_STATE,INTEGER IERROR*)
MPI_Keyval_free	int MPI_Keyval_free(*int *keyval*);
(none)	(none)
MPI_KEYVAL_FREE	MPI_KEYVAL_FREE(*INTEGER KEYVAL,INTEGER IERROR*)

Bindings for conversion functions

This is a list of the C bindings for conversion functions. These functions do not have C++ or FORTRAN bindings.

Function name:	**C binding:**
MPI_Comm_c2f	MPI_Fint MPI_Comm_c2f(*MPI_Comm comm*);
MPI_Comm_f2c	MPI_Comm MPI_Comm_f2c(*MPI_Fint comm*);
MPI_Errhandler_c2f	MPI_Fint MPI_Errhandler_c2f(*MPI_Errhandler errhandler*);
MPI_Errhandler_f2c	MPI_Errhandler MPI_Errhandler_f2c(*MPI_Fint errorhandler*);
MPI_File_c2f	MPI_Fint MPI_File_c2f(*MPI_File file*);

MPI_File_f2c	MPI_File MPI_File_f2c(*MPI_Fint file*);
MPI_Group_c2f	MPI_Fint MPI_Group_c2f(*MPI_Group group*);
MPI_Group_f2c	MPI_Group MPI_Group_f2c(*MPI_Fint group*);
MPI_Info_c2f	MPI_Fint MPI_Info_c2f(*MPI_Info info*);
MPI_Info_f2c	MPI_Info MPI_Info_f2c(*MPI_Fint file*);
MPI_Op_c2f	MPI_Fint MPI_Op_c2f(*MPI_Op op*);
MPI_Op_f2c	MPI_Op MPI_Op_f2c(*MPI_Fint op*);
MPI_Request_c2f	MPI_Fint MPI_Request_c2f(*MPI_Request request*);
MPI_Request_f2c	MPI_Request MPI_Request_f2c(*MPI_Fint request*);
MPI_Status_c2f	int MPI_Status_c2f(*MPI_Status *c_status, MPI_Fint *f_status*);
MPI_Status_f2c	int MPI_Status_f2c(*MPI_Fint *f_status, MPI_Status *c_status*);
MPI_Type_c2f	MPI_Fint MPI_Type_c2f(*MPI_Type datatype*);
MPI_Type_f2c	MPI_Type MPI_Type_f2c(*MPI_Fint datatype*);
MPI_Win_c2f	MPI_Fint MPI_Win_c2f(*MPI_Win win*);
MPI_Win_f2c	MPI_Win MPI_Win_f2c(*MPI_Fint win*);

Bindings for derived data types

This is a list of the bindings for derived data type subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Address	int MPI_Address(*void* location, MPI_Aint *address*);
(none)	(none)
MPI_ADDRESS	MPI_ADDRESS(*CHOICE LOCATION, INTEGER ADDRESS, INTEGER IERROR*)
MPI_Get_address	int MPI_Get_address(*void *location, MPI_Aint *address*);
MPI::Get_address	MPI::Aint MPI::Get_address(*void* location*);
MPI_GET_ADDRESS	MPI_GET_ADDRESS(*CHOICE LOCATION(*), INTEGER(KIND=MPI_ADDRESS_KIND) ADDRESS, INTEGER IERROR*)
MPI_Get_elements	int MPI_Get_elements(*MPI_Status *status,MPI_Datatype datatype,int *count*);
MPI::Status::Get_elements	int MPI::Status::Get_elements(*const MPI::Datatype& datatype*) *const*;
MPI_GET_ELEMENTS	MPI_GET_ELEMENTS(*INTEGER STATUS(MPI_STATUS_SIZE),INTEGER DATATYPE,INTEGER COUNT,INTEGER IERROR*)
MPI_Pack	int MPI_Pack(*void* inbuf,int incount,MPI_Datatype*

	*datatype,void *outbuf, int outsize,int *position,MPI_Comm comm*);
MPI::Datatype::Pack	void MPI::Datatype::Pack(*const void* inbuf, int incount, void* outbuf, int outsize, int& position, const MPI::Comm& comm*) *const*;
MPI_PACK	MPI_PACK(*CHOICE INBUF,INTEGER INCOUNT,INTEGER DATATYPE,CHOICE OUTBUF,INTEGER OUTSIZE,INTEGER POSITION,INTEGER COMM,INTEGER IERROR*)
MPI_Pack_external	int MPI_Pack_external(*char *datarep, void *inbuf, int incount, MPI_Datatype datatype, void *outbuf, MPI_Aint outsize, MPI_Aint *position*);
MPI::Datatype::Pack_external	void MPI::Datatype::Pack_external(*const char* datarep, const void* inbuf, int incount, void* outbuf, MPI::Aint outsize, MPI_Aint& position*) *const*;
MPI_PACK_EXTERNAL	MPI_PACK_EXTERNAL(*CHARACTER*(*) DATAREP, CHOICE INBUF(*), INTEGER INCOUNT, INTEGER DATATYPE, CHOICE OUTBUF(*), INTEGER(KIND=MPI_ADDRESS_KIND) OUTSIZE, INTEGER(KIND=MPI_ADDRESS_KIND) POSITION, INTEGER IERROR*)
MPI_Pack_external_size	int MPI_Pack_external_size(*char *datarep, int incount, MPI_Datatype datatype,MPI_Aint *size*);
MPI::Datatype::Pack_external_size	MPI::Aint MPI::Datatype::Pack_external_size(*const char* datarep, int incount*) *const*;
MPI_PACK_EXTERNAL_SIZE	MPI_PACK_EXTERNAL_SIZE(*CHARACTER*(*) DATAREP, INTEGER INCOUNT, INTEGER DATATYPE, INTEGER(KIND=MPI_ADDRESS_KIND) SIZE, INTEGER IERROR*
MPI_Pack_size	int MPI_Pack_size(*int incount,MPI_Datatype datatype,MPI_Comm comm,int *size*);
MPI::Datatype::Pack_size	int MPI::Datatype::Pack_size(*int incount, const MPI::Comm& comm*) *const*;
MPI_PACK_SIZE	MPI_PACK_SIZE(*INTEGER INCOUNT,INTEGER DATATYPE,INTEGER COMM,INTEGER SIZE,INTEGER IERROR*)
(none)	(none)
(none)	(none)
MPI_SIZEOF	MPI_SIZEOF(*CHOICE X, INTEGER SIZE, INTEGER IERROR*)
MPI_Type_commit	int MPI_Type_commit(*MPI_Datatype *datatype*);
MPI::Datatype::Commit	void MPI::Datatype::Commit();

MPI_TYPE_COMMIT MPI_TYPE_COMMIT(*INTEGER DATATYPE,INTEGER IERROR*)

MPI_Type_contiguous int MPI_Type_contiguous(*int count,MPI_Datatype oldtype,MPI_Datatype *newtype*);

MPI::Datatype::Create_contiguous
MPI::Datatype MPI::Datatype::Create_contiguous(*int count*) *const*;

MPI_TYPE_CONTIGUOUS MPI_TYPE_CONTIGUOUS(*INTEGER COUNT,INTEGER OLDTYPE,INTEGER NEWTYPE,INTEGER IERROR*)

MPI_Type_create_darray int MPI_Type_create_darray (*int size,int rank,int ndims, int array_of_gsizes[],int array_of_distribs[], int array_of_dargs[],int array_of_psizes[], int order,MPI_Datatype oldtype,MPI_Datatype *newtype*);

MPI::Datatype::Create_darray
MPI::Datatype MPI::Datatype::Create_darray(*int size, int rank, int ndims, const int array_of_gsizes[], const int array_of_distribs[], const int array_of_dargs[], const int array_of_psizes[], int order*) *const*;

MPI_TYPE_CREATE_DARRAY
MPI_TYPE_CREATE_DARRAY (*INTEGER SIZE,INTEGER RANK,INTEGER NDIMS, INTEGER ARRAY_OF_GSIZES(*),INTEGER ARRAY_OF_DISTRIBS(*), INTEGER ARRAY_OF_DARGS(*),INTEGER ARRAY_OF_PSIZES(*), INTEGER ORDER,INTEGER OLDTYPE,INTEGER NEWTYPE,INTEGER IERROR*)

MPI_Type_create_f90_complex
int MPI_Type_create_f90_complex(*int p, int r, MPI_Datatype *newtype*);

MPI::Datatype::Create_f90_complex
static MPI::Datatype
MPI::Datatype::Create_f90_complex(*int p, int r*);

MPI_TYPE_CREATE_F90_COMPLEX
MPI_TYPE_CREATE_F90_COMPLEX(*INTEGER P, INTEGER R, INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_f90_integer
int MPI_Type_create_f90_integer(*int r, MPI_Datatype *newtype*);

MPI::Datatype::Create_f90_integer
static MPI::Datatype
MPI::Datatype::Create_f90_integer(*int r*);

MPI_TYPE_CREATE_F90_INTEGER
MPI_TYPE_CREATE_F90_INTEGER(*INTEGER R, INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_f90_real int MPI_Type_create_f90_real(*int p, int r, MPI_Datatype *newtype*);

MPI::Datatype::Create_f90_real
static MPI::Datatype MPI::Datatype::Create_f90_real(*int p, int r*);

MPI_TYPE_CREATE_F90_REAL
MPI_TYPE_CREATE_F90_REAL(*INTEGER P, INTEGER R, INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_hindexed int MPI_Type_create_hindexed(*int count, int array_of_blocklengths[], MPI_Aint array_of_displacements[], MPI_Datatype oldtype,MPI_Datatype *newtype*);

MPI::Datatype::Create_hindexed
MPI::Datatype MPI::Datatype::Create_hindexed(*int count, const int array_of_blocklengths[], const MPI::Aint array_of_displacements[]*) *const*;

MPI_TYPE_CREATE_HINDEXED
MPI_TYPE_CREATE_HINDEXED(*INTEGER COUNT, INTEGER ARRAY_OF_BLOCKLENGTHS(*), INTEGER(KIND=MPI_ADDRESS_KIND) ARRAY_OF DISPLACEMENTS(*), INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_hvector int MPI_Type_create_hvector(*int count, int blocklength, MPI_Aint stride, MPI_Datatype oldtype, MPI_Datatype *newtype*);

MPI::Datatype::Create_hvector
MPI::Datatype MPI::Datatype::Create_hvector(*int count, int blocklength, MPI::Aint stride*) *const*;

MPI_TYPE_CREATE_HVECTOR
MPI_TYPE_CREATE_HVECTOR(*INTEGER COUNT, INTEGER BLOCKLENGTH, INTEGER(KIND=MPI_ADDRESS_KIND) STRIDE, INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_indexed_block
int MPI_Type_create_indexed_block(*int count, int blocklength, int array_of_displacements[], MPI_Datatype oldtype, MPI_datatype *newtype*);

MPI::Datatype::Create_indexed_block
MPI::Datatype MPI::Datatype::Create_indexed_block(*int count, int blocklength, const int array_of_displacements[]*) *const*;

MPI_TYPE_CREATE_INDEXED_BLOCK
MPI_TYPE_CREATE_INDEXED_BLOCK(*INTEGER COUNT, INTEGER BLOCKLENGTH, INTEGER*

ARRAY_OF DISPLACEMENTS(*), INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR)

MPI_Type_create_keyval int MPI_Type_create_keyval (*MPI_Type_copy_attr_function *type_copy_attr_fn, MPI_Type_delete_attr_function *type_delete_attr_fn, int *type_keyval, void *extra_state*);

MPI::Datatype::Create_keyval
int MPI::Datatype::Create_keyval (*MPI::Datatype::Copy_attr_function* type_copy_attr_fn, MPI::Datatype::Delete_attr_function* type_delete_attr_fn, void* extra_state*);

MPI_TYPE_CREATE_KEYVAL
MPI_TYPE_CREATE_KEYVAL(*EXTERNAL TYPE_COPY_ATTR_FN, EXTERNAL TYPE_DELETE_ATTR_FN, INTEGER TYPE_KEYVAL, INTERGER EXTRA_STATE, INTEGER IERROR*)

MPI_Type_create_resized int MPI_Type_create_resized(*MPI_Datatype oldtype, MPI_Aint lb, MPI_Aint extent, MPI_Datatype *newtype*);

MPI::Datatype::Create_resized
MPI::Datatype MPI::Datatype::Create_resized(*const MPI::Aint lb, const MPI::Aint extent*) *const*;

MPI_TYPE_CREATE_RESIZED
MPI_TYPE_CREATE_RESIZED(*INTEGER OLDTYPE, INTEGER LB, INTEGER(KIND=MPI_ADDRESS_KIND) EXTENT, INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_struct int MPI_Type_create_struct(*int count, int array_of_blocklengths[], MPI_Aint array_of_displacements[], MPI_Datatype array_of_types[], MPI_datatype *newtype*);

MPI::Datatype::Create_struct static MPI::Datatype MPI::Datatype::Create_struct(*int count, const int array_of_blocklengths[], const MPI::Aint array_of_displacements[], const MPI::Datatype array_of_types[]*);

MPI_TYPE_CREATE_STRUCT
MPI_TYPE_CREATE_STRUCT(*INTEGER COUNT, INTEGER ARRAY_OF_BLOCKLENGTHS(*), INTEGER(KIND=MPI_ADDRESS_KIND) ARRAY_OF DISPLACEMENTS(*), INTEGER ARRAY_OF_TYPES(*), INTEGER NEWTYPE, INTEGER IERROR*)

MPI_Type_create_subarray int MPI_Type_create_subarray (*int ndims,int array_of_sizes[], int array_of_subsizes[],int array_of_starts[], int order,MPI_Datatype oldtype,MPI_Datatype *newtype*);

MPI::Datatype::Create_subarray	int MPI_Type_create_subarray (*int ndims,int array_of_sizes[], int array_of_subsizes[],int array_of_starts[], int order,MPI_Datatype oldtype,MPI_Datatype *newtype*);
MPI_TYPE_CREATE_SUBARRAY	MPI_TYPE_CREATE_SUBARRAY (*INTEGER NDIMS,INTEGER ARRAY_OF_SUBSIZES(*), INTEGER ARRAY_OF_SIZES(*),INTEGER ARRAY_OF_STARTS(*), INTEGER ORDER,INTEGER OLDTYPE,INTEGER NEWTYPE,INTEGER IERROR*)
MPI_Type_delete_attr	int MPI_Type_delete_attr (*MPI_Datatype type, int type_keyval*);
MPI::Datatype::Delete_attr	void MPI::Datatype::Delete_attr(*int type_keyval*);
MPI_TYPE_DELETE_ATTR	MPI_TYPE_DELETE_ATTR(*INTEGER TYPE, INTEGER TYPE_KEYVAL, INTEGER IERROR*)
MPI_Type_dup	int MPI_Type_dup (*MPI_Datatype type, MPI_Datatype *newtype*);
MPI::Datatype::Dup	MPI::Datatype MPI::Datatype::Dup() *const*;
MPI_TYPE_DUP	MPI_TYPE_DUP(*INTEGER TYPE, INTEGER NEWTYPE, INTEGER IERROR*)
MPI_Type_extent	int MPI_Type_extent(*MPI_Datatype datatype, int *extent*);
(none)	(none)
MPI_TYPE_EXTENT	MPI_TYPE_EXTENT(*INTEGER DATATYPE, INTEGER EXTENT, INTEGER IERROR*)
MPI_Type_free	int MPI_Type_free(*MPI_Datatype *datatype*);
MPI::Datatype::Free	void MPI::Datatype::Free();
MPI_TYPE_FREE	MPI_TYPE_FREE(*INTEGER DATATYPE,INTEGER IERROR*)
MPI_Type_free_keyval	int MPI_Type_free_keyval (*int *type_keyval*);
MPI::Datatype::Free_keyval	void MPI::Datatype::Free_keyval(*int& type_keyval*);
MPI_TYPE_FREE_KEYVAL	MPI_TYPE_FREE_KEYVAL(*INTEGER TYPE_KEYVAL, INTEGER IERROR*)
MPI_Type_get_attr	int MPI_Type_get_attr (*MPI_Datatype type, int type_keyval, void *attribute_val, int *flag*);
MPI::Datatype::Get_attr	bool MPI::Datatype::Get_attr(*int type_keyval, void* attribute_val*) *const*;
MPI_TYPE_GET_ATTR	MPI_TYPE_GET_ATTR(*INTEGER TYPE, INTEGER TYPE_KEYVAL, INTEGER ATTRIBUTE_VAL, LOGICAL FLAG, INTEGER IERROR*)
MPI_Type_get_contents	int MPI_Type_get_contents(*MPI_Datatype datatype, int *max_integers, int *max_addresses, int*

	**max_datatypes, int array_of_integers[], int array_of_addresses[], int array_of_datatypes[]*);
MPI::Datatype::Get_contents	void MPI::Datatype::Get_contents(*int max_integers, int max_addresses, int max_datatypes, int array_of_integers[], MPI::Aint array_of_addresses[], MPI::Datatype array_of_datatypes[]*) *const*;
MPI_TYPE_GET_CONTENTS	MPI_TYPE_GET_CONTENTS(*INTEGER DATATYPE, INTEGER MAX_INTEGERS, INTEGER MAX_ADDRESSES, INTEGER MAX_DATATYPES, INTEGER ARRAY_of_INTEGERS(*), INTEGER ARRAY_OF_ADDRESSES(*), INTEGER ARRAY_of_DATATYPES(*), INTEGER IERROR*)
MPI_Type_get_envelope	int MPI_Type_get_envelope(*MPI_Datatype datatype, int *num_integers, int *num_addresses, int *num_datatypes, int *combiner*);
MPI::Datatype::Get_envelope	void MPI::Datatype::Get_envelope(*int& num_integers, int& num_addresses, int& num_datatypes, int& combiner*) *const*;
MPI_TYPE_GET_ENVELOPE	MPI_TYPE_GET_ENVELOPE(*INTEGER DATATYPE, INTEGER NUM_INTEGERS, INTEGER NUM_ADDRESSES, INTEGER NUM_DATATYPES, INTEGER COMBINER, INTEGER IERROR*)
MPI_Type_get_extent	int MPI_Type_get_extent(*MPI_Datatype datatype, MPI_Aint *lb, MPI_Aint *extent*);
MPI::Datatype::Get_extent	void MPI::Datatype::Get_extent(*MPI::Aint& lb, MPI::Aint& extent*) *const*;
MPI_TYPE_GET_EXTENT	MPI_TYPE_GET_EXTENT(*INTEGER DATATYPE, INTEGER(KIND=MPI_ADDRESS_KIND) LB, INTEGER(KIND=MPI_ADDRESS_KIND) EXTENT, INTEGER IERROR*)
MPI_Type_get_true_extent	int MPI_Type_get_true_extent(*MPI_Datatype datatype, MPI_Aint *true_lb, MPI_Aint *true_extent*);
MPI::Datatype::Get_true_extent	void MPI::Datatype::Get_true_extent(*MPI::Aint& true_lb, MPI::Aint& true_extent*) *const*;
MPI_TYPE_GET_TRUE_EXTENT	MPI_TYPE_GET_TRUE_EXTENT(*INTEGER DATATYPE, INTEGER TRUE_LB, INTEGER(KIND=MPI_ADDRESS_KIND) TRUE_EXTENT, INTEGER IERROR*)
MPI_Type_hindexed	int MPI_Type_hindexed(*int count, int *array_of_blocklengths, MPI_Aint *array_of_displacements, MPI_Datatype oldtype, MPI_Datatype *newtype*);
(none)	(none)
MPI_TYPE_HINDEXED	MPI_TYPE_HINDEXED(*INTEGER COUNT, INTEGER ARRAY_OF_BLOCKLENGTHS(*),*

	INTEGER ARRAY_OF DISPLACEMENTS(*), INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR)
MPI_Type_hvector	int MPI_Type_hvector(*int count, int blocklength, MPI_Aint stride, MPI_Datatype oldtype, MPI_Datatype *newtype*);
(none)	(none)
MPI_TYPE_HVECTOR	MPI_TYPE_HVECTOR(*INTEGER COUNT, INTEGER BLOCKLENGTH, INTEGER STRIDE, INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR*)
MPI_Type_indexed	int MPI_Type_indexed(*int count, int *array_of_blocklengths, int *array_of_displacements, MPI_Datatype oldtype, MPI_Datatype *newtype*);
MPI::Datatype::Create_indexed	MPI::Datatype MPI::Datatype::Create_indexed(*int count, const int array_of_blocklengths[], const int array_of_displacements[]*) *const*;
MPI_TYPE_INDEXED	MPI_TYPE_INDEXED(*INTEGER COUNT, INTEGER ARRAY_OF_BLOCKLENGTHS(*), INTEGER ARRAY_OF DISPLACEMENTS(*), INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR*)
MPI_Type_lb	int MPI_Type_lb(*MPI_Datatype datatype, int* displacement*);
(none)	(none)
MPI_TYPE_LB	MPI_TYPE_LB(*INTEGER DATATYPE,INTEGER DISPLACEMENT,INTEGER IERROR*)
MPI_Type_match_size	int MPI_Type_match_size(*int typeclass, int size, MPI_Datatype *type*);
MPI::Datatype::Match_size	static MPI::Datatype MPI::Datatype::Match_size(*int typeclass, int size*);
MPI_TYPE_MATCH_SIZE	MPI_TYPE_MATCH_SIZE(*INTEGER TYPECLASS, INTEGER SIZE, INTEGER TYPE, INTEGER IERROR*)
MPI_Type_set_attr	int MPI_Type_set_attr (*MPI_Datatype type, int type_keyval, void *attribute_val*);
MPI::Datatype::Set_attr	void MPI::Datatype::Set_attr(*int type_keyval, const void* attribute_val*);
MPI_TYPE_SET_ATTR	MPI_TYPE_SET_ATTR(*INTEGER TYPE, INTEGER TYPE_KEYVAL, INTEGER ATTRIBUTE_VAL, INTEGER IERROR*)
MPI_Type_size	int MPI_Type_size(*MPI_Datatype datatype,int *size*);
MPI::Datatype::Get_size	int MPI::Datatype::Get_size() *const*;

MPI_TYPE_SIZE	MPI_TYPE_SIZE(*INTEGER DATATYPE, INTEGER SIZE, INTEGER IERROR*)
MPI_Type_struct	int MPI_Type_struct(*int count, int *array_of_blocklengths, MPI_Aint *array_of_displacements, MPI_Datatype *array_of_types, MPI_Datatype *newtype*);
(none)	(none)
MPI_TYPE_STRUCT	MPI_TYPE_STRUCT(*INTEGER COUNT, INTEGER ARRAY_OF_BLOCKLENGTHS(*), INTEGER ARRAY_OF DISPLACEMENTS(*), INTEGER ARRAY_OF_TYPES(*), INTEGER NEWTYPE, INTEGER IERROR*)
MPI_Type_ub	int MPI_Type_ub(*MPI_Datatype datatype,int* displacement*);
(none)	(none)
MPI_TYPE_UB	MPI_TYPE_UB(*INTEGER DATATYPE,INTEGER DISPLACEMENT,INTEGER IERROR*)
MPI_Type_vector	int MPI_Type_vector(*int count, int blocklength, int stride, MPI_Datatype oldtype, MPI_Datatype *newtype*);
MPI::Datatype::Create_vector	MPI::Datatype MPI::Datatype::Create_vector(*int count, int blocklength, int stride*) *const*;
MPI_TYPE_VECTOR	MPI_TYPE_VECTOR(*INTEGER COUNT, INTEGER BLOCKLENGTH, INTEGER STRIDE, INTEGER OLDTYPE, INTEGER NEWTYPE, INTEGER IERROR*)
MPI_Unpack	int MPI_Unpack(*void* inbuf,int insize,int *position,void *outbuf,int outcount,MPI_Datatype datatype,MPI_Comm comm*);
MPI::Datatype::Unpack	void MPI::Datatype::Unpack(*const void* inbuf, int insize, void* outbuf, int outcount, int& position, const MPI::Comm& comm*) *const*;
MPI_UNPACK	MPI_UNPACK(*CHOICE INBUF,INTEGER INSIZE,INTEGER POSITION,CHOICE OUTBUF,INTEGER OUTCOUNT,INTEGER DATATYPE,INTEGER COMM, INTEGER IERRROR*)
MPI_Unpack_external	int MPI_Unpack_external(*char *datarep, void *inbuf, MPI_Aint insize, MPI_Aint *position, void *outbuf, int outcount, MPI_Datatype datatype*);
MPI::Datatype::Unpack_external	void MPI::Datatype::Unpack_external(*const char* datarep, const void* inbuf, MPI::Aint insize, MPI::Aint& position, void* outbuf, int outcount*) *const*;
MPI_UNPACK_EXTERNAL	MPI_UNPACK_EXTERNAL(*CHARACTER*(*) DATAREP, CHOICE INBUF(*),*

INTEGER(KIND=MPI_ADDRESS_KIND) INSIZE, INTEGER(KIND=MPI_ADDRESS_KIND) POSITION, CHOICE OUTBUF(*), INTEGER OUTCOUNT, INTEGER DATATYPE, INTEGER IERROR)

Bindings for environment management

This is a list of the bindings for environment management subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Abort	int MPI_Abort(*MPI_Comm comm, int errorcode*);
MPI::Comm::Abort	void MPI::Comm::Abort(*int errorcode*);
MPI_ABORT	MPI_ABORT(*INTEGER COMM,INTEGER ERRORCODE,INTEGER IERROR*)
MPI_Errhandler_create	int MPI_Errhandler_create(*MPI_Handler_function *function, MPI_Errhandler *errhandler*);
(none)	(none)
MPI_ERRHANDLER_CREATE	MPI_ERRHANDLER_CREATE(*EXTERNAL FUNCTION,INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_Errhandler_free	int MPI_Errhandler_free(*MPI_Errhandler *errhandler*);
MPI::Errhandler::Free	void MPI::Errhandler::Free();
MPI_ERRHANDLER_FREE	MPI_ERRHANDLER_FREE(*INTEGER ERRHANDLER,INTEGER IERROR*)
MPI_Errhandler_get	int MPI_Errhandler_get(*MPI_Comm comm,MPI_Errhandler *errhandler*);
(none)	(none)
MPI_ERRHANDLER_GET	MPI_ERRHANDLER_GET(*INTEGER COMM,INTEGER ERRHANDLER,INTEGER IERROR*)
MPI_Errhandler_set	int MPI_Errhandler_set(*MPI_Comm comm,MPI_Errhandler errhandler*);
(none)	(none)
MPI_ERRHANDLER_SET	MPI_ERRHANDLER_SET(*INTEGER COMM,INTEGER ERRHANDLER,INTEGER IERROR*)
MPI_Error_class	int MPI_Error_class(*int errorcode, int *errorclass*);
MPI::Get_error_class	int MPI::Get_error_class(*int errorcode*);
MPI_ERROR_CLASS	MPI_ERROR_CLASS(*INTEGER ERRORCODE,INTEGER ERRORCLASS,INTEGER IERROR*)

MPI_Error_string	int MPI_Error_string(*int errorcode, char *string, int *resultlen*);
MPI::Get_error_string	void MPI::Get_error_string(*int errorcode, char* string, int& resultlen*);
MPI_ERROR_STRING	MPI_ERROR_STRING(*INTEGER ERRORCODE,CHARACTER STRING(*),INTEGER RESULTLEN,INTEGER IERROR*)
MPI_File_create_errhandler	int MPI_File_create_errhandler (*MPI_File_errhandler_fn *function, MPI_Errhandler *errhandler*);
MPI::File::Create_errhandler	static MPI::Errhandler MPI::File::Create_errhandler (*MPI::File::Errhandler_fn* function*);
MPI_FILE_CREATE_ERRHANDLER	MPI_FILE_CREATE_ERRHANDLER(*EXTERNAL FUNCTION,INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_File_get_errhandler	int MPI_File_get_errhandler (*MPI_File file,MPI_Errhandler *errhandler*);
MPI::File::Get_errhandler	MPI::Errhandler MPI::File::Get_errhandler() *const*;
MPI_FILE_GET_ERRHANDLER	MPI_FILE_GET_ERRHANDLER (*INTEGER FILE,INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_File_set_errhandler	int MPI_File_set_errhandler (*MPI_File fh, MPI_Errhandler errhandler*);
MPI::File::Set_errhandler	void MPI::File::Set_errhandler(*const MPI::Errhandler& errhandler*);
MPI_FILE_SET_ERRHANDLER	MPI_FILE_SET_ERRHANDLER(*INTEGER FH,INTEGER ERRHANLDER, INTEGER IERROR*)
MPI_Finalize	int MPI_Finalize(*void*);
MPI::Finalize	void MPI::Finalize();
MPI_FINALIZE	MPI_FINALIZE
MPI_Finalized	int MPI_Finalized(*int *flag*);
MPI::Is_finalized	bool MPI::Is_finalized();
MPI_FINALIZED	MPI_FINALIZED(*LOGICAL FLAG, INTEGER IERROR*)
MPI_Get_processor_name	int MPI_Get_processor_name(*char *name,int *resultlen*);
MPI::Get_processor_name	void MPI::Get_processor_name(*char*& name, int& resultlen*);
MPI_GET_PROCESSOR_NAME	MPI_GET_PROCESSOR_NAME(*CHARACTER NAME(*),INTEGER RESULTLEN,INTEGER IERROR*)

MPI_Get_version	int MPI_Get_version(*int *version,int *subversion*);
MPI::Get_version	void MPI::Get_version(*int& version, int& subversion*);
MPI_GET_VERSION	MPI_GET_VERSION(*INTEGER VERSION,INTEGER SUBVERSION,INTEGER IERROR*)
MPI_Init	int MPI_Init(*int *argc, char ***argv*);
MPI::Init	void MPI::Init(*int& argc, char**& argv*);
	void MPI::Init();
MPI_INIT	MPI_INIT(*INTEGER IERROR*)
MPI_Init_thread	int MPI_Init_thread(*int *argc, char *((*argv)[]), int required, int *provided*);
MPI::Init_thread	int MPI::Init_thread(*int& argc, char**& argv, int required*);
	int MPI::Init_thread(*int required*);
MPI_INIT_THREAD	MPI_INIT_THREAD(*INTEGER REQUIRED, INTEGER PROVIDED, INTEGER IERROR*)
MPI_Initialized	int MPI_Initialized(*int *flag*);
MPI::Is_initialized	bool MPI::Is_initialized();
MPI_INITIALIZED	MPI_INITIALIZED(*INTEGER FLAG,INTEGER IERROR*)
MPI_Is_thread_main	int MPI_Is_thread_main(*int *flag*);
MPI::Is_thread_main	bool MPI::Is_thread_main();
MPI_IS_THREAD_MAIN	MPI_IS_THREAD_MAIN(*LOGICAL FLAG, INTEGER IERROR*)
MPI_Query_thread	int MPI_Query_thread(*int *provided*);
MPI::Query_thread	int MPI::Query_thread();
MPI_QUERY_THREAD	MPI_QUERY_THREAD(*INTEGER PROVIDED, INTEGER IERROR*)
MPI_Wtick	double MPI_Wtick(*void*);
MPI::Wtick	double MPI::Wtick();
MPI_WTICK	DOUBLE PRECISION MPI_WTICK()
MPI_Wtime	double MPI_Wtime(*void*);
MPI::Wtime	double MPI::Wtime();
MPI_WTIME	DOUBLE PRECISION MPI_WTIME()

Bindings for external interfaces

This is a list of the bindings for external interfaces. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN **Binding: C C++ FORTRAN**

MPI_Add_error_class	int MPI_Add_error_class(*int *errorclass*);
MPI::Add_error_class	int MPI::Add_error_class();
MPI_ADD_ERROR_CLASS	MPI_ADD_ERROR_CLASS(*INTEGER ERRORCLASS, INTEGER IERROR*)
MPI_Add_error_code	int MPI_Add_error_code(*int errorclass, int *errorcode*);
MPI::Add_error_code	int MPI::Add_error_code(*int errorclass*);
MPI_ADD_ERROR_CODE	MPI_ADD_ERROR_CODE(*INTEGER ERRORCLASS, INTEGER ERRORCODE, INTEGER IERROR*)
MPI_Add_error_string	int MPI_Add_error_string(*int errorcode, char *string*);
MPI::Add_error_string	void MPI::Add_error_string(*int errorcode, const char* string*);
MPI_ADD_ERROR_STRING	MPI_ADD_ERROR_STRING(*INTEGER ERRORCODE, CHARACTER*(*) STRING, INTEGER IERROR*)
MPI_Comm_call_errhandler	int MPI_Comm_call_errhandler (*MPI_Comm comm, int errorcode*);
MPI::Comm::Call_errhandler	void MPI::Comm::Call_errhandler(*int errorcode*) *const*;
MPI_COMM_CALL_ERRHANDLER	MPI_COMM_CALL_ERRHANDLER(*INTEGER COMM, INTEGER ERRORCODE, INTEGER IERROR*)
MPI_Comm_get_name	int MPI_Comm_get_name (*MPI_Comm comm, char *comm_name, int *resultlen*);
MPI::Comm::Get_name	void MPI::Comm::Get_name(*char* comm_name, int& resultlen*) *const*;
MPI_COMM_GET_NAME	MPI_COMM_GET_NAME(*INTEGER COMM, CHARACTER*(*) COMM_NAME, INTEGER RESULTLEN, INTEGER IERROR*)
MPI_Comm_set_name	int MPI_Comm_set_name (*MPI_Comm comm, char *comm_name*);
MPI::Comm::Set_name	void MPI::Comm::Set_name(*const char* comm_name*);
MPI_COMM_SET_NAME	MPI_COMM_SET_NAME(*INTEGER COMM, CHARACTER*(*) COMM_NAME, INTEGER IERROR*)
MPI_File_call_errhandler	int MPI_File_call_errhandler (*MPI_File fh, int errorcode*);
MPI::File::Call_errhandler	void MPI::File::Call_errhandler(*int errorcode*) *const*;
MPI_FILE_CALL_ERRHANDLER	MPI_FILE_CALL_ERRHANDLER(*INTEGER FH, INTEGER ERRORCODE, INTEGER IERROR*)

MPI_Grequest_complete int MPI_Grequest_complete(*MPI_Request request*);

MPI::Grequest::Complete void MPI::Grequest::Complete();

MPI_GREQUEST_COMPLETE
MPI_GREQUEST_COMPLETE(*INTEGER REQUEST, INTEGER IERROR*)

MPI_Grequest_start int MPI_Grequest_start(*MPI_Grequest_query_function *query_fn, MPI_Grequest_free_function *free_fn, MPI_Grequest_cancel_function *cancel_fn, void *extra_state, MPI_Request *request*);

MPI::Grequest::Start MPI::Grequest MPI::Grequest::Start(*MPI::Grequest::Query_function query_fn, MPI::Grequest::Free_function free_fn, MPI::Grequest::Cancel_function cancel_fn, void *extra_state*);

MPI_GREQUEST_START MPI_GREQUEST_START(*EXTERNAL QUERY_FN, EXTERNAL FREE_FN, EXTERNAL CANCEL_FN, INTEGER EXTRA_STATE, INTEGER REQUEST, INTEGER IERROR*)

MPI_Status_set_cancelled int MPI_Status_set_cancelled(*MPI_Status *status, int flag*);

MPI::Status::Set_cancelled void MPI::Status::Set_cancelled(*bool flag*);

MPI_STATUS_SET_CANCELLED
MPI_STATUS_SET_CANCELLED(*INTEGER STATUS(MPI_STATUS_SIZE), LOGICAL FLAG, INTEGER IERROR*)

MPI_Status_set_elements int MPI_Status_set_elements(*MPI_Status *status, MPI_Datatype datatype, int count*);

MPI::Status::Set_elements void MPI::Status::Set_elements(*const MPI::Datatype& datatype, int count*);

MPI_STATUS_SET_ELEMENTS
MPI_STATUS_SET_ELEMENTS(*INTEGER STATUS(MPI_STATUS_SIZE), INTEGER DATATYPE, INTEGER COUNT, INTEGER IERROR*)

MPI_Type_get_name int MPI_Type_get_name(*MPI_Datatype type, char *type_name, int *resultlen*);

MPI::Datatype::Get_name void MPI::Datatype::Get_name(*char* type_name, int& resultlen*) *const*;

MPI_TYPE_GET_NAME MPI_TYPE_GET_NAME(*INTEGER TYPE, CHARACTER*(*) TYPE_NAME, INTEGER RESULTLEN, INTEGER IERROR*)

MPI_Type_set_name int MPI_Type_set_name (*MPI_Datatype type, char *type_name*);

MPI::Datatype::Set_name void MPI::Datatype::Set_name(*const char* type_name*);

MPI_TYPE_SET_NAME	MPI_TYPE_SET_NAME(*INTEGER TYPE, CHARACTER*(*) TYPE_NAME, INTEGER IERROR*)
MPI_Win_call_errhandler	int MPI_Win_call_errhandler (*MPI_Win win, int errorcode*);
MPI::Win::Call_errhandler	void MPI::Win::Call_errhandler(*int errorcode*) *const*;
MPI_WIN_CALL_ERRHANDLER	MPI_WIN_CALL_ERRHANDLER(*INTEGER WIN, INTEGER ERRORCODE, INTEGER IERROR*)
MPI_Win_get_name	int MPI_Win_get_name (*MPI_Win win, char *win_name, int *resultlen*);
MPI::Win::Get_name	void MPI::Win::Get_name(*char* win_name, int& resultlen*) *const*;
MPI_WIN_GET_NAME	MPI_WIN_GET_NAME(*INTEGER WIN, CHARACTER*(*) WIN_NAME, INTEGER RESULTLEN, INTEGER IERROR*)
MPI_Win_set_name	int MPI_Win_set_name (*MPI_Win win, char *win_name*);
MPI::Win::Set_name	void MPI::Win::Set_name(*const char* win_name*);
MPI_WIN_SET_NAME	MPI_WIN_SET_NAME(*INTEGER WIN, CHARACTER*(*) WIN_NAME, INTEGER IERROR*)

Bindings for group management

This is a list of the bindings for group management subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Comm_group	int MPI_Comm_group(*MPI_Comm comm,MPI_Group *group*);
MPI::Comm::Get_group	MPI::Group MPI::Comm::Get_group() *const*;
MPI_COMM_GROUP	MPI_COMM_GROUP(*INTEGER COMM,INTEGER GROUP,INTEGER IERROR*)
MPI_Group_compare	int MPI_Group_compare(*MPI_Group group1,MPI_Group group2,int *result*);
MPI::Group::Compare	static int MPI::Group::Compare(*const MPI::Group& group1, const MPI::Group& group2*);
MPI_GROUP_COMPARE	MPI_GROUP_COMPARE(*INTEGER GROUP1,INTEGER GROUP2,INTEGER RESULT,INTEGER IERROR*)
MPI_Group_difference	int MPI_Group_difference(*MPI_Group group1,MPI_Group group2,MPI_Group *newgroup*);
MPI::Group::Difference	static MPI::Group MPI::Group::Difference(*const MPI::Group& group1, const MPI::Group& group2*);
MPI_GROUP_DIFFERENCE	MPI_GROUP_DIFFERENCE(*INTEGER*

	GROUP1,INTEGER GROUP2,INTEGER NEWGROUP,INTEGER IERROR)
MPI_Group_excl	int MPI_Group_excl(*MPI_Group group,int n,int *ranks,MPI_Group *newgroup*);
MPI::Group::Excl	MPI::Group MPI::Group::Excl(*int n, const int ranks[]*) *const*;
MPI_GROUP_EXCL	MPI_GROUP_EXCL(*INTEGER GROUP,INTEGER N,INTEGER RANKS(*),INTEGER NEWGROUP,INTEGER IERROR*)
MPI_Group_free	int MPI_Group_free(*MPI_Group *group*);
MPI::Group::Free	void MPI::Group::Free();
MPI_GROUP_FREE	MPI_GROUP_FREE(*INTEGER GROUP,INTEGER IERROR*)
MPI_Group_incl	int MPI_Group_incl(*MPI_Group group,int n,int *ranks,MPI_Group *newgroup*);
MPI::Group::Incl	MPI::Group MPI::Group::Incl(*int n, const int ranks[]*) *const*;
MPI_GROUP_INCL	MPI_GROUP_INCL(*INTEGER GROUP,INTEGER N,INTEGER RANKS(*),INTEGER NEWGROUP,INTEGER IERROR*)
MPI_Group_intersection	int MPI_Group_intersection(*MPI_Group group1,MPI_Group group2,MPI_Group *newgroup*);
MPI::Group::Intersect	static MPI::Group MPI::Group::Intersect(*const MPI::Group& group1, const MPI::Group& group2*);
MPI_GROUP_INTERSECTION	MPI_GROUP_INTERSECTION(*INTEGER GROUP1,INTEGER GROUP2,INTEGER NEWGROUP,INTEGER IERROR*)
MPI_Group_range_excl	int MPI_Group_range_excl(*MPI_Group group,int n,int ranges [][3],MPI_Group *newgroup*);
MPI::Group::Range_excl	MPI::Group MPI::Group::Range_excl(*int n, const int ranges[]*[3]) *const*;
MPI_GROUP_RANGE_EXCL	MPI_GROUP_RANGE_EXCL(*INTEGER GROUP,INTEGER N,INTEGER RANGES(3,*),INTEGER NEWGROUP,INTEGER IERROR*)
MPI_Group_range_incl	int MPI_Group_range_incl(*MPI_Group group,int n,int ranges[][3],MPI_Group *newgroup*);
MPI::Group::Range_incl	MPI::Group MPI::Group::Range_incl(*int n, const int ranges[]*[3]) *const*;
MPI_GROUP_RANGE_INCL	MPI_GROUP_RANGE_INCL(*INTEGER GROUP,INTEGER N,INTEGER RANGES(3,*),INTEGER NEWGROUP,INTEGER IERROR*)
MPI_Group_rank	int MPI_Group_rank(*MPI_Group group,int *rank*);
MPI::Group::Get_rank	int MPI::Group::Get_rank() *const*;

MPI_GROUP_RANK	MPI_GROUP_RANK(*INTEGER GROUP,INTEGER RANK,INTEGER IERROR*)
MPI_Group_size	int MPI_Group_size(*MPI_Group group,int *size*);
MPI::Group::Get_size	int MPI::Group::Get_size() *const*;
MPI_GROUP_SIZE	MPI_GROUP_SIZE(*INTEGER GROUP,INTEGER SIZE,INTEGER IERROR*)
MPI_Group_translate_ranks	int MPI_Group_translate_ranks (*MPI_Group group1,int n,int *ranks1,MPI_Group group2,int *ranks2*);
MPI::Group::Translate_ranks	void MPI::Group::Translate_ranks(*const MPI::Group& group1, int n, const int ranks1[], const MPI::Group& group2, int ranks2[]*);
MPI_GROUP_TRANSLATE_RANKS	MPI_GROUP_TRANSLATE_RANKS(*INTEGER GROUP1, INTEGER N,INTEGER RANKS1(*),INTEGER GROUP2,INTEGER RANKS2(*),INTEGER IERROR*)
MPI_Group_union	int MPI_Group_union(*MPI_Group group1,MPI_Group group2,MPI_Group *newgroup*);
MPI::Group::Union	static MPI::Group MPI::Group::Union(*const MPI::Group& group1, const MPI::Group& group2*);
MPI_GROUP_UNION	MPI_GROUP_UNION(*INTEGER GROUP1,INTEGER GROUP2,INTEGER NEWGROUP,INTEGER IERROR*)

Bindings for Info objects

This is a list of the bindings for Info objects. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Info_create	int MPI_Info_create(*MPI_Info *info*);
MPI::Info::Create	static MPI::Info MPI::Info::Create();
MPI_INFO_CREATE	MPI_INFO_CREATE(*INTEGER INFO,INTEGER IERROR*)
MPI_Info_delete	int MPI_Info_delete(*MPI_Info info,char *key*);
MPI::Info::Delete	void MPI::Info::Delete(*const char* key*);
MPI_INFO_DELETE	MPI_INFO_DELETE(*INTEGER INFO,CHARACTER KEY(*), INTEGER IERROR*)
MPI_Info_dup	int MPI_Info_dup(*MPI_Info info,MPI_Info *newinfo*);
MPI::Info::Dup	MPI::Info MPI::Info::Dup() *const*;
MPI_INFO_DUP	MPI_INFO_DUP(*INTEGER INFO,INTEGER NEWINFO,INTEGER IERROR*)
MPI_Info_free	int MPI_Info_free(*MPI_Info *info*);
MPI::Info::Free	void MPI::Info::Free();

MPI_INFO_FREE	MPI_INFO_FREE(*INTEGER INFO,INTEGER IERROR*)
MPI_Info_get	int MPI_Info_get(*MPI_Info info,char *key,int valuelen, char *value,int *flag*);
MPI::Info::Get	bool MPI::Info::Get(*const char* key, int valuelen, char* value*) *const*;
MPI_INFO_GET	MPI_INFO_GET (*INTEGER INFO,CHARACTER KEY(*),INTEGER VALUELEN, CHARACTER VALUE(*),LOGICAL FLAG,INTEGER IERROR*)
MPI_Info_get_nkeys	int MPI_Info_get_nkeys(*MPI_Info info,int *nkeys*);
MPI::Info::Get_nkeys	int MPI::Info::Get_nkeys() *const*;
MPI_INFO_GET_NKEYS	MPI_INFO_GET_NKEYS(*INTEGER INFO,INTEGER NKEYS,INTEGER IERROR*)
MPI_Info_get_nthkey	int MPI_Info_get_nthkey(*MPI_Info info, int n, char *key*);
MPI::Info::Get_nthkey	void MPI::Info::Get_nthkey(*int n, char* key*) *const*;
MPI_INFO_GET_NTHKEY	MPI_INFO_GET_NTHKEY(*INTEGER INFO,INTEGER N,CHARACTER KEY(*), INTEGER IERROR*)
MPI_Info_get_valuelen	int MPI_Info_get_valuelen(*MPI_Info info,char *key,int *valuelen, int *flag*);
MPI::Info::Get_valuelen	bool MPI::Info::Get_valuelen(*const char* key, int& valuelen*) *const*;
MPI_INFO_GET_VALUELEN	MPI_INFO_GET_VALUELEN(*INTEGER INFO,CHARACTER KEY(*),INTEGER VALUELEN,LOGICAL FLAG, INTEGER IERROR*)
MPI_Info_set	int MPI_Info_set(*MPI_Info info,char *key,char *value*);
MPI::Info::Set	void MPI::Info::Set(*const char* key, const char* value*);
MPI_INFO_SET	MPI_INFO_SET(*INTEGER INFO,CHARACTER KEY(*),CHARACTER VALUE(*), INTEGER IERROR*)

Bindings for memory allocation

This is a list of the bindings for memory allocation subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Alloc_mem	int MPI_Alloc_mem (*MPI_Aint size, MPI_Info info, void *baseptr*);
MPI::Alloc_mem	void* MPI::Alloc_mem(*MPI::Aint size, const MPI::Info& info*);

MPI_ALLOC_MEM	MPI_ALLOC_MEM(*INTEGER SIZE, INTEGER INFO, INTEGER BASEPTR, INTEGER IERROR*)
MPI_Free_mem	int MPI_Free_mem (*void *base*);
MPI::Free_mem	void MPI::Free_mem(*void *base*):
MPI_FREE_MEM	MPI_FREE_MEM(*CHOICE BASE, INTEGER IERROR*)

Bindings for MPI-IO

This is a list of the bindings for MPI-IO subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_File_close	int MPI_File_close (*MPI_File *fh*);
MPI::File::Close	void MPI::File::Close();
MPI_FILE_CLOSE	MPI_FILE_CLOSE(*INTEGER FH,INTEGER IERROR*)
MPI_File_delete	int MPI_File_delete (*char *filename,MPI_Info info*);
MPI::File::Delete	static void MPI::File::Delete(*const char* filename, const MPI::Info& info*);
MPI_FILE_DELETE	MPI_FILE_DELETE(*CHARACTER*(*) FILENAME,INTEGER INFO, INTEGER IERROR*)
MPI_File_get_amode	int MPI_File_get_amode (*MPI_File fh,int *amode*);
MPI::File::Get_amode	int MPI::File::Get_amode() *const*;
MPI_FILE_GET_AMODE	MPI_FILE_GET_AMODE(*INTEGER FH,INTEGER AMODE,INTEGER IERROR*)
MPI_File_get_atomicity	int MPI_File_get_atomicity (*MPI_File fh,int *flag*);
MPI::File::Get_atomicity	bool MPI::File::Get_atomicity() *const*;
MPI_FILE_GET_ATOMICITY	MPI_FILE_GET_ATOMICITY (*INTEGER FH,LOGICAL FLAG,INTEGER IERROR*)
MPI_File_get_byte_offset	int MPI_File_get_byte_offset(*MPI_File fh, MPI_Offset offset, MPI_Offset *disp*);
MPI::File::Get_byte_offset	MPI::Offset MPI::File::Get_byte_offset(const MPI::Offset disp) *const*;
MPI_FILE_GET_BYTE_OFFSET	MPI_FILE_GET_BYTE_OFFSET(*INTEGER FH, INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, INTEGER(KIND=MPI_OFFSET_KIND) DISP, INTEGER IERROR*)
MPI_File_get_group	int MPI_File_get_group (*MPI_File fh,MPI_Group *group*);
MPI::File::Get_group	MPI::Group MPI::File::Get_group() *const*;
MPI_FILE GET_GROUP	MPI_FILE GET_GROUP (*INTEGER FH,INTEGER GROUP,INTEGER IERROR*)

MPI_File_get_info	int MPI_File_get_info (*MPI_File fh,MPI_Info *info_used*);
MPI::File::Get_info	MPI::Info MPI::File::Get_info() *const*;
MPI_FILE_GET_INFO	MPI_FILE_GET_INFO (*INTEGER FH,INTEGER INFO_USED, INTEGER IERROR*)
MPI_File_get_position	int MPI_File_get_position(*MPI_File fh,MPI_Offset *offset*);
MPI::File::Get_position	MPI::Offset MPI::File::Get_position() *const*;
MPI_FILE_GET_POSITION	MPI_FILE_GET_POSITION(*INTEGER FH, INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, INTEGER IERROR*)
MPI_File_get_position_shared	int MPI_File_get_position_shared(*MPI_File fh, MPI_Offset *offset*);
MPI::File::Get_position_shared	MPI::Offset MPI::File::Get_position_shared() *const*;
MPI_FILE_GET_POSITION_SHARED	MPI_FILE_GET_POSITION_SHARED(*INTEGER FH, INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, INTEGER IERROR*)
MPI_File_get_size	int MPI_File_get_size (*MPI_File fh,MPI_Offset size*);
MPI::File::Get_size	MPI::Offset MPI::File::Get_size() *const*;
MPI_FILE_GET_SIZE	MPI_FILE_GET_SIZE (*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) SIZE, INTEGER IERROR*)
MPI_File_get_type_extent	int MPI_File_get_type_extent(*MPI_File fh, MPI_Datatype datatype, MPI_Aint *extent*);
MPI::File::Get_type_extent	MPI::Aint MPI::File::Get_type_extent(*const MPI::Datatype& datatype*) *const*;
MPI_FILE_GET_TYPE_EXTENT	MPI_FILE_GET_TYPE_EXTENT (*INTEGER FH, INTEGER DATATYPE, INTEGER(KIND=MPI_ADDRESS_KIND) EXTENT, INTEGER IERROR*)
MPI_File_get_view	nt MPI_File_get_view (*MPI_File fh,MPI_Offset *disp, MPI_Datatype *etype,MPI_Datatype *filetype,char *datarep*);
MPI::File::Get_view	void MPI::File::Get_view(*MPI::Offset& disp,MPI::Datatype& etype, MPI::Datatype& filetype, char* datarep*) *const*;
MPI_FILE_GET_VIEW	MPI_FILE_GET_VIEW (*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) DISP, INTEGER ETYPE,INTEGER FILETYPE,INTEGER DATAREP,INTEGER IERROR*)
MPI_File_iread	int MPI_File_iread (*MPI_File fh,void *buf, int count, MPI_Datatype datatype,MPI_Request *request*);

MPI::File::Iread	MPI::Request MPI::File::Iread(*void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_IREAD	MPI_FILE_IREAD (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER REQUEST, INTEGER IERROR*)
MPI_File_iread_at	int MPI_File_iread_at (*MPI_File fh,MPI_Offset offset,void *buf, int count,MPI_Datatype datatype,MPI_Request *request*);
MPI::File::Iread_at	MPI::Request MPI::File::Iread_at(*MPI::Offset offset, void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_IREAD_AT	MPI_FILE_IREAD_AT (*INTEGER FH,INTEGER (KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER REQUEST, INTEGER IERROR*)
MPI_File_iread_shared	int MPI_File_iread_shared (*MPI_File fh,void *buf, int count, MPI_Datatype datatype,MPI_Request *request*);
MPI::File::Iread_shared	MPI::Request MPI::File::Iread_shared(*void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_IREAD_SHARED	MPI_FILE_IREAD_SHARED (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER REQUEST, INTEGER IERROR*)
MPI_File_iwrite	int MPI_File_iwrite (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Request *request*);
MPI::File::Iwrite	MPI::Request MPI::File::Iwrite(*const void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_IWRITE	MPI_FILE_IWRITE(*INTEGER FH,CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER REQUEST,INTEGER IERROR*)
MPI_File_iwrite_at	int MPI_File_iwrite_at (*MPI_File fh,MPI_Offset offset,void *buf, int count,MPI_Datatype datatype,MPI_Request *request*);
MPI::File::Iwrite_at	MPI::Request MPI::File::Iwrite_at(*MPI::Offset offset, const void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_IWRITE_AT	MPI_FILE_IWRITE_AT(*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER REQUEST, INTEGER IERROR*)
MPI_File_iwrite_shared	int MPI_File_iwrite_shared (*MPI_File fh,void *buf, int count, MPI_Datatype datatype,MPI_Request *request*);
MPI::File::Iwrite_shared	MPI::Request MPI::File::Iwrite_shared(*const void* buf, int count, const MPI::Datatype& datatype*);

MPI_FILE_IWRITE_SHARED	MPI_FILE_IWRITE_SHARED (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER REQUEST, INTEGER IERROR*)
MPI_File_open	int MPI_File_open (*MPI_Comm comm,char *filename,int amode,MPI_info, MPI_File *fh*);
MPI::File::Open	static MPI::File MPI::File::Open(*const MPI::Intracomm& comm, const char* filename, int amode, const MPI::Info& info*);
MPI_FILE_OPEN	MPI_FILE_OPEN(*INTEGER COMM,CHARACTER FILENAME(*),INTEGER AMODE, INTEGER INFO,INTEGER FH,INTEGER IERROR*)
MPI_File_preallocate	int MPI_File_preallocate (*MPI_File fh, MPI_Offset size*);
MPI::File::Preallocate	void MPI::File::Preallocate(*MPI::Offset size*);
MPI_FILE_PREALLOCATE	MPI_FILE_PREALLOCATE(*INTEGER FH, INTEGER SIZE, INTEGER IERROR*)
MPI_File_read	int MPI_File_read (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);
MPI::File::Read	void MPI::File::Read(*void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
MPI_FILE_READ	MPI_FILE_READ(*INTEGER FH,CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_read_all	int MPI_File_read_all (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);

MPI::File::Read_all	void MPI::File::Read_all(*void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
	
	void MPI::File::Read_all(*void* buf, int count, const MPI::Datatype& datatype*);

MPI_FILE_READ_ALL	MPI_FILE_READ_ALL(*INTEGER FH,CHOICE BUF,INTEGER COUNT, INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_read_all_begin	int MPI_File_read_all_begin (*MPI_File fh, void *buf, int count, MPI_Datatype datatype*);
MPI::File::Read_all_begin	void MPI::File::Read_all_begin(*void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_READ_ALL_BEGIN	MPI_FILE_READ_ALL_BEGIN (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER IERROR*)
MPI_File_read_all_end	nt MPI_File_read_all_end(*MPI_File fh,void *buf, MPI_Status *status*);
MPI::File::Read_all_end	void MPI::File::Read_all_end(*void* buf*);

	void MPI::File::Read_all_end(*void* buf, MPI::Status& status*);
MPI_FILE_READ_ALL_END	MPI_FILE_READ_ALL_END(*INTEGER FH,CHOICE BUF, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)
MPI_File_read_at	int MPI_File_read_at (*MPI_File fh,MPI_Offset offset,void *buf, int count,MPI_Datatype datatype,MPI_Status *status*);
MPI::File::Read_at	void MPI::File::Read_at(*MPI::Offset offset, void* buf, int count, const MPI::Datatype& datatype*);
	void MPI::File::Read_at(*MPI::Offset offset, void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
MPI_FILE_READ_AT	MPI_FILE_READ_AT(*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_read_at_all	int MPI_File_read_at_all (*MPI_File fh,MPI_Offset offset,void *buf, int count,MPI_Datatype datatype,MPI_Status *status*);
MPI::File::Read_at_all	void MPI::File::Read_at_all(*MPI::Offset offset, void* buf, int count, const MPI::Datatype& datatype*);
	void MPI::File::Read_at_all(*MPI::Offset offset, void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
MPI_FILE_READ_AT_ALL	MPI_FILE_READ_AT_ALL(*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_read_at_all_begin	int MPI_File_read_at_all_begin(*MPI_File fh,MPI_Offset offset, void *buf, int count,MPI_Datatype datatype*);
MPI::File::Read_at_all_begin	void MPI::File::Read_at_all_begin(*MPI::Offset offset, void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_READ_AT_ALL_BEGIN	MPI_FILE_READ_AT_ALL_BEGIN(*INTEGER FH, INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER IERROR*)
MPI_File_read_at_all_end	int MPI_File_read_at_all_end(*MPI_File fh,void *buf, MPI_Status *status*);
MPI::File::Read_at_all_end	void MPI::File::Read_at_all_end(*void *buf*, MPI::Status& status);
	void MPI::File::Read_at_all_end(*void *buf*);

MPI_FILE_READ_AT_ALL_END

MPI_FILE_READ_AT_ALL_END(*INTEGER FH,CHOICE BUF, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)

MPI_File_read_ordered

int MPI_File_read_ordered(*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);

MPI::File::Read_ordered

void MPI::File::Read_ordered(*void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);

MPI_FILE_READ_ORDERED

MPI_FILE_READ_ORDERED(*INTEGER FH,CHOICE BUF,INTEGER COUNT, INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)

MPI_File_read_ordered_begin

int MPI_File_read_ordered_begin(*MPI_File fh, void *buf, int count, MPI_Datatype datatype*);

MPI::File::Read_ordered_begin

void MPI::File::Read_ordered_begin(*void* buf, int count, const MPI::Datatype& datatype*);

MPI_FILE_READ_ORDERED_BEGIN

MPI_FILE_READ_ORDERED_BEGIN (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER IERROR*)

MPI_File_read_ordered_end

int MPI_File_read_ordered_end(*MPI_File fh,void *buf, MPI_Status *status*);

MPI::File::Read_ordered_end

void MPI::File::Read_ordered_end(*void* buf, MPI::Status& status*);

void MPI::File::Read_ordered_end(*void* buf*);

MPI_FILE_READ_ORDERED_END

MPI_FILE_READ_ORDERED_END(*INTEGER FH,CHOICE BUF, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)

MPI_File_read_shared

int MPI_File_read_shared (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);

MPI::File::Read_shared

void MPI::File::Read_shared(*void* buf, int count, const MPI::Datatype& datatype*);

void MPI::File::Read_shared(*void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);

MPI_FILE_READ_SHARED

MPI_FILE_READ_SHARED(*INTEGER FH,CHOICE BUF,INTEGER COUNT, INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)

MPI_File_seek

int MPI_File_seek (*MPI_File fh,MPI_Offset offset, int whence*);

MPI::File::Seek	void MPI::File::Seek(*MPI::Offset offset, int whence*);
MPI_FILE_SEEK	MPI_FILE_SEEK (*INTEGER FH, INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, INTEGER WHENCE, INTEGER IERROR*)
MPI_File_seek_shared	int MPI_File_seek_shared(*MPI_File fh,MPI_Offset offset, int whence*);
MPI::File::Seek_shared	void MPI::File::Seek_shared(*MPI::Offset offset, int whence*);
MPI_FILE_SEEK_SHARED	MPI_FILE_SEEK_SHARED(*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, INTEGER WHENCE, INTEGER IERROR*)
MPI_File_set_atomicity	int MPI_File_set_atomicity (*MPI_File fh,int flag*);
MPI::File::Set_atomicity	void MPI::File::Set_atomicity(*bool flag*);
MPI_FILE_SET_ATOMICITY	MPI_FILE_SET_ATOMICITY (*INTEGER FH,LOGICAL FLAG,INTEGER IERROR*)
MPI_File_set_info	int MPI_File_set_info (*MPI_File fh,MPI_Info info*);
MPI::File::Set_info	void MPI::File::Set_info(*const MPI::Info& info*);
MPI_FILE_SET_INFO	MPI_FILE_SET_INFO(*INTEGER FH,INTEGER INFO,INTEGER IERROR*)
MPI_File_set_size	int MPI_File_set_size (*MPI_File fh,MPI_Offset size*);
MPI::File::Set_size	void MPI::File::Set_size(*MPI::Offset size*);
MPI_FILE_SET_SIZE	MPI_FILE_SET_SIZE (*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) SIZE, INTEGER IERROR*)
MPI_File_set_view	int MPI_File_set_view (*MPI_File fh,MPI_Offset disp, MPI_Datatype etype,MPI_Datatype filetype, char *datarep,MPI_Info info*);
MPI::File::Set_view	void MPI::File::Set_view(*MPI::Offset disp, const MPI::Datatype& etype, const MPI::Datatype& filetype, const char* datarep, const MPI::Info& info*);
MPI_FILE_SET_VIEW	MPI_FILE_SET_VIEW (*INTEGER FH,INTEGER(KIND=MPI_OFFSET_KIND) DISP, INTEGER ETYPE,INTEGER FILETYPE,CHARACTER DATAREP(*),INTEGER INFO, INTEGER IERROR*)
MPI_File_sync	int MPI_File_sync (*MPI_File fh*);
MPI::File::Sync	void MPI::File::Sync();
MPI_FILE_SYNC	MPI_FILE_SYNC (*INTEGER FH,INTEGER IERROR*)
MPI_File_write	int MPI_File_write (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);
MPI::File::Write	void MPI::File::Write(*const void* buf, int count, const MPI::Datatype& datatype*);

	void MPI::File::Write(*const void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
MPI_FILE_WRITE	MPI_FILE_WRITE(*INTEGER FH,CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_write_all	int MPI_File_write_all (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);
MPI::File::Write_all	void MPI::File::Write_all(*const void* buf, int count, const MPI::Datatype& datatype*);
	void MPI::File::Write_all(*const void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
MPI_FILE_WRITE_ALL	MPI_FILE_WRITE_ALL(*INTEGER FH,CHOICE BUF,INTEGER COUNT, INTEGER DATATYPE,INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_write_all_begin	int MPI_File_write_all_begin (*MPI_File fh, void *buf, int count, MPI_Datatype datatype*);
MPI::File::Write_all_begin	void MPI::File::Write_all_begin(*const void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_WRITE_ALL_BEGIN	MPI_FILE_WRITE_ALL_BEGIN (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER IERROR*)
MPI_File_write_all_end	int MPI_File_write_all_end(*MPI_File fh,void *buf, MPI_Status *status*);
MPI::File::Write_all_end	void MPI::File::Write_all_end(*void* buf*);
	void MPI::File::Write_all_end(*void* buf, MPI::Status& status*);
MPI_FILE_WRITE_ALL_END	MPI_FILE_WRITE_ALL_END(*INTEGER FH,CHOICE BUF, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)
MPI_File_write_at	int MPI_File_write_at (*MPI_File fh,MPI_Offset offset,void *buf, int count,MPI_Datatype datatype,MPI_Status *status*);
MPI::File::Write_at	void MPI::File::Write_at(*MPI::Offset offset, const void* buf, int count, const MPI::Datatype& datatype*);
	void MPI::File::Write_at(*MPI::Offset offset, const void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);
MPI_FILE_WRITE_AT	MPI_FILE_WRITE_AT(*INTEGER FH,INTEGER(KIND_MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)

MPI_File_write_at_all	int MPI_File_write_at_all (*MPI_File fh,MPI_Offset offset,void *buf, int count,MPI_Datatype datatype,MPI_Status *status*);

MPI::File::Write_at_all	void MPI::File::Write_at_all(*MPI::Offset offset, const void* buf, int count, const MPI::Datatype& datatype*);
	
	void MPI::File::Write_at_all(*MPI::Offset offset, const void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);

MPI_FILE_WRITE_AT_ALL	MPI_FILE_WRITE_AT_ALL (*INTEGER FH, INTEGER (KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_File_write_at_all_begin	int MPI_File_write_at_all_begin(*MPI_File fh,MPI_Offset offset, void *buf, int count,MPI_Datatype datatype*);
MPI::File::Write_at_all_begin	void MPI::File::Write_at_all_begin(*MPI::Offset offset, const void* buf, int count, const MPI::Datatype& datatype*);
MPI_FILE_WRITE_AT_ALL_BEGIN	MPI_FILE_WRITE_AT_ALL_BEGIN(*INTEGER FH, INTEGER(KIND=MPI_OFFSET_KIND) OFFSET, CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE, INTEGER IERROR*)
MPI_File_write_at_all_end	int MPI_File_write_at_all_end(*MPI_File fh,void *buf, MPI_Status *status*);

MPI::File::Write_at_all_end	void MPI::File::Write_at_all_end(*const void* buf*);
	
	void MPI::File::Write_at_all_end(*const void* buf, MPI::Status& status*);

MPI_FILE_WRITE_AT_ALL_END	MPI_FILE_WRITE_AT_ALL_END(*INTEGER FH,CHOICE BUF, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)
MPI_File_write_ordered	int MPI_File_write_ordered(*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);

MPI::File::Write_ordered	void MPI::File::Write_ordered(*const void* buf, int count, const MPI::Datatype& datatype*);
	
	void MPI::File::Write_ordered(*const void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);

MPI_FILE_WRITE_ORDERED	MPI_FILE_WRITE_ORDERED(*INTEGER FH,CHOICE BUF,INTEGER COUNT, INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)

MPI_File_write_ordered_begin

int MPI_File_write_ordered_begin(*MPI_File fh, void *buf, int count, MPI_Datatype datatype*);

MPI::File::Write_ordered_begin

void MPI::File::Write_ordered_begin(*const void* buf, int count, const MPI::Datatype& datatype*);

MPI_FILE_WRITE_ORDERED_BEGIN

MPI_FILE_WRITE_ORDERED_BEGIN (*INTEGER FH, CHOICE BUF, INTEGER COUNT, INTEGER DATATYPE, INTEGER IERROR*)

MPI_File_write_ordered_end

int MPI_File_write_ordered_end(*MPI_File fh,void *buf, MPI_Status *status*);

MPI::File::Write_ordered_end

void MPI::File::Write_ordered_end(*const void* buf*);

void MPI::File::Write_ordered_end(*const void* buf, MPI::Status& status*);

MPI_FILE_WRITE_ORDERED_END

MPI_FILE_WRITE_ORDERED_END(*INTEGER FH,CHOICE BUF, INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)

MPI_File_write_shared

int MPI_File_write_shared (*MPI_File fh, void *buf, int count, MPI_Datatype datatype,MPI_Status *status*);

MPI::File::Write_shared

void MPI::File::Write_shared(*const void* buf, int count, const MPI::Datatype& datatype*);

void MPI::File::Write_shared(*const void* buf, int count, const MPI::Datatype& datatype, MPI::Status& status*);

MPI_FILE_WRITE_SHARED

MPI_FILE_WRITE_SHARED(*INTEGER FH,CHOICE BUF,INTEGER COUNT, INTEGER DATATYPE, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)

MPI_Register_datarep

int MPI_Register_datarep(*char *datarep, MPI_Datarep_conversion_function *read_conversion_fn, MPI_Datarep_conversion_function *write_conversion_fn, MPI_Datarep_extent_function *dtype_file_extent_fn, void *extra_state*);

MPI::Register_datarep

void MPI::Register_datarep(*const char* datarep, MPI::Datarep_conversion_function* read_conversion_fn, MPI::Datarep_conversion_function* write_conversion_fn, MPI::Datarep_extent_function* dtype_file_extent_fn, void* extra_state*);

MPI_REGISTER_DATAREP

MPI_REGISTER_DATAREP(*CHARACTER*(*) DATAREP, EXTERNAL READ_CONVERSION_FN, EXTERNAL WRITE_CONVERSION_FN, EXTERNAL DTYPE_FILE_EXTENT_FN,*

INTEGER(KIND=MPI_ADDRESS_KIND), INTEGER EXTRA_STATE, INTEGER IERROR)

Bindings for MPI_Status objects

This is a list of the bindings for MPI_Status object subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	Binding: C C++ FORTRAN
MPI_Request_get_status	int MPI_Request_get_status(*MPI_Request request, int *flag, MPI_Status *status*);
MPI::Request::Get_status	bool MPI::Request::Get_status() *const*; bool MPI::Request::Get_status(*MPI::Status&status*) *const*;
MPI_REQUEST_GET_STATUS	MPI_REQUEST_GET_STATUS(*INTEGER REQUEST, LOGICAL FLAG, INTEGER STATUS, INTEGER IERROR*)

Bindings for one-sided communication

This is a list of the bindings for one-sided communication subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	Binding: C C++ FORTRAN
MPI_Accumulate	int MPI_Accumulate (*void *origin_addr, int origin_count, MPI_Datatype origin_datatype, int target_rank, MPI_Aint target_disp, int target_count, MPI_Datatype target_datatype, MPI_Op op, MPI_Win win*);
MPI::Win::Accumulate	void MPI::Win::Accumulate(*const void* origin_addr, int origin_count, const MPI::Datatype& origin_datatype, int target_rank, MPI::Aint target_disp, int target_count, const MPI::Datatype& target_datatype, const MPI::Op& op*) *const*;
MPI_ACCUMULATE	MPI_ACCUMULATE (*CHOICE ORIGIN_ADDR, INTEGER ORIGIN_COUNT, INTEGER ORIGIN_DATATYPE, INTEGER TARGET_RANK, INTEGER TARGET_DISP, INTEGER TARGET_COUNT, INTEGER TARGET_DATATYPE, INTEGER OP, INTEGER WIN, INTEGER IERROR*)
MPI_Get	int MPI_Get (*void *origin_addr, int origin_count, MPI_Datatype origin_datatype, int target_rank, MPI_Aint target_disp, int target_count, MPI_Datatype target_datatype, MPI_Win win*);
MPI::Win::Get	void MPI::Win::Get(*void* origin_addr, int origin_count, const MPI::Datatype& origin_datatype,*

	int target_rank, MPI::Aint target_disp, int target_count, const MPI::Datatype& target_datatype) *const*;
MPI_GET	MPI_GET(*CHOICE ORIGIN_ADDR, INTEGER ORIGIN_COUNT, INTEGER ORIGIN_DATATYPE, INTEGER TARGET_RANK, INTEGER TARGET_DISP, INTEGER TARGET_COUNT, INTEGER TARGET_DATATYPE, INTEGER WIN, INTEGER IERROR*)
MPI_Put	int MPI_Put (*void *origin_addr, int origin_count, MPI_Datatype origin_datatype, int target_rank, MPI_Aint target_disp, int target_count, MPI_Datatype target_datatype, MPI_Win win*);
MPI::Win::Put	void MPI::Win::Put(*const void* origin_addr, int origin_count, const MPI::Datatype& origin_datatype, int target_rank, MPI::Aint target_disp, int target_count, const MPI::Datatype& target_datatype*) *const*;
MPI_PUT	MPI_PUT(*CHOICE ORIGIN_ADDR, INTEGER ORIGIN_COUNT, INTEGER ORIGIN_DATATYPE, INTEGER TARGET_RANK, INTEGER TARGET_DISP, INTEGER TARGET_COUNT, INTEGER TARGET_DATATYPE, INTEGER WIN, INTEGER IERROR*)
MPI_Win_complete	int MPI_Win_complete (*MPI_Win win*);
MPI::Win::Complete	void MPI::Win::Complete() *const*;
MPI_WIN_COMPLETE	MPI_WIN_COMPLETE(*INTEGER WIN, INTEGER IERROR*)
MPI_Win_create	int MPI_Win_create (*void *base, MPI_Aint size, int disp_unit, MPI_Info info, MPI_Comm comm, MPI_Win *win*); MPI_WIN_CREATE(*CHOICE BASE, INTEGER SIZE, INTEGER DISP_UNIT, INTEGER INFO, INTEGER COMM, INTEGER WIN, INTEGER IERROR*)
MPI::Win::Create	static MPI::Win MPI::Win::Create(*const void* base, MPI::Aint size, int disp_unit, const MPI::Info& info, const MPI::Intracomm& comm*);
MPI_WIN_CREATE	MPI_WIN_CREATE(*CHOICE BASE, INTEGER SIZE, INTEGER DISP_UNIT, INTEGER INFO, INTEGER COMM, INTEGER WIN, INTEGER IERROR*)
MPI_Win_create_errhandler	int MPI_Win_create_errhandler (*MPI_Win_errhandler_fn *function, MPI_Errhandler *errhandler*);
MPI::Win::Create_errhandler	MPI::Errhandler MPI::Win::Create_errhandler (*MPI::Win::Errhandler_fn* function*);

MPI_WIN_CREATE_ERRHANDLER	MPI_WIN_CREATE_ERRHANDLER(*EXTERNAL FUNCTION, INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_Win_create_keyval	int MPI_Win_create_keyval (*MPI_Win_copy_attr_function *win_copy_attr_fn, MPI_Win_delete_attr_function *win_delete_attr_fn, int *win_keyval, void *extra_state*);
MPI::Win::Create_keyval	static int MPI::Win::Create_keyval (*MPI::Win::Copy_attr_function* win_copy_attr_fn, MPI::Win::Delete_attr_function* win_delete_attr_fn, void* extra_state*);
MPI_WIN_CREATE_KEYVAL	MPI_WIN_CREATE_KEYVAL(*EXTERNAL WIN_COPY_ATTR_FN, EXTERNAL WIN_DELETE_ATTR_FN, INTEGER WIN_KEYVAL, INTEGER EXTRA_STATE, INTEGER IERROR*)
MPI_Win_delete_attr	int MPI_Win_delete_attr (*MPI_Win win, int win_keyval*);
MPI::Win::Delete_attr	void MPI::Win::Delete_attr(*int win_keyval*);
MPI_WIN_DELETE_ATTR	MPI_WIN_DELETE_ATTR(*INTEGER WIN, INTEGER WIN_KEYVAL, INTEGER IERROR*)
MPI_Win_fence	int MPI_Win_fence (*int assert, MPI_Win win*);
MPI::Win::Fence	void MPI::Win::Fence(*int assert*) *const*;
MPI_WIN_FENCE	MPI_WIN_FENCE(*INTEGER ASSERT, INTEGER WIN, INTEGER IERROR*)
MPI_Win_free	int MPI_Win_free (*MPI_Win *win*);
MPI::Win::Free	void MPI::Win::Free();
MPI_WIN_FREE	MPI_WIN_FREE(*INTEGER WIN, INTEGER IERROR*)
MPI_Win_free_keyval	int MPI_Win_free_keyval (*int *win_keyval*);
MPI::Win::Free_keyval	void MPI::Win::Free_keyval(*int& win_keyval*);
MPI_WIN_FREE_KEYVAL	MPI_WIN_FREE_KEYVAL(*INTEGER WIN_KEYVAL, INTEGER IERROR*)
MPI_Win_get_attr	int MPI_Win_get_attr (*MPI_Win win, int win_keyval, void *attribute_val, int *flag*);
MPI::Win::Get_attr	bool MPI::Win::Get_attr(*int win_keyval, void* attribute_val*) *const*;
MPI_WIN_GET_ATTR	MPI_WIN_GET_ATTR(*INTEGER WIN, INTEGER WIN_KEYVAL, INTEGER ATTRIBUTE_VAL, LOGICAL FLAG, INTEGER IERROR*)
MPI_Win_get_errhandler	int MPI_Win_get_errhandler (*MPI_Win win, MPI_Errhandler *errhandler*);
MPI::Win::Get_errhandler	MPI::Errhandler MPI::Win::Get_errhandler() *const*;

MPI_WIN_GET_ERRHANDLER	MPI_WIN_GET_ERRHANDLER(*INTEGER WIN, INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_Win_get_group	int MPI_Win_get_group (*MPI_Win *win, MPI_Group *group*);
MPI::Win::Get_group	MPI::Group MPI::Win::Get_group() *const*;
MPI_WIN_GET_GROUP	MPI_WIN_GET_GROUP(*INTEGER WIN, INTEGER GROUP, INTEGER IERROR*)
MPI_Win_lock	int MPI_Win_lock (*int lock_type, int rank, int assert, MPI_Win win*);
MPI::Win::Lock	void MPI::Win::Lock(*int lock_type, int rank, int assert*) *const*;
MPI_WIN_LOCK	MPI_WIN_LOCK(*INTEGER LOCK_TYPE, INTEGER RANK, INTEGER ASSERT, INTEGER WIN, INTEGER IERROR*)
MPI_Win_post	int MPI_Win_post (*MPI_Group group, int assert, MPI_Win win*);
MPI::Win::Post	void MPI::Win::Post(*const MPI::Group& group, int assert*) *const*;
MPI_WIN_POST	MPI_WIN_POST(*INTEGER GROUP, INTEGER ASSERT, INTEGER WIN, INTEGER IERROR*
MPI_Win_set_attr	int MPI_Win_set_attr (*MPI_Win win, int win_keyval, void *attribute_val*);
MPI::Win::Set_attr	void MPI::Win::Set_attr(*int win_keyval, const void* attribute_val*);
MPI_WIN_SET_ATTR	MPI_WIN_SET_ATTR(*INTEGER WIN, INTEGER WIN_KEYVAL, INTEGER ATTRIBUTE_VAL, INTEGER IERROR*)
MPI_Win_set_errhandler	int MPI_Win_set_errhandler (*MPI_Win win, MPI_Errhandler errhandler*);
MPI::Win::Set_errhandler	void MPI::Win::Set_errhandler(*const MPI::Errhandler& errhandler*);
MPI_WIN_SET_ERRHANDLER	MPI_WIN_SET_ERRHANDLER(*INTEGER WIN, INTEGER ERRHANDLER, INTEGER IERROR*)
MPI_Win_start	int MPI_Win_start (*MPI_Group group, int assert, MPI_Win win*);
MPI::Win::Start	void MPI::Win::Start(*const MPI::Group& group, int assert*) *const*;
MPI_WIN_START	MPI_WIN_START(*INTEGER GROUP, INTEGER ASSERT, INTEGER WIN, INTEGER IERROR*)
MPI_Win_test	int MPI_Win_test (*MPI_Win win, int *flag*);
MPI::Win::Test()	bool MPI::Win::Test() *const*;
MPI_WIN_TEST	MPI_WIN_TEST(*INTEGER WIN, LOGICAL FLAG, INTEGER IERROR*)

MPI_Win_unlock	int MPI_Win_unlock (*int rank, MPI_Win win*);
MPI::Win::Unlock	void MPI::Win::Unlock(*int rank*) *const*;
MPI_WIN_UNLOCK	MPI_WIN_UNLOCK(*INTEGER RANK, INTEGER WIN, INTEGER IERROR*)
MPI_Win_wait	int MPI_Win_wait (*MPI_Win win*);
MPI::Win::Wait	void MPI::Win::Wait() *const*;
MPI_WIN_WAIT	MPI_WIN_WAIT(*INTEGER WIN, INTEGER IERROR*)

Bindings for point-to-point communication

This is a list of the bindings for point-to-point communication subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Bsend	int MPI_Bsend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm*);
MPI::Comm::Bsend	void MPI::Comm::Bsend(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_BSEND	MPI_BSEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST, INTEGER TAG,INTEGER COMM,INTEGER IERROR*)
MPI_Bsend_init	int MPI_Bsend_init(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Bsend_init	MPI::Prequest MPI::Comm::Bsend_init(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_BSEND_INIT	MPI_SEND_INIT(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Buffer_attach	int MPI_Buffer_attach(*void* buffer,int size*);
MPI::Attach_buffer	void MPI::Attach_buffer(*void* buffer, int size*);
MPI_BUFFER_ATTACH	MPI_BUFFER_ATTACH(*CHOICE BUFFER,INTEGER SIZE,INTEGER IERROR*)
MPI_Buffer_detach	int MPI_Buffer_detach(*void* buffer,int* size*);
MPI::Detach_buffer	int MPI::Detach_buffer(*void*& buffer*);
MPI_BUFFER_DETACH	MPI_BUFFER_DETACH(*CHOICE BUFFER,INTEGER SIZE,INTEGER IERROR*)
MPI_Cancel	int MPI_Cancel(*MPI_Request *request*);
MPI::Request::Cancel	void MPI::Request::Cancel(*void*) *const*;

MPI_CANCEL	MPI_CANCEL(*INTEGER REQUEST,INTEGER IERROR*)
MPI_Get_count	int MPI_Get_count(*MPI_Status *status, MPI_Datatype datatype, int *count*);
MPI::Status::Get_count	int MPI::Status::Get_count(*const MPI::Datatype& datatype*) *const*;
MPI_GET_COUNT	MPI_GET_COUNT(*INTEGER STATUS(MPI_STATUS_SIZE),,INTEGER DATATYPE,INTEGER COUNT, INTEGER IERROR*)
MPI_Ibsend	int MPI_Ibsend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Ibsend	MPI::Request MPI::Comm::Ibsend(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_IBSEND	MPI_IBSEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Iprobe	int MPI_Iprobe(*int source,int tag,MPI_Comm comm,int *flag,MPI_Status *status*);
MPI::Comm::Iprobe	bool MPI::Comm::Iprobe(*int source, int tag*) *const*;
MPI_IPROBE	MPI_IPROBE(*INTEGER SOURCE,INTEGER TAG,INTEGER COMM,INTEGER FLAG,INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*
MPI_Irecv	int MPI_Irecv(*void* buf,int count,MPI_Datatype datatype,int source,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Irecv	MPI::Request MPI::Comm::Irecv(*void *buf, int count, const MPI::Datatype& datatype, int source, int tag*) *const*;
MPI_IRECV	MPI_IRECV(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER SOURCE,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Irsend	int MPI_Irsend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Irsend	MPI::Request MPI::Comm::Irsend(*const void *buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_IRSEND	MPI_IRSEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Isend	int MPI_Isend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);

MPI::Comm::Isend	MPI::Request MPI::Comm::Isend(*const void *buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_ISEND	MPI_ISEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Issend	int MPI_Issend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Issend	MPI::Request MPI::Comm::Issend(*const void *buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_ISSEND	MPI_ISSEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Probe	int MPI_Probe(*int source,int tag,MPI_Comm comm,MPI_Status *status*);
MPI::Comm::Probe	void MPI::Comm::Probe(*int source, int tag*) *const*;
	void MPI::Comm::Probe(*int source, int tag, MPI::Status& status*) *const*;
MPI_PROBE	MPI_PROBE(*INTEGER SOURCE,INTEGER TAG,INTEGER COMM,INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)
MPI_Recv	int MPI_Recv(*void* buf,int count,MPI_Datatype datatype,int source,int tag, MPI_Comm comm, MPI_Status *status*);
MPI::Comm::Recv	void MPI::Comm::Recv(*void* buf, int count, const MPI::Datatype& datatype, int source, int tag*) *const*;
	void MPI::Comm::Recv(*void* buf, int count, const MPI::Datatype& datatype, int source, int tag, MPI::Status& status*) *const*;
MPI_RECV	MPI_RECV(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER SOURCE, INTEGER TAG,INTEGER COMM,INTEGER STATUS(MPI_STATUS_SIZE),,INTEGER IERROR*)
MPI_Recv_init	int MPI_Recv_init(*void* buf,int count,MPI_Datatype datatype,int source,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Recv_init	MPI::Prequest MPI::Comm::Recv_init(*void* buf, int count, const MPI::Datatype& datatype, int source, int tag*) *const*;
MPI_RECV_INIT	MPI_RECV_INIT(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER SOURCE,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Request_free	int MPI_Request_free(*MPI_Request *request*);

MPI::Request::Free	void MPI::Request::Free();
MPI_REQUEST_FREE	MPI_REQUEST_FREE(*INTEGER REQUEST,INTEGER IERROR*)
MPI_Rsend	int MPI_Rsend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm*);
MPI::Comm::Rsend	void MPI::Comm::Rsend(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_RSEND	MPI_RSEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER IERROR*)
MPI_Rsend_init	int MPI_Rsend_init(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Rsend_init	MPI::Prequest MPI::Comm::Rsend_init(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_RSEND_INIT	MPI_RSEND_INIT(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Send	int MPI_Send(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm*);
MPI::Comm::Send	void MPI::Comm::Send(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_SEND	MPI_SEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM, INTEGER IERROR*)
MPI_Send_init	int MPI_Send_init(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Send_init	MPI::Prequest MPI::Comm::Send_init(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_SEND_INIT	MPI_SEND_INIT(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,INTEGER IERROR*)
MPI_Sendrecv	int MPI_Sendrecv(*void *sendbuf,int sendcount,MPI_Datatype sendtype,int dest,int sendtag,void *recvbuf,int recvcount, MPI_Datatype recvtype,int source,int recvtag,MPI_Comm comm,MPI_Status *status*);
MPI::Comm::Sendrecv	void MPI::Comm::Sendrecv(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, int*

	dest, int sendtag, void recvbuf, int recvcount, const MPI::Datatype& recvtype, int source, int recvtag*) *const*;
	void MPI::Comm::Sendrecv(*const void* sendbuf, int sendcount, const MPI::Datatype& sendtype, int dest, int sendtag, void* recvbuf, int recvcount, const MPI::Datatype& recvtype, int source, int recvtag, MPI::Status& status*) *const*;
MPI_SENDRECV	MPI_SENDRECV(*CHOICE SENDBUF,INTEGER SENDCOUNT,INTEGER SENDTYPE,INTEGER DEST,INTEGER SENDTAG,CHOICE RECVBUF,INTEGER RECVCOUNT,INTEGER RECVTYPE,INTEGER SOURCE,INTEGER RECVTAG,INTEGER COMM,INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_Sendrecv_replace	int MPI_Sendrecv_replace(*void* buf,int count,MPI_Datatype datatype,int dest,int sendtag,int source,int recvtag,MPI_Comm comm,MPI_Status *status*);
MPI::Comm::Sendrecv_replace	
	void MPI::Comm::Sendrecv_replace(*void* buf, int count, const MPI::Datatype& datatype, int dest, int sendtag, int source, int recvtag*) *const*;
	void MPI::Comm::Sendrecv_replace(*void *buf, int count, const MPI::Datatype& datatype, int dest, int sendtag, int source, int recvtag, MPI::Status& status*) *const*;
MPI_SENDRECV_REPLACE	MPI_SENDRECV_REPLACE(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER SENDTAG,INTEGER SOURCE,INTEGER RECVTAG,INTEGER COMM,INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_Ssend	int MPI_Ssend(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm*);
MPI::Comm::Ssend	void MPI::Comm::Ssend(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_SSEND	MPI_SSEND(*CHOICE BUF,INTEGER COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER IERROR*
MPI_Ssend_init	int MPI_Ssend_init(*void* buf,int count,MPI_Datatype datatype,int dest,int tag,MPI_Comm comm,MPI_Request *request*);
MPI::Comm::Ssend_init	MPI::Prequest MPI::Comm::Ssend_init(*const void* buf, int count, const MPI::Datatype& datatype, int dest, int tag*) *const*;
MPI_SSEND_INIT	MPI_SSEND_INIT(*CHOICE BUF,INTEGER*

	COUNT,INTEGER DATATYPE,INTEGER DEST,INTEGER TAG,INTEGER COMM,INTEGER REQUEST,IERROR
MPI_Start	int MPI_Start(*MPI_Request *request*);
MPI::Prequest::Start	void MPI::Prequest::Start();
MPI_START	MPI_START(*INTEGER REQUEST,INTEGER IERROR*)
MPI_Startall	int MPI_Startall(*int count,MPI_Request *array_of_requests*);
MPI::Prequest::Startall	void MPI::Prequest::Startall(*int count, MPI::Prequest array_of_requests[]*);
MPI_STARTALL	MPI_STARTALL(*INTEGER COUNT,INTEGER ARRAY_OF_REQUESTS(*),INTEGER IERROR*)
MPI_Test	int MPI_Test(*MPI_Request *request,int *flag,MPI_Status *status*);
MPI::Request::Test	bool MPI::Request::Test();
MPI_TEST	MPI_TEST(*INTEGER REQUEST,INTEGER FLAG,INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR*)
MPI_Test_cancelled	int MPI_Test_cancelled(*MPI_Status *status,int *flag*);
MPI::Status::Is_cancelled	bool MPI::Status::Is_cancelled() *const*;
MPI_TEST_CANCELLED	MPI_TEST_CANCELLED(*INTEGER STATUS(MPI_STATUS_SIZE),INTEGER FLAG,INTEGER IERROR*)
MPI_Testall	int MPI_Testall(*int count,MPI_Request *array_of_requests,int *flag,MPI_Status *array_of_statuses*);
MPI::Request::Testall	bool MPI::Request::Testall(*int count, MPI::Request req_array[]*);
	bool MPI::Request::Testall(*int count, MPI::Request req_array[], MPI::Status stat_array[]*);
MPI_TESTALL	MPI_TESTALL(*INTEGER COUNT,INTEGER ARRAY_OF_REQUESTS(*),INTEGER FLAG, INTEGER ARRAY_OF_STATUSES(MPI_STATUS_SIZE,*), INTEGER IERROR*)
MPI_Testany	int MPI_Testany(*int count, MPI_Request *array_of_requests, int *index, int *flag,MPI_Status *status*);
MPI::Request::Testany	bool MPI::Request::Testany(*int count, MPI::Request array[], int& index*);
	bool MPI::Request::Testany(*int count, MPI::Request array[], int& index, MPI::Status& status*);
MPI_TESTANY	MPI_TESTANY(*INTEGER COUNT,INTEGER ARRAY_OF_REQUESTS(*),INTEGER*

	INDEX,INTEGER FLAG,INTEGER STATUS(MPI_STATUS_SIZE), INTEGER IERROR)
MPI_Testsome	int MPI_Testsome(*int incount,MPI_Request *array_of_requests,int *outcount,int *array_of_indices,MPI_Status *array_of_statuses*);
MPI::Request::Testsome	int MPI::Request::Testsome(*int incount, MPI::Request req_array[], int array_of_indices[]*);
	int MPI::Request::Testsome(*int incount, MPI::Request req_array[], int array_of_indices[], MPI::Status stat_array[]*);
MPI_TESTSOME	MPI_TESTSOME(*INTEGER INCOUNT,INTEGER ARRAY_OF_REQUESTS(*),INTEGER OUTCOUNT,INTEGER ARRAY_OF_INDICES(*),INTEGER ARRAY_OF_STATUSES(MPI_STATUS_SIZE),*), INTEGER IERROR*)
MPI_Wait	int MPI_Wait(*MPI_Request *request,MPI_Status *status*);
MPI::Request::Wait	void MPI::Request::Wait();
	void MPI::Request::Wait(*MPI::Status& status*);
MPI_WAIT	MPI_WAIT(*INTEGER REQUEST,INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_Waitall	int MPI_Waitall(*int count,MPI_Request *array_of_requests,MPI_Status *array_of_statuses*);
MPI::Request::Waitall	void MPI::Request::Waitall(*int count, MPI::Request req_array[]*);
	void MPI::Request::Waitall(*int count, MPI::Request req_array[], MPI::Status stat_array[]*);
MPI_WAITALL	MPI_WAITALL(*INTEGER COUNT,INTEGER ARRAY_OF_ REQUESTS(*),INTEGER ARRAY_OF_STATUSES(MPI_STATUS_SIZE,*), INTEGER IERROR*)
MPI_Waitany	int MPI_Waitany(*int count,MPI_Request *array_of_requests,int *index,MPI_Status *status*);
MPI::Request::Waitany	int MPI::Request::Waitany(*int count, MPI::Request array[]*);
	int MPI::Request::Waitany(*int count, MPI::Request array[], MPI::Status& status*);
MPI_WAITANY	MPI_WAITANY(*INTEGER COUNT,INTEGER ARRAY_OF_REQUESTS(*),INTEGER INDEX, INTEGER STATUS(MPI_STATUS_SIZE),INTEGER IERROR*)
MPI_Waitsome	int MPI_Waitsome(*int incount,MPI_Request *array_of_requests,int *outcount,int *array_of_indices,MPI_Status *array_of_statuses*);
MPI::Request::Waitsome	int MPI::Request::Waitsome(*int incount, MPI::Request req_array[], int array_of_indices[]*);

	int MPI::Request::Waitsome(*int incount, MPI::Request req_array[], int array_of_indices[], MPI::Status stat_array[]*);
MPI_WAITSOME	MPI_WAITSOME(*INTEGER INCOUNT,INTEGER ARRAY_OF_REQUESTS,INTEGER OUTCOUNT,INTEGER ARRAY_OF_INDICES(*),INTEGER ARRAY_OF_STATUSES(MPI_STATUS_SIZE),*), INTEGER IERROR*)

Binding for profiling control

This is a list of the binding for profiling control subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Pcontrol	int MPI_Pcontrol(*const int level,...*);
MPI::Pcontrol	void MPI::Pcontrol(*const int level, ...*);
MPI_PCONTROL	MPI_PCONTROL(*INTEGER LEVEL,...*)

Bindings for topologies

This is a list of the bindings for topology subroutines. For each subroutine, the C version is listed first, followed by the C++ version, then the FORTRAN version. If a subroutine does not have a version in one particular language, (none) has been inserted.

Name: C C++ FORTRAN	**Binding: C C++ FORTRAN**
MPI_Cart_coords	int MPI_Cart_coords(*MPI_Comm comm,int rank,int maxdims,int *coords*);
MPI::Cartcomm::Get_coords	void MPI::Cartcomm::Get_coords(*int rank, int maxdims, int coords[]*) *const*;
MPI_CART_COORDS	MPI_CART_COORDS(*INTEGER COMM,INTEGER RANK,INTEGER MAXDIMS,INTEGER COORDS(*),INTEGER IERROR*)
MPI_Cart_create	int MPI_Cart_create(*MPI_Comm comm_old,int ndims,int *dims,int *periods,int reorder,MPI_Comm *comm_cart*);
MPI::Intracomm::Create_cart	MPI::Cartcomm MPI::Intracomm::Create_cart(*int ndims, const int dims[], const bool periods[], bool reorder*) *const*;
MPI_CART_CREATE	MPI_CART_CREATE(*INTEGER COMM_OLD,INTEGER NDIMS,INTEGER DIMS(*), INTEGER PERIODS(*),INTEGER REORDER,INTEGER COMM_CART,INTEGER IERROR*)
MPI_Cart_get	int MPI_Cart_get(*MPI_Comm comm,int maxdims,int *dims,int *periods,int *coords*);

MPI::Cartcomm::Get_topo	void MPI::Cartcomm::Get_topo(*int maxdims, int dims[], bool periods[], int coords[]*) *const*;
MPI_CART_GET	MPI_CART_GET(*INTEGER COMM,INTEGER MAXDIMS,INTEGER DIMS(*),INTEGER PERIODS(*),INTEGER COORDS(*),INTEGER IERROR*)
MPI_Cart_map	int MPI_Cart_map(*MPI_Comm comm,int ndims,int *dims,int *periods,int *newrank*);
MPI::Cartcomm::Map	int MPI::Cartcomm::Map(*int ndims, const int dims[], const bool periods[]*) *const*;
MPI_CART_MAP	MPI_CART_MAP(*INTEGER COMM,INTEGER NDIMS,INTEGER DIMS(*),INTEGER PERIODS(*),INTEGER NEWRANK,INTEGER IERROR*)
MPI_Cart_rank	int MPI_Cart_rank(*MPI_Comm comm,int *coords,int *rank*);
MPI::Cartcomm::Get_cart_rank	int MPI::Cartcomm::Get_cart_rank(*const int coords[]*) *const*;
MPI_CART_RANK	MPI_CART_RANK(*INTEGER COMM,INTEGER COORDS(*),INTEGER RANK,INTEGER IERROR*)
MPI_Cart_shift	int MPI_Cart_shift(*MPI_Comm comm,int direction,int disp,int *rank_source,int *rank_dest*);
MPI::Cartcomm::Shift	void MPI::Cartcomm::Shift(*int direction, int disp, int &rank_source, int &rank_dest*) *const*;
MPI_CART_SHIFT	MPI_CART_SHIFT(*INTEGER COMM,INTEGER DIRECTION,INTEGER DISP, INTEGER RANK_SOURCE,INTEGER RANK_DEST,INTEGER IERROR*)
MPI_Cart_sub	int MPI_Cart_sub(*MPI_Comm comm,int *remain_dims,MPI_Comm *newcomm*);
MPI::Cartcomm::Sub	MPI::Cartcomm MPI::Cartcomm::Sub(*const bool remain_dims[]*) *const*;
MPI_CART_SUB	MPI_CART_SUB(*INTEGER COMM,INTEGER REMAIN_DIMS,INTEGER NEWCOMM, INTEGER IERROR*)
MPI_Cartdim_get	int MPI_Cartdim_get(*MPI_Comm comm, int *ndims*);
MPI::Cartcomm::Get_dim	int MPI::Cartcomm::Get_dim() *const*;
MPI_CARTDIM_GET	MPI_CARTDIM_GET(*INTEGER COMM,INTEGER NDIMS,INTEGER IERROR*)
MPI_Dims_create	int MPI_Dims_create(*int nnodes,int ndims,int *dims*);
MPI::Compute_dims	void MPI::Compute_dims(*int nnodes, int ndims, int dims[]*);

MPI_DIMS_CREATE MPI_DIMS_CREATE(*INTEGER NNODES,INTEGER NDIMS,INTEGER DIMS(*), INTEGER IERROR*)

MPI_Graph_create int MPI_Graph_create(*MPI_Comm comm_old,int nnodes,int *index,int *edges,int reorder,MPI_Comm *comm_graph*);

MPI::Intracomm::Create_graph
MPI::Graphcomm MPI::Intracomm::Create_graph(*int nnodes, const int index[], const int edges[], bool reorder*) *const*;

MPI_GRAPH_CREATE MPI_GRAPH_CREATE(*INTEGER COMM_OLD,INTEGER NNODES,INTEGER INDEX(*), INTEGER EDGES(*),INTEGER REORDER,INTEGER COMM_GRAPH,INTEGER IERROR*)

MPI_Graph_get int MPI_Graph_get(*MPI_Comm comm,int maxindex,int maxedges,int *index, int *edges*);

MPI::Graphcomm::Get_topo void MPI::Graphcomm::Get_topo(*int maxindex, int maxedges, int index[], int edges[]*) *const*;

MPI_GRAPH_GET MPI_GRAPH_GET(*INTEGER COMM,INTEGER MAXINDEX,INTEGER MAXEDGES,INTEGER INDEX(*),INTEGER EDGES(*),INTEGER IERROR*)

MPI_Graph_map int MPI_Graph_map(*MPI_Comm comm,int nnodes,int *index,int *edges,int *newrank*);

MPI::Graphcomm::Map int MPI::Graphcomm::Map(*int nnodes, const int index[], const int edges[]*) *const*;

MPI_GRAPH_MAP MPI_GRAPH_MAP(*INTEGER COMM,INTEGER NNODES,INTEGER INDEX(*),INTEGER EDGES(*),INTEGER NEWRANK,INTEGER IERROR*)

MPI_Graph_neighbors int MPI_Graph_neighbors(*MPI_Comm comm,int rank,int maxneighbors,int *neighbors*);

MPI::Graphcomm::Get_neighbors
void MPI::Graphcomm::Get_neighbors(*int rank, int maxneighbors, int neighbors[]*) *const*;

MPI_GRAPH_NEIGHBORS MPI_GRAPH_NEIGHBORS(*MPI_COMM COMM,INTEGER RANK,INTEGER MAXNEIGHBORS,INTEGER NNEIGHBORS(*),INTEGER IERROR*)

MPI_Graph_neighbors_count
int MPI_Graph_neighbors_count(*MPI_Comm comm,int rank,int *nneighbors*);

MPI::Graphcomm::Get_neighbors_count
int MPI::Graphcomm::Get_neighbors_count(*int rank*) *const*;

MPI_GRAPH_NEIGHBORS_COUNT	MPI_GRAPH_NEIGHBORS_COUNT(*INTEGER COMM,INTEGER RANK,INTEGER NEIGHBORS, INTEGER IERROR*)
MPI_Graphdims_get	int MPI_Graphdims_get(*MPI_Comm comm,int *nnodes,int *nedges*);
MPI::Graphcomm::Get_dims	void MPI::Graphcomm::Get_dims(*int nnodes[], int nedges[]*) *const*;
MPI_GRAPHDIMS_GET	MPI_GRAPHDIMS_GET(*INTEGER COMM,INTEGER NNDODES,INTEGER NEDGES, INTEGER IERROR*)
MPI_Topo_test	int MPI_Topo_test(*MPI_Comm comm,int *status*);
MPI::Comm::Get_topology	int MPI::Comm::Get_topology() *const*;
MPI_TOPO_TEST	

Appendix E. PE MPI buffer management for eager protocol

The Parallel Environment implementation of MPI uses an **eager send** protocol for messages whose size is up to the **eager limit**. This value can be allowed to default, or can be specified with the **MP_EAGER_LIMIT** environment variable or the **-eager_limit** command-line flag. In an eager send, the entire message is sent immediately to its destination and the send buffer is returned to the application. Since the message is sent without knowing if there is a matching receive waiting, the message may need to be stored in the early arrival buffer at the destination, until a matching receive is posted by the application. The MPI standard requires that an eager send be done only if it can be guaranteed that there is sufficient buffer space. If a send is posted at some source (sender) when buffer space cannot be guaranteed, the send must not complete at the source until it is known that there will be a place for the message at the destination.

PE MPI uses a **credit flow control**, by which senders track the buffer space that can be guaranteed at each destination. For each source-destination pair, an eager send consumes a **message credit** at the source, and a match at the destination generates a message credit. The message credits generated at the destination are returned to the sender to enable additional eager sends. The message credits are returned piggyback on an application message when possible. If there is no return traffic, they will accumulate at the destination until their number reaches some threshold, and then be sent back as a batch to minimize network traffic. When a sender has no message credits, its sends must proceed using **rendezvous protocol** until message credits become available. The fallback to rendezvous protocol may impact performance. With a reasonable supply of message credits, most applications will find that the credits return soon enough to enable messages that are not larger than the eager limit to continue to be sent eagerly.

Assuming a pre-allocated early arrival buffer (whose size cannot increase), the number of message credits that the early arrival buffer represents is equal to the early arrival buffer size divided by the eager limit. Since no sender can know how many other tasks will also send eagerly to a given destination, the message credits must be divided among sender tasks equally. If every task sends eagerly to a single destination that is not posting receives, each sender consumes its message credits, fills its share of the destination early arrival buffer, and reverts to rendezvous protocol. This prevents an overflow at the destination, which would result in job failure. To offer a reasonable number of message credits per source-destination pair at larger task counts, either a very large pre-allocated early arrival buffer, or a very small eager limit is needed.

It would be unusual for a real application to flood a single destination this way, and well-written applications try to pre-post their receives. An eager send must consume a message credit at the send side, but when the message arrives and matches a waiting receive, it does not consume any of the early arrival buffer space. The message credit is available to be returned to the sender, but does not return instantly. When they pre-post and do not flood, real applications seldom use more than a small percentage of the total early arrival buffer space. However, because message credits must be managed for the worst case, they may be depleted at the send side. The send side then reverts to rendezvous protocol, even though there is plenty of early arrival buffer space available, or there is a matching receive waiting at the receive side, which would then not need to use the early arrival buffer.

The advantage of a pre-allocated early arrival buffer is that the Parallel Environment implementation of MPI is able to allocate and free early arrival space in the

pre-allocated buffer quickly, and because the space is owned by the MPI library, it is certain to be available if needed. There is nothing an application can do to make the space that is promised by message credits unavailable in the event that all message credits are used. A disadvantage is that the space that is pre-allocated to the early arrival buffer to support adequate message credits is denied to the application, even if only a small portion of that pre-allocated space is ever used.

With PE 4.2, MPI users are given new control over buffer pre-allocation and message credits. MPI users can specify both a pre-allocated and maximum early arrival buffer size. The pre-allocated early arrival buffer is set aside for efficient management, and guaranteed availability. If the early arrival buffer requirement exceeds the pre-allocated space, extra early arrival buffer space comes from the heap using **malloc** and **free**. Message credits are calculated based on the maximum buffer size, and all of the pre-allocated early arrival buffer is used before using malloc and free. Since message credits are based on the maximum buffer size, an application that floods a single destination with unmatched eager messages from all senders, could require the specified maximum. If other heap usage has made that space unavailable, a malloc could fail and the job would be terminated. However, well-designed applications might see better performance from additional credits, but may not even fill the pre-allocated early arrival buffer, let alone come near needing the promised maximum. An omitted maximum, or any value at or below the **pre_allocated_size**, will cause message credits to be limited so that there will never be an overflow of the pre-allocated early arrival buffer.

For most applications, the default value for the early arrival buffer should be satisfactory, and with the default, the message credits are calculated based on the pre-allocated size. The pre-allocated size can be changed from its default by setting the **MP_BUFFER_MEM** environment variable or using the **-buffer_mem** command-line flag with a single value. The message credits are calculated based on the modified pre-allocated size. There will be no use of malloc and free after initialization (MPI_Init). This is the way earlier versions of the Parallel Environment implementation of MPI worked, so there is no need to learn new habits for command-line arguments, or to make changes to existing run scripts and default shell environments.

For some applications, in particular those that are memory constrained or run at large task counts, it may be useful to adjust the size of the pre-allocated early arrival buffer to slightly more than the application's peak demand, but specify a higher maximum early arrival buffer size so that enough message credits are available to ensure few or no fallbacks to rendezvous protocol. For a given run, you can use the **MP_STATISTICS** environment variable to see how much early arrival buffer space is used at peak demand, and how often a send that is small enough to be an eager send, was processed using rendezvous protocol due to a message credit shortage.

By decreasing the pre-allocated early arrival buffer size to slightly larger than the application's peak demand, you avoid wasting pre-allocated buffer space. By increasing the maximum buffer size, you provide credits which can reduce or eliminate fallbacks to rendezvous protocol. The application's peak demand and fallback frequency can vary from run to run, and the amount of variation may depend on the nature of the application. If the application's peak demand is larger than the pre-allocated early arrival buffer size, the use of malloc and free may cause a performance impact. The credit flow control will guarantee that the application's peak demand will never exceed the specified maximum. However, if you pick a maximum that cannot be satisfied, it is possible for an MPI application that does aggressive but valid flooding of a single destination to fail in a malloc.

The risk of needing the maximum early arrival buffer size is small in well-structured applications, so with very large task counts, you may choose to set an unrealistic maximum to allow a higher eager limit and get enough message credits to maximize performance. However, be aware that if the application behaves differently than expected and requires significantly more storage than the pre-allocated early arrival buffer size, and this storage is not available before message credit shortages throttle eager sending, unexpected paging or even malloc failures are possible. (To **throttle** a car engine is to choke off its air and fuel intake by lifting your foot from the gas pedal when you want to keep the car from going faster than you can control).

Note: PE 4.3 has changed the default size of the early arrival buffer for IP from 2.8 MB to 64 MB. By default, a 32-bit application can malloc approximately 200 MB before malloc fails. An application that needs to malloc more than that needs to be compiled with option **-bmaxdata**, to set aside more heap space. Both the user applications and the MPI/LAPI libraries perform mallocs that go toward this limit of approximately 200 MB.

With the change to the default size of the early arrival buffer, an IP application that got by before because its memory needs plus the 2.8 MB allocated by libmpi for the early arrival buffer was less than approximately 200 MB, can fail because now its memory needs plus 64 MB for the early arrival buffer exceeds that limit. Note that LAPI in IP mode takes 32 MB for sn_single and 64 MB for sn_all, which also goes against this limit. If an application that ran before now fails with an 'out of memory' condition, the programmer can either recompile the application with the **-bmaxdata** option, or set environment variable **MP_BUFFER_MEM** to a smaller value.

The 2.8 MB previously allocated is insufficient for good performance with more than a few tasks, because it does not allow enough message credits per task. In fact for many applications, the 2.8 MB is more than will actually be needed, so using 2.8 MB as the pre-allocated buffer and 64 MB as the maximum may be the best choice. Be aware that if you do this and your application really takes the maximum, you will still run out of memory.

Appendix F. Accessibility features for PE

Accessibility features help a user who has a physical disability, such as restricted mobility or limited vision, to use information technology products successfully.

Accessibility features

The following list includes the major accessibility features in IBM Parallel Environment. These features support:

- Keyboard-only operation.
- Interfaces that are commonly used by screen readers.
- Keys that are tactilely discernible and do not activate just by touching them.
- Industry-standard devices for ports and connectors.
- The attachment of alternative input and output devices.

Note: The IBM eServer Cluster Information Center and its related publications are accessibility-enabled for the IBM Home Page Reader. You can operate all features using the keyboard instead of the mouse.

Keyboard navigation

This product uses standard Microsoft® Windows® navigation keys.

IBM and accessibility

See the *IBM Accessibility Center* at **http://www.ibm.com/able** for more information about the commitment that IBM has to accessibility.

Notices

This information was developed for products and services offered in the U.S.A.

IBM may not offer the products, services, or features discussed in this document in other countries. Consult your local IBM representative for information on the products and services currently available in your area. Any reference to an IBM product, program, or service is not intended to state or imply that only that IBM product, program, or service may be used. Any functionally equivalent product, program, or service that does not infringe any IBM intellectual property right may be used instead. However, it is the user's responsibility to evaluate and verify the operation of any non-IBM product, program, or service.

IBM may have patents or pending patent applications covering subject matter described in this document. The furnishing of this document does not grant you any license to these patents. You can send license inquiries, in writing, to:

IBM Director of Licensing
IBM Corporation
North Castle Drive
Armonk, NY 10504-1785
U.S.A.

For license inquiries regarding double-byte (DBCS) information, contact the IBM Intellectual Property Department in your country or send inquiries, in writing, to:

IBM World Trade Asia Corporation
Licensing
2-31 Roppongi 3-chome, Minato-ku
Tokyo 106-0032, Japan

The following paragraph does not apply to the United Kingdom or any other country where such provisions are inconsistent with local law:

INTERNATIONAL BUSINESS MACHINES CORPORATION PROVIDES THIS PUBLICATION "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some states do not allow disclaimer of express or implied warranties in certain transactions, therefore, this statement may not apply to you.

This information could include technical inaccuracies or typographical errors. Changes are periodically made to the information herein; these changes will be incorporated in new editions of the publication. IBM may make improvements and/or changes in the product(s) and/or the program(s) described in this publication at any time without notice.

Any references in this information to non-IBM Web sites are provided for convenience only and do not in any manner serve as an endorsement of those Web sites. The materials at those Web sites are not part of the materials for this IBM product and use of those Web sites is at your own risk.

IBM may use or distribute any of the information you supply in any way it believes appropriate without incurring any obligation to you.

Licensees of this program who wish to have information about it for the purpose of enabling: (i) the exchange of information between independently created programs and other programs (including this one) and (ii) the mutual use of the information which has been exchanged, should contact:

IBM Corporation
Department LJEB/P905
2455 South Road
Poughkeepsie, NY 12601-5400
U.S.A

Such information may be available, subject to appropriate terms and conditions, including in some cases, payment of a fee.

The licensed program described in this document and all licensed material available for it are provided by IBM under terms of the IBM Customer Agreement, IBM International Program License Agreement or any equivalent agreement between us.

Any performance data contained herein was determined in a controlled environment. Therefore, the results obtained in other operating environments may vary significantly. Some measurements may have been made on development-level systems and there is no guarantee that these measurements will be the same on generally available systems. Furthermore, some measurement may have been estimated through extrapolation. Actual results may vary. Users of this document should verify the applicable data for their specific environment.

Information concerning non-IBM products was obtained from the suppliers of those products, their published announcements or other publicly available sources. IBM has not tested those products and cannot confirm the accuracy of performance, compatibility or any other claims related to non-IBM products. Questions on the capabilities of non-IBM products should be addressed to the suppliers of those products.

All statements regarding IBM's future direction or intent are subject to change or withdrawal without notice, and represent goals and objectives only.

This information contains examples of data and reports used in daily business operations. To illustrate them as completely as possible, the examples include the names of individuals, companies, brands, and products. All of these names are fictitious and any similarity to the names and addresses used by an actual business enterprise is entirely coincidental.

COPYRIGHT LICENSE:

This information contains sample application programs in source language, which illustrates programming techniques on various operating platforms. You may copy, modify, and distribute these sample programs in any form without payment to IBM, for the purposes of developing, using, marketing or distributing application programs conforming to the application programming interface for the operating platform for which the sample programs are written. These examples have not been thoroughly tested under all conditions. IBM, therefore, cannot guarantee or imply reliability, serviceability, or function of these programs.

Each copy or any portion of these sample programs or any derivative work, must include a copyright notice as follows:

© (your company name) (year). Portions of this code are derived from IBM Corp. Sample Programs. © Copyright IBM Corp. _enter the year or years_. All rights reserved.

All implemented function in the PE MPI product is designed to comply with the requirements of the Message Passing Interface Forum, MPI: A Message-Passing Interface Standard. The standard is documented in two volumes, Version 1.1, University of Tennessee, Knoxville, Tennessee, June 6, 1995 and *MPI-2: Extensions to the Message-Passing Interface*, University of Tennessee, Knoxville, Tennessee, July 18, 1997. The second volume includes a section identified as MPI 1.2 with clarifications and limited enhancements to MPI 1.1. It also contains the extensions identified as MPI 2.0. The three sections, MPI 1.1, MPI 1.2 and MPI 2.0 taken together constitute the current standard for MPI.

PE MPI provides support for all of MPI 1.1 and MPI 1.2. PE MPI also provides support for all of the MPI 2.0 Enhancements, except the contents of the chapter titled *Process Creation and Management*.

If you believe that PE MPI does not comply with the MPI standard for the portions that are implemented, please contact IBM Service.

Trademarks

The following are trademarks of International Business Machines Corporation in the United States, other countries, or both:

AFS
AIX
AIX 5L
DFS
eServer
IBM
IBMLink™
IBM Tivoli Workload Scheduler LoadLeveler
LoadLeveler
POWER
POWER3
POWER4
pSeries
RS/6000
SP
System p
System p5
System x
Tivoli
xSeries

Linux is a trademark of Linus Torvalds in the United States, other countries, or both.

InfiniBand is a registered trademark and service mark of the InfiniBand Trade Association.

Microsoft is a registered trademark of Microsoft Corporation in the United States, other countries, or both.

UNIX is a registered trademark of The Open Group in the United States and other countries.

Windows is a registered trademark of Microsoft Corporation in the United States, other countries, or both.

Other company, product, and service names may be the trademarks or service marks of others.

Acknowledgments

The PE Benchmarker product includes software developed by the Apache Software Foundation, *http://www.apache.org*.

Glossary

A

AFS. Andrew File System.

address. A value, possibly a character or group of characters that identifies a register, a device, a particular part of storage, or some other data source or destination.

AIX. Abbreviation for Advanced Interactive Executive, IBM's licensed version of the UNIX operating system. AIX is particularly suited to support technical computing applications, including high-function graphics and floating-point computations.

API. Application programming interface.

application. The use to which a data processing system is put; for example, a payroll application, an airline reservation application.

argument. A parameter passed between a calling program and a called program or subprogram.

attribute. A named property of an entity.

Authentication. The process of validating the identity of a user or server.

Authorization. The process of obtaining permission to perform specific actions.

B

bandwidth. For a specific amount of time, the amount of data that can be transmitted. Bandwidth is expressed in bits or bytes per second (bps) for digital devices, and in cycles per second (Hz) for analog devices.

blocking operation. An operation that does not complete until the operation either succeeds or fails. For example, a blocking receive will not return until a message is received or until the channel is closed and no further messages can be received.

breakpoint. A place in a program, specified by a command or a condition, where the system halts execution and gives control to the workstation user or to a specified program.

broadcast operation. A communication operation where one processor sends (or broadcasts) a message to all other processors.

buffer. A portion of storage used to hold input or output data temporarily.

C

C. A general-purpose programming language. It was formalized by Uniforum in 1983 and the ANSI standards committee for the C language in 1984.

C++. A general-purpose programming language that is based on the C language. C++ includes extensions that support an object-oriented programming paradigm. Extensions include:

- strong typing
- data abstraction and encapsulation
- polymorphism through function overloading and templates
- class inheritance.

chaotic relaxation. An iterative relaxation method that uses a combination of the Gauss-Seidel and Jacobi-Seidel methods. The array of discrete values is divided into subregions that can be operated on in parallel. The subregion boundaries are calculated using the Jacobi-Seidel method, while the subregion interiors are calculated using the Gauss-Seidel method. See also *Gauss-Seidel*.

client. A function that requests services from a server and makes them available to the user.

cluster. A group of processors interconnected through a high-speed network that can be used for high-performance computing.

Cluster 1600. See IBM eServer Cluster 1600.

collective communication. A communication operation that involves more than two processes or tasks. Broadcasts, reductions, and the **MPI_Allreduce** subroutine are all examples of collective communication operations. All tasks in a communicator must participate.

command alias. When using the PE command-line debugger **pdbx**, you can create abbreviations for existing commands using the **pdbx alias** command. These abbreviations are known as *command aliases.*

communicator. An MPI object that describes the communication context and an associated group of processes.

compile. To translate a source program into an executable program.

condition. One of a set of specified values that a data item can assume.

core dump. A process by which the current state of a program is preserved in a file. Core dumps are usually associated with programs that have encountered an unexpected, system-detected fault, such as a

Segmentation Fault or a severe user error. The current program state is needed for the programmer to diagnose and correct the problem.

core file. A file that preserves the state of a program, usually just before a program is terminated for an unexpected error. See also *core dump.*

current context. When using the **pdbx** debugger, control of the parallel program and the display of its data can be limited to a subset of the tasks belonging to that program. This subset of tasks is called the *current context.* You can set the current context to be a single task, multiple tasks, or all the tasks in the program.

D

data decomposition. A method of breaking up (or decomposing) a program into smaller parts to exploit parallelism. One divides the program by dividing the data (usually arrays) into smaller parts and operating on each part independently.

data parallelism. Refers to situations where parallel tasks perform the same computation on different sets of data.

dbx. A symbolic command-line debugger that is often provided with UNIX systems. The PE command-line debugger **pdbx** is based on the **dbx** debugger.

debugger. A debugger provides an environment in which you can manually control the execution of a program. It also provides the ability to display the program's data and operation.

distributed shell (dsh). An IBM Parallel System Support Programs for AIX command that lets you issue commands to a group of hosts in parallel. See *IBM Parallel System Support Programs for AIX: Command and Technical Reference* for details.

domain name. The hierarchical identification of a host system (in a network), consisting of human-readable labels, separated by decimal points.

DPCL target application. The executable program that is instrumented by a Dynamic Probe Class Library (DPCL) analysis tool. It is the process (or processes) into which the DPCL analysis tool inserts probes. A target application could be a serial or parallel program. Furthermore, if the target application is a parallel program, it could follow either the SPMD or the MPMD model, and may be designed for either a message-passing or a shared-memory system.

E

environment variable. (1) A variable that describes the operating environment of the process. Common environment variables describe the home directory, command search path, and the current time zone. (2) A variable that is included in the current software environment and is therefore available to any called program that requests it.

Ethernet. A baseband local area network (LAN) that allows multiple stations to access the transmission medium at will without prior coordination, avoids contention by using carrier sense and deference, and resolves contention by using collision detection and delayed retransmission. Ethernet uses carrier sense multiple access with collision detection (CSMA/CD).

event. An occurrence of significance to a task — the completion of an asynchronous operation such as an input/output operation, for example.

executable. A program that has been link-edited and therefore can be run in a processor.

execution. To perform the actions specified by a program or a portion of a program.

expression. In programming languages, a language construct for computing a value from one or more operands.

F

fairness. A policy in which tasks, threads, or processes must be allowed eventual access to a resource for which they are competing. For example, if multiple threads are simultaneously seeking a lock, no set of circumstances can cause any thread to wait indefinitely for access to the lock.

Fiber Distributed Data Interface (FDDI). An American National Standards Institute (ANSI) standard for a local area network (LAN) using optical fiber cables. An FDDI LAN can be up to 100 kilometers (62 miles) long, and can include up to 500 system units. There can be up to 2 kilometers (1.24 miles) between system units and concentrators.

file system. The collection of files and file management structures on a physical or logical mass storage device, such as a diskette or minidisk.

fileset. (1) An individually-installable option or update. Options provide specific functions. Updates correct an error in, or enhance, a previously installed program. (2) One or more separately-installable, logically-grouped units in an installation package. See also *licensed program* and *package.*

foreign host. See *remote host.*

FORTRAN. One of the oldest of the modern programming languages, and the most popular language for scientific and engineering computations. Its name is a contraction of *FORmula TRANslation.* The two most common FORTRAN versions are FORTRAN

77, originally standardized in 1978, and FORTRAN 90. FORTRAN 77 is a proper subset of FORTRAN 90.

function cycle. A chain of calls in which the first caller is also the last to be called. A function that calls itself recursively is not considered a function cycle.

functional decomposition. A method of dividing the work in a program to exploit parallelism. The program is divided into independent pieces of functionality, which are distributed to independent processors. This method is in contrast to data decomposition, which distributes the same work over different data to independent processors.

functional parallelism. Refers to situations where parallel tasks specialize in particular work.

G

Gauss-Seidel. An iterative relaxation method for solving Laplace's equation. It calculates the general solution by finding particular solutions to a set of discrete points distributed throughout the area in question. The values of the individual points are obtained by averaging the values of nearby points. Gauss-Seidel differs from Jacobi-Seidel in that, for the *i+1*st iteration, Jacobi-Seidel uses only values calculated in the *i*th iteration. Gauss-Seidel uses a mixture of values calculated in the *i*th and *i+1*st iterations.

global max. The maximum value across all processors for a given variable. It is global in the sense that it is global to the available processors.

global variable. A variable defined in one portion of a computer program and used in at least one other portion of the computer program.

gprof. A UNIX command that produces an execution profile of C, COBOL, FORTRAN, or Pascal programs. The execution profile is in a textual and tabular format. It is useful for identifying which routines use the most CPU time. See the man page on **gprof**.

graphical user interface (GUI). A type of computer interface consisting of a visual metaphor of a real-world scene, often of a desktop. Within that scene are icons, which represent actual objects, that the user can access and manipulate with a pointing device.

GUI. Graphical user interface.

H

high performance switch. The high-performance message-passing network that connects all processor nodes together.

hook. A **pdbx** command that lets you re-establish control over all tasks in the current context that were previously unhooked with this command.

home node. The node from which an application developer compiles and runs his program. The home node can be any workstation on the LAN.

host. A computer connected to a network that provides an access method to that network. A host provides end-user services.

host list file. A file that contains a list of host names, and possibly other information, that was defined by the application that reads it.

host name. The name used to uniquely identify any computer on a network.

hot spot. A memory location or synchronization resource for which multiple processors compete excessively. This competition can cause a disproportionately large performance degradation when one processor that seeks the resource blocks, preventing many other processors from having it, thereby forcing them to become idle.

I

IBM eServer Cluster 1600. An IBM eServer Cluster 1600 is any CSM-managed cluster comprised of POWER microprocessor based systems (including RS/6000 SMPs, RS/6000 SP nodes, and pSeries SMPs).

IBM Parallel Environment (PE) for AIX. A licensed program that provides an execution and development environment for parallel C, C++, and FORTRAN programs. It also includes tools for debugging, profiling, and tuning parallel programs.

installation image. A file or collection of files that are required in order to install a software product on system nodes. These files are in a form that allows them to be installed or removed with the AIX **installp** command. See also *fileset*, *licensed program*, and *package.*

Internet. The collection of worldwide networks and gateways that function as a single, cooperative virtual network.

Internet Protocol (IP). The IP protocol lies beneath the UDP protocol, which provides packet delivery between user processes and the TCP protocol, which provides reliable message delivery between user processes.

IP. Internet Protocol.

J

Jacobi-Seidel. See *Gauss-Seidel.*

K

Kerberos. A publicly available security and authentication product that works with the IBM Parallel System Support Programs for AIX software to authenticate the execution of remote commands.

kernel. The core portion of the UNIX operating system that controls the resources of the CPU and allocates them to the users. The kernel is memory-resident, is said to run in *kernel mode* (in other words, at higher execution priority level than *user mode*), and is protected from user tampering by the hardware.

L

Laplace's equation. A homogeneous partial differential equation used to describe heat transfer, electric fields, and many other applications.

latency. The time interval between the initiation of a send by an origin task and the completion of the matching receive by the target task. More generally, latency is the time between a task initiating data transfer and the time that transfer is recognized as complete at the data destination.

licensed program. A collection of software packages sold as a product that customers pay for to license. A licensed program can consist of packages and file sets a customer would install. These packages and file sets bear a copyright and are offered under the terms and conditions of a licensing agreement. See also *fileset* and *package.*

lightweight corefiles. An alternative to standard AIX corefiles. Corefiles produced in the *Standardized Lightweight Corefile Format* provide simple process stack traces (listings of function calls that led to the error) and consume fewer system resources than traditional corefiles.

LoadLeveler. A job management system that works with POE to let users run jobs and match processing needs with system resources, in order to make better use of the system.

local variable. A variable that is defined and used only in one specified portion of a computer program.

loop unrolling. A program transformation that makes multiple copies of the body of a loop, also placing the copies within the body of the loop. The loop trip count and index are adjusted appropriately so the new loop computes the same values as the original. This transformation makes it possible for a compiler to take additional advantage of instruction pipelining, data cache effects, and software pipelining.

See also *optimization.*

M

management domain . A set of nodes configured for manageability by the Clusters Systems Management (CSM) product. Such a domain has a management server that is used to administer a number of managed nodes. Only management servers have knowledge of the whole domain. Managed nodes only know about the servers managing them; they know nothing of each other. Contrast with *peer domain*.

menu. A list of options displayed to the user by a data processing system, from which the user can select an action to be initiated.

message catalog. A file created from a message source file that contains application error and other messages, which can later be translated into other languages without having to recompile the application source code.

message passing. Refers to the process by which parallel tasks explicitly exchange program data.

Message Passing Interface (MPI). A standardized API for implementing the message-passing model.

MIMD. Multiple instruction stream, multiple data stream.

Multiple instruction stream, multiple data stream (MIMD). A parallel programming model in which different processors perform different instructions on different sets of data.

MPMD. Multiple program, multiple data.

Multiple program, multiple data (MPMD). A parallel programming model in which different, but related, programs are run on different sets of data.

MPI. Message Passing Interface.

N

network. An interconnected group of nodes, lines, and terminals. A network provides the ability to transmit data to and receive data from other systems and users.

Network Information Services. A set of network services (for example, a distributed service for retrieving information about the users, groups, network addresses, and gateways in a network) that resolve naming and addressing differences among computers in a network.

NIS. See *Network Information Services*.

node. (1) In a network, the point where one or more functional units interconnect transmission lines. A computer location defined in a network. (2) A single location or workstation in a network. Usually a physical entity, such as a processor.

node ID. A string of unique characters that identifies the node on a network.

nonblocking operation. An operation, such as sending or receiving a message, that returns immediately whether or not the operation was completed. For example, a nonblocking receive will not wait until a message arrives. By contrast, a blocking receive will wait. A nonblocking receive must be completed by a later test or wait.

O

object code. The result of translating a computer program to a relocatable, low-level form. Object code contains machine instructions, but symbol names (such as array, scalar, and procedure names), are not yet given a location in memory. Contrast with *source code.*

optimization. A widely-used (though not strictly accurate) term for program performance improvement, especially for performance improvement done by a compiler or other program translation software. An optimizing compiler is one that performs extensive code transformations in order to obtain an executable that runs faster but gives the same answer as the original. Such code transformations, however, can make code debugging and performance analysis very difficult because complex code transformations obscure the correspondence between compiled and original source code.

option flag. Arguments or any other additional information that a user specifies with a program name. Also referred to as *parameters* or *command-line options.*

P

package. A number of file sets that have been collected into a single installable image of licensed programs. Multiple file sets can be bundled together for installing groups of software together. See also *fileset* and *licensed program.*

parallelism. The degree to which parts of a program may be concurrently executed.

parallelize. To convert a serial program for parallel execution.

parallel operating environment (POE). An execution environment that smooths the differences between serial and parallel execution. It lets you submit and manage parallel jobs. It is abbreviated and commonly known as POE.

parameter. (1) In FORTRAN, a symbol that is given a constant value for a specified application. (2) An item in a menu for which the operator specifies a value or for which the system provides a value when the menu is interpreted. (3) A name in a procedure that is used to refer to an argument that is passed to the procedure. (4) A particular piece of information that a system or application program needs to process a request.

partition. (1) A fixed-size division of storage. (2) A logical collection of nodes to be viewed as one system or domain. System partitioning is a method of organizing the system into groups of nodes for testing or running different levels of software of product environments.

Partition Manager. The component of the parallel operating environment (POE) that allocates nodes, sets up the execution environment for remote tasks, and manages distribution or collection of standard input (STDIN), standard output (STDOUT), and standard error (STDERR).

pdbx. The parallel, symbolic command-line debugging facility of PE. **pdbx** is based on the **dbx** debugger and has a similar interface.

PE. The Parallel Environment for AIX licensed program.

peer domain. A set of nodes configured for high availability by the RSCT configuration manager. Such a domain has no distinguished or master node. All nodes are aware of all other nodes, and administrative commands can be issued from any node in the domain. All nodes also have a consistent view of the domain membership. Contrast with *management domain*.

performance monitor. A utility that displays how effectively a system is being used by programs.

PID. Process identifier.

POE. parallel operating environment.

pool. Groups of nodes on a system that are known to LoadLeveler, and are identified by a pool name or number.

point-to-point communication. A communication operation that involves exactly two processes or tasks. One process initiates the communication through a *send* operation. The partner process issues a *receive* operation to accept the data being sent.

procedure. (1) In a programming language, a block, with or without formal parameters, whose execution is invoked by means of a procedure call. (2) A set of related control statements that cause one or more programs to be performed.

process. A program or command that is actually running the computer. It consists of a loaded version of the executable file, its data, its stack, and its kernel data structures that represent the process's state within a multitasking environment. The executable file contains the machine instructions (and any calls to shared

objects) that will be executed by the hardware. A process can contain multiple threads of execution.

The process is created with a **fork()** system call and ends using an **exit()** system call. Between **fork** and **exit**, the process is known to the system by a unique process identifier (PID).

Each process has its own virtual memory space and cannot access another process's memory directly. Communication methods across processes include pipes, sockets, shared memory, and message passing.

prof. A utility that produces an execution profile of an application or program. It is useful to identify which routines use the most CPU time. See the man page for **prof**.

profiling. The act of determining how much CPU time is used by each function or subroutine in a program. The histogram or table produced is called the execution profile.

pthread. A thread that conforms to the POSIX Threads Programming Model.

R

reduced instruction-set computer. A computer that uses a small, simplified set of frequently-used instructions for rapid execution.

reduction operation. An operation, usually mathematical, that reduces a collection of data by one or more dimensions. For example, the arithmetic SUM operation is a reduction operation that reduces an array to a scalar value. Other reduction operations include MAXVAL and MINVAL.

Reliable Scalable Cluster Technology. A set of software components that together provide a comprehensive clustering environment for AIX. RSCT is the infrastructure used by a variety of IBM products to provide clusters with improved system availability, scalability, and ease of use.

remote host. Any host on a network except the one where a particular operator is working.

remote shell (rsh). A command that lets you issue commands on a remote host.

RISC. See *reduced instruction-set computer*.

RSCT. See *Reliable Scalable Cluster Technology*.

RSCT peer domain. See *peer domain*.

S

shell script. A sequence of commands that are to be executed by a shell interpreter such as the Bourne shell (**sh**), the C shell (**csh**), or the Korn shell (**ksh**). Script commands are stored in a file in the same format as if they were typed at a terminal.

segmentation fault. A system-detected error, usually caused by referencing an non-valid memory address.

server. A functional unit that provides shared services to workstations over a network — a file server, a print server, or a mail server, for example.

signal handling. In the context of a message passing library (such as MPI), there is a need for asynchronous operations to manage packet flow and data delivery while the application is doing computation. This asynchronous activity can be carried out either by a signal handler or by a service thread. The early IBM message passing libraries used a signal handler and the more recent libraries use service threads. The older libraries are often referred to as the *signal handling* versions.

Single program, multiple data (SPMD). A parallel programming model in which different processors execute the same program on different sets of data.

source code. The input to a compiler or assembler, written in a source language. Contrast with *object code.*

source line. A line of source code.

SPMD. Single program, multiple data.

standard error (STDERR). An output file intended to be used for error messages for C programs.

standard input (STDIN). The primary source of data entered into a command. Standard input comes from the keyboard unless redirection or piping is used, in which case standard input can be from a file or the output from another command.

standard output (STDOUT). The primary destination of data produced by a command. Standard output goes to the display unless redirection or piping is used, in which case standard output can go to a file or to another command.

STDERR. Standard error.

STDIN. Standard input.

STDOUT. Standard output.

stencil. A pattern of memory references used for averaging. A 4-point stencil in two dimensions for a given array cell, x(i,j), uses the four adjacent cells, x(i-1,j), x(i+1,j), x(i,j-1), and x(i,j+1).

subroutine. (1) A sequence of instructions whose execution is invoked by a call. (2) A sequenced set of instructions or statements that can be used in one or more computer programs and at one or more points in a

computer program. (3) A group of instructions that can be part of another routine or can be called by another program or routine.

synchronization. The action of forcing certain points in the execution sequences of two or more asynchronous procedures to coincide in time.

system administrator. (1) The person at a computer installation who designs, controls, and manages the use of the computer system. (2) The person who is responsible for setting up, modifying, and maintaining the Parallel Environment.

T

target application. See *DPCL target application*.

task. A unit of computation analogous to a process. In a parallel job, there are two or more concurrent tasks working together through message passing. Though it is common to allocate one task per processor, the terms *task* and *processor* are not interchangeable.

thread. A single, separately dispatchable, unit of execution. There can be one or more threads in a process, and each thread is executed by the operating system concurrently.

TPD. Third party debugger.

tracing. In PE, the collection of information about the execution of the program. This information is accumulated into a trace file that can later be examined.

tracepoint. Tracepoints are places in the program that, when reached during execution, cause the debugger to print information about the state of the program.

trace record. In PE, a collection of information about a specific event that occurred during the execution of your program. For example, a trace record is created for each send and receive operation that occurs in your program (this is optional and might not be appropriate). These records are then accumulated into a trace file that can later be examined.

U

unrolling loops. See *loop unrolling.*

user. (1) A person who requires the services of a computing system. (2) Any person or any thing that can issue or receive commands and message to or from the information processing system.

User Space. A version of the message passing library that is optimized for direct access to the high performance switch. User Space maximizes performance by passing up all kernel involvement in sending or receiving a message.

utility program. A computer program in general support of computer processes; for example, a diagnostic program, a trace program, a sort program.

utility routine. A routine in general support of the processes of a computer; for example, an input routine.

V

variable. (1) In programming languages, a named object that may take different values, one at a time. The values of a variable are usually restricted to one data type. (2) A quantity that can assume any of a given set of values. (3) A name used to represent a data item whose value can be changed while the program is running. (4) A name used to represent data whose value can be changed, while the program is running, by referring to the name of the variable.

X

X Window System. The UNIX industry's graphics windowing standard that provides simultaneous views of several executing programs or processes on high resolution graphics displays.

Index

Special characters

-bmaxdata 34, 207
-buffer_mem command-line flag 206
-eager_limit command-line flag 205
-hostfile command-line flag 16
-infolevel command-line flag 39
-procs command-line flag 16
-q64 42
-qarch compiler option 33
-qextcheck compiler option 33
-qintsize 42
-shared_memory command-line flag 2, 15
-stdoutmode command-line flag 31
@bulkxfer 9

Numerics

32-bit addressing 34
32-bit application 25, 33, 35, 36, 42
32-bit executable 15, 16
64-bit application 25, 33, 36, 42
64-bit executable 15

A

abbreviated names x
accessibility 209
  keyboard 209
  shortcut keys 209
acknowledgments 214
acronyms for product names x
address segments 34
AIX function limitation 30
AIX kernel thread 25
AIX message catalog 33
AIX profiling 11
AIX signals 28
AIXTHREAD_SCOPE environment variable 38
APIs
  parallel task identification 123
archive 13
assorted constants 60
asynchronous signals 28, 29
atomic lock 41

B

bindings
  subroutine 129, 153
blocking collective 16, 30
blocking communication 1
blocking MPI call 41, 43
blocking receive 4, 6
blocking send 3, 6, 8
buffering messages 205
bulk transfer mode 9

C

C bindings 11
C language binding data types 49
C reduction function dattypes 50
checkpoint
  hang 41
CHECKPOINT environment variable 38, 39, 41
checkpoint restrictions 38
child process 41
choice arguments 33
clock source 34
collective communication 15
collective communication call 38, 41
collective constants 60
collective operations 61
combiner constants 59
command-line flags
  -buffer_mem 206
  -eager_limit 205
  -hostfile 16
  -infolevel 39
  -procs 16
  -shared_memory 2, 15
  -stdoutmode 31
commands
  poe 25, 32
communication stack 45
communications adapter 9
communicator 64
constants
  assorted 60
  collective 60
  collective operations 61
  communicator and group comparisons 59
  data type decoding 59
  derived data types 60
  elementary data type 60, 61
  empty group 62
  environment inquiry keys 58
  error classes 57
  error handling specifiers 60
  file operation 59
  FORTRAN 90 data type matching 62
  maximum sizes 58
  MPI 57
  MPI-IO 59
  null handles 62
  one-sided 59
  optional data types 61
  predefined attribute keys 58
  reduction function 61
  special data types 60
  threads 62
  topologies 59
construction of derived data types 60
contention for processors 6
conventions x

credit flow control 4, 205, 206

D

data type constructors 23
data type decoding functions 59
data types
  C language binding 49
  C reduction functions 50
  FORTRAN language bindings 49
  FORTRAN reduction functions 51
  predefined MPI 49
  special purpose 49
data types for reduction functions (C and C++) 61
data types for reduction functions (FORTRAN) 61
deadlock 19
debugger restrictions 38
DEVELOP mode 30
disability 209
dropped packets 10
dynamic probe class library 38

E

eager limit 3, 5, 8, 63, 64, 205
eager protocol 3, 5
eager send 3, 4, 8, 64, 205, 206, 207
early arrival buffer 4, 5, 63, 205, 206, 207
early arrival list 4, 5
elementary data types (C and C++) 60
elementary data types (FORTRAN) 61
empty group 62
environment inquiry keys 58
environment variables 1
  AIXTHREAD_SCOPE 38
  CHECKPOINT 38, 39, 41
  LAPI_USE_SHM 34
  MP_ 33
  MP_ACK_INTERVAL 45
  MP_ACK_THRESH 9, 45
  MP_BUFFER_MEM 4, 63, 64, 206
  MP_CC_SCRATCH_BUFFER 9
  MP_CLOCK_SOURCE 34
  MP_CSS_INTERRUPT 6, 21, 43, 44
  MP_EAGER_LIMIT 3, 4, 63, 64, 205
  MP_EUIDEVELOP 30, 127, 129
  MP_EUIDEVICE 8
  MP_EUILIB 2, 3
  MP_HINTS_FILTERED 23
  MP_HOSTFILE 16
  MP_INFOLEVEL 33, 39
  MP_INSTANCES 8
  MP_INTRDELAY 45
  MP_IO_BUFFER_SIZE 23
  MP_IO_ERRLOG 22
  MP_IONODEFILE 20
  MP_LAPI_INET_ADDR 17
  MP_MSG_API 44
  MP_PIPE_SIZE 45
  MP_POLLING_INTERVAL 6, 43
  MP_PRIORITY 10
environment variables *(continued)*
  MP_PROCS 16
  MP_RETRANSMIT_INTERVAL 10
  MP_REXMIT_BUF_CNT 7
  MP_REXMIT_BUF_SIZE 7
  MP_SHARED_MEMORY 1, 2, 15, 30, 34, 127, 129
  MP_SINGLE_THREAD 7, 20, 21, 36, 38
  MP_SNDBUF 31
  MP_STATISTICS 9, 10, 206
  MP_STDOUTMODE 31
  MP_SYNC_ON_CONNECT 45
  MP_TASK_AFFINITY 10
  MP_THREAD_STACKSIZE 36
  MP_UDP_PACKET_SIZE 2, 45
  MP_USE_BULK_XFER 9, 45
  MP_WAIT_MODE 6
  MPI_WAIT_MODE 43
  not recognized by PE 33
  OBJECT_MODE 42
  reserved 33
error classes 57
error handler 47
error handling specifiers 60
Ethernet adapter 16
exit status
  abnormal 29
  continuing job step 27
  normal 29
  parallel application 26
  terminating job step 27
  values 26, 29, 37
export file 13
extended heap
  specifying 35

F

file descriptor numbers 29
file handle 64
file operation constants 59
flags, command-line
  -buffer_mem 206
  -eager_limit 205
  -hostfile 16
  -infolevel 39
  -procs 16
  -shared_memory 2, 15
  -stdoutmode 31
FORTRAN 77 153
FORTRAN 90 153
FORTRAN 90 data type matching constants 62
FORTRAN bindings 11, 12
FORTRAN language binding data types 49
FORTRAN reduction function data types 51
function overloading 33
functions
  MPI 133

G

General Parallel File System (GPFS) 20
gprof 11

H

heap space 207
hidden threads 21
High Performance FORTRAN (HPF) 153
hint filtering 23

I

I/O agent 20
I/O node file 20
IBM General Parallel File System (GPFS) 20
IBM POWER4 server 10
IBM System p5 server 10
import file 13
Info objects 23
ipcrm 16

J

job control 27
job step progression 27
job step termination 27
  default 27

K

key collision 16
key, value pair 23
ksh93 30

L

language bindings
  MPI 33
LAPI 1, 17, 44, 45, 207
  sliding window protocol 4
  used with MPI 44
LAPI data transfer function 3
LAPI dispatcher 4, 6, 9, 10
LAPI parallel program 45
LAPI protocol 25
LAPI send side copy 7
LAPI user message 7
LAPI_INIT 45
LAPI_TERM 45
LAPI_USE_SHM environment variable 34
limits, system
  on size of MPI elements 63
llcancel 16
LoadLeveler 9, 26, 65
LookAt message retrieval tool xii

M

M:N threads 38
malloc 207
malloc and free 206
MALLOCDEBUG 35
MALLOCTYPE 35
maximum sizes 58
maximum tasks per node 65
message address range 15
message buffer 15, 25
message credit 4, 5, 63, 205, 206, 207
message descriptor 4
message envelope 5
message envelope buffer 63
message packet transfer 6
message passing
  profiling 11
message queue 42
message retrieval tool, LookAt xii
message traffic 9
message transport mechanisms 1
messages
  buffering 205
mixed parallelism with MPI and threads 43
MP_ACK_INTERVAL environment variable 45
MP_ACK_THRESH environment variable 9, 45
MP_BUFFER_MEM 207
MP_BUFFER_MEM environment variable 4, 63, 64, 206
MP_CC_SCRATCH_BUFFER environment variable 9
MP_CLOCK_SOURCE environment variable 34
MP_CSS_INTERRUPT environment variable 6, 21, 43, 44
MP_EAGER_LIMIT environment variable 3, 4, 63, 64, 205
MP_EUIDEVELOP environment variable 30, 127, 129
MP_EUIDEVICE environment variable 8
MP_EUILIB environment variable 2, 3
MP_HINTS_FILTERED environment variable 23
MP_HOSTFILE environment variable 16
MP_INFOLEVEL environment variable 33, 39
MP_INSTANCES environment variable 8
mp_intrdelay 45
MP_INTRDELAY environment variable 45
MP_IO_BUFFER_SIZE environment variable 23
MP_IO_ERRLOG environment variable 22
MP_IONODEFILE environment variable 20
MP_LAPI_INET_ADDR environment variable 17
MP_MSG_API environment variable 44
MP_PIPE_SIZE environment variable 45
MP_POLLING_INTERVAL environment variable 6, 43
MP_PRIORITY environment variable 10
MP_PROCS environment variable 16
MP_RETRANSMIT_INTERVAL environment variable 10
MP_REXMIT_BUF_CNT environment variable 7
MP_REXMIT_BUF_SIZE environment variable 7
MP_SHARED_MEMORY environment variable 1, 2, 15, 30, 34, 127, 129
MP_SINGLE_THREAD environment variable 7, 20, 21, 36, 38

MP_SNDBUF environment variable 31
MP_STATISTICS environment variable 9, 10, 206
MP_STDOUTMODE environment variable 31
MP_SYNC_ON_CONNECT environment variable 45
MP_TASK_AFFINITY environment variable 10
MP_THREAD_STACKSIZE environment variable 36
MP_UDP_PACKET_SIZE environment variable 2, 45
MP_USE_BULK_XFER environment variable 9, 45
MP_WAIT_MODE environment variable 6
MPCI 44
MPE subroutine bindings 129
MPE subroutines 127
MPI
  functions 133
  subroutines 133
  used with LAPI 44
MPI application exit without setting exit value 27
MPI applications
  performance 1
MPI constants 57, 58, 59, 60, 61, 62
MPI data type 19, 49
MPI eager limit 64
MPI envelope 7
MPI internal locking 7
MPI IP performance 2
MPI library 37
  architecture considerations 33
MPI Library
  performance 1
MPI message size 7
MPI reduction operations 53
MPI size limits 63
MPI subroutine bindings 153
MPI wait call 1, 3, 4, 6
MPI_Abort 26, 28
MPI_ABORT 26, 28
MPI_File 19
MPI_File object 22
MPI_Finalize 27
MPI_FINALIZE 27, 37, 45
MPI_INIT 37, 45
MPI_INIT_THREAD 37
MPI_THREAD_FUNNELED 37
MPI_THREAD_MULTIPLE 37
MPI_THREAD_SINGLE 37
MPI_WAIT_MODE environment variable 43
MPI_WTIME_IS_GLOBAL 34
MPI-IO
  API user tasks 20
  considerations 20
  data buffer size 23
  data type constructors 23
  deadlock prevention 19
  definition 19
  error handling 22
  features 19
  file interoperability 24
  file management 20
  file open 20
  file tasks 21
  hidden threads 21
MPI-IO *(continued)*
  I/O agent 20
  Info objects 23
  logging errors 22
  portability 19
  robustness 19
  versatility 19
MPI-IO constants 59
MPL 25
  not supported 25
mpxlf_r 13
multi-chip module (MCM) 10
mutex lock 43

N

n-task parallel job 25
named pipes 31, 32
nonblocking collective 16, 30
nonblocking collective communication subroutines 127
nonblocking communication 1
nonblocking receive 4
nonblocking send 3
null handles 62

O

OBJECT_MODE environment variable 42
OK to send response 6
one-sided constants 59
one-sided message passing API 1, 7, 23, 36, 38, 43, 133, 190
op operation
  data types 54
operations
  predefined 53
  reduction 53
optional data types 61

P

packet sliding window 9
packet statistics 10
parallel application 45
parallel I/O 19
parallel job 25
parallel job termination 29
parallel task identification API
  subroutines 123
parallel utility subroutines 67
  MP_BANDWIDTH 71
  MP_DISABLEINTR 76
  MP_ENABLEINTR 79
  MP_FLUSH 82
  MP_INIT_CKPT 84
  MP_QUERYINTR 86
  MP_SET_CKPT_CALLBACKS 89
  MP_STATISTICS_WRITE 92
  MP_STATISTICS_ZERO 95
  MP_STDOUT_MODE 96
  MP_STDOUTMODE_QUERY 99

parallel utility subroutines *(continued)*
MP_UNSET_CKPT_CALLBACKS 101
mpc_bandwidth 71
mpc_disableintr 76
mpc_enableintr 79
mpc_flush 82
mpc_init_ckpt 84
mpc_isatty 69
mpc_queryintr 86
mpc_set_ckpt_callbacks 89
mpc_statistics_write 92
mpc_statistics_zero 95
mpc_stdout_mode 96
mpc_stdoutmode_query 99
mpc_unset_ckpt_callbacks 101
pe_dbg_breakpoint 103
pe_dbg_checkpnt 109
pe_dbg_checkpnt_wait 113
pe_dbg_getcrid 115
pe_dbg_getrtid 116
pe_dbg_getvtid 117
pe_dbg_read_cr_errfile 118
pe_dbg_restart 119
Partition Manager Daemon (PMD) 16, 25, 29, 30, 31, 32
PCI adapter 65
PE 3.2 44
PE 4.1 44
PE coscheduler 10
performance
shared memory 15
pipes 39, 41
STDIN, STDOUT, or STDERR 32
pmd 32
POE
argument limits 31
program argument 31
shell script 30
user applications 25
poe command 25, 32
POE command-line flags
-buffer_mem 206
-eager_limit 205
-hostfile 16
-infolevel 39
-procs 16
-shared_memory 2, 15
-stdoutmode 31
POE considerations
64-bit application 42
AIX function limitation 30
AIX message catalog considerations 33
architecture 33
automount daemon 30
checkpoint and restart 38
child task 37
collective communication call 38
entry point 36
environment overview 25
exit status 26
exits, abnormal 29
POE considerations *(continued)*
exits, normal 29
exits, parallel task 29
file descriptor numbers 29
fork limitations 37
job step default termination 27
job step function 27
job step progression 27
job step termination 27
job termination 29
language bindings 33
large numbers of tasks 35
LoadLeveler 26
M:N threads 38
MALLOCDEBUG 35
mixing collective 30
MPI_INIT 37
MPI_INIT_THREAD 37
MPI_WAIT_MODE 43
network tuning 31
nopoll 43
order requirement for system includes 37
other differences 45
parent task 37
POE additions 27
remote file system 30
reserved environment variables 33
root limitation 30
shell scripts 30
signal handler 28
signal library 25
single threaded 36
STDIN, STDOUT, or STDERR 30, 32
STDIN, STDOUT, or STDERR, output 31
STDIN, STDOUT, or STDERR, rewinding 30
task initialization 36
thread stack size 36
thread termination 37
threads 35
threadsafe libraries 37
user limits 26
user program, passing string arguments 31
using MPI and LAPI together 44
virtual memory segments 34
POE environment variables
MP_ACK_INTERVAL 45
MP_ACK_THRESH 9, 45
MP_BUFFER_MEM 4, 63, 64, 206
MP_CC_SCRATCH_BUFFER 9
MP_CLOCK_SOURCE 34
MP_CSS_INTERRUPT 6, 21, 43, 44
MP_EAGER_LIMIT 3, 4, 63, 64, 205
MP_EUIDEVELOP 30, 127, 129
MP_EUIDEVICE 8
MP_EUILIB 2, 3
MP_HINTS_FILTERED 23
MP_HOSTFILE 16
MP_INFOLEVEL 33, 39
MP_INSTANCES 8
MP_INTRDELAY 45
MP_IO_BUFFER_SIZE 23

POE environment variables *(continued)*
MP_IO_ERRLOG 22
MP_IONODEFILE 20
MP_LAPI_INET_ADDR 17
MP_MSG_API 44
MP_PIPE_SIZE 45
MP_POLLING_INTERVAL 6, 43
MP_PRIORITY 10
MP_PROCS 16
MP_RETRANSMIT_INTERVAL 10
MP_REXMIT_BUF_CNT 7
MP_REXMIT_BUF_SIZE 7
MP_SHARED_MEMORY 1, 2, 15, 30, 34, 127, 129
MP_SINGLE_THREAD 7, 20, 21, 36, 38
MP_SNDBUF 31
MP_STATISTICS 9, 10, 206
MP_STDOUTMODE 31
MP_SYNC_ON_CONNECT 45
MP_TASK_AFFINITY 10
MP_THREAD_STACKSIZE 36
MP_UDP_PACKET_SIZE 2, 45
MP_USE_BULK_XFER 9, 45
MP_WAIT_MODE 6
MPI_WAIT_MODE 43
POE threads 45
point-to-point communications 3
point-to-point messages 15
polling considerations 6
predefined attribute keys 58
predefined error handler 47
predefined MPI data type 49
process contention scope 38
process profiling 42
prof 11
profiling
counts 11
export file 11
library 11, 12
message passing 11
MPI nameshift 11
shared library 12
profiling library 11
profiling MPI routines 11
program exit without setting exit value 27
programming considerations
user applications 25
protocol striping 8
pthread lock 41

Q

quotation marks 31

R

receive buffer 9
reduction operations
C example 55
data type arguments 53
examples 55
FORTRAN example 55
reduction operations *(continued)*
MPI 53
predefined 53
Remote Direct Memory Access (RDMA) 9
rendezvous message 5, 6
rendezvous protocol 3, 5, 64, 205, 206
reserved environment variables 33
resource limits 26
restart restrictions 41
results of communicator and group comparisons 59
retransmission buffer 7, 8
return code 19
rewinding STDIN, STDOUT, or STDER 30
root limitation 30
rtl_enable 12

S

sa_sigaction 28
scratch buffer 9
semaphore 42
send buffer 9
service thread 6, 45
setuid program 39
shared memory 1, 2, 15, 30, 38, 41, 42, 65, 205
reclaiming 16
shared memory key collision 16
shared memory performance considerations 15
shmat 38
shmget 34
shortcut keys
keyboard 209
sigaction 28
SIGALRM 29
SIGIO 29
signal handler 28, 36
POE 28
user defined 28, 29
signal library 25
SIGPIPE 29
sigwait 28
Simultaneous Multi-Threading (SMT) 65
single thread considerations 6
single threaded applications 36
sockets 41
special data types 60
special purpose data types 49
striping 8
subroutine bindings 129, 153
collective communication 153
communicator 157
conversion functions 161
derived data type 162
environment management 171
external interfaces 173
group management 176
Info object 178
memory allocation 179
MPI-IO 180, 190
nonblocking collective communication 129
one-sided communication 190

subroutine bindings *(continued)*
point-to-point communication 194
profiling control 201
topology 201
subroutines
MPE 127
MPI 133
nonblocking collective communication 127
parallel task identification API 123
parallel utility subroutines 67
poe_master_tasks 124
poe_task_info 125
switch clock 34
system contention scope 38
system limits
on size of MPI elements 63

T

tag 64
task limits 65
task synchronization 25
thread context 6
thread stack size
default 36
threaded MPI library 25
threaded programming 35
threads and mixed parallelism with MPI 43
threads constants 62
threads library 25
threads library considerations
AIX signals 28
threadsafe library 7
topologies 59
trademarks 213
tuning parameter
sb_max 2
udp_recvspace 2
udp_sendspace 2

U

UDP ports 8
UDP/IP 2, 4
UDP/IP transport 2
unacknowledged packets 10
unsent data 64
upcall 4, 6
user resource limits 26
User Space 1, 2, 4
User Space FIFO mechanism 8
User Space FIFO packet buffer 8
User Space library 1
User space protocol 44
User Space transport 2, 3, 6
User Space window 3

V

virtual address space 9
virtual memory segments 34

W

wait
MPI 1, 2, 3, 4, 6
window 64

X

xprofiler 11

Readers' comments – We'd like to hear from you

IBM Parallel Environment for AIX 5L
MPI Programming Guide
Version 4 Release 3.0

Publication No. SA22-7945-05

We appreciate your comments about this publication. Please comment on specific errors or omissions, accuracy, organization, subject matter, or completeness of this book. The comments you send should pertain to only the information in this manual or product and the way in which the information is presented.

For technical questions and information about products and prices, please contact your IBM branch office, your IBM business partner, or your authorized remarketer.

When you send comments to IBM, you grant IBM a nonexclusive right to use or distribute your comments in any way it believes appropriate without incurring any obligation to you. IBM or any other organizations will only use the personal information that you supply to contact you about the issues that you state on this form.

Comments:

Thank you for your support.

Submit your comments using one of these channels:

- Send your comments to the address on the reverse side of this form.
- Send your comments via e-mail to: mhvrcfs@us.ibm.com

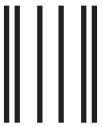
If you would like a response from IBM, please fill in the following information:

Name	Address
Company or Organization	
Phone No.	E-mail address

Readers' Comments — We'd Like to Hear from You
SA22-7945-05

Cut or Fold
Along Line

Fold and Tape | **Please do not staple** | Fold and Tape



NO POSTAGE
NECESSARY
IF MAILED IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 40 ARMONK, NEW YORK

POSTAGE WILL BE PAID BY ADDRESSEE

IBM Corporation
Department 55JA, Mail Station P384
2455 South Road
Poughkeepsie, NY
12601-5400

Fold and Tape | **Please do not staple** | Fold and Tape

Cut or Fold
Along Line

Program Number: 5765-F83

SA22-7945-05